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### **ENVIRONMENTAL CHANGE, AGRICULTURAL SUSTAINABILITY AND ECONOMIC DEVELOPMENT IN THE MEKONG DELTA OF VIETNAM**

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## ***Precarious Paddies: The Uncertain, Unstable, and Insecure Lives of Rice Farmer in the Mekong Delta***

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In recent decades the concept “precarious work” has gained great currency both in policy circles and in the literature of the social sciences. Generally speaking, “precarious work” is defined as work that is uncertain, unstable, and insecure, wherein the preponderance of risks are borne by workers rather than by employers or government.<sup>1</sup> Up until now the concept has almost always been used with reference to wage workers employed, whether formally or informally, in the manufacturing or service sectors. In this paper we propose to broaden this valuable concept by extending it to the agricultural sector and by including various types of “insecure” agriculturalists—whether wage laborers, tenants, or owner operators—in its embrace. More specifically, we shall apply the concept to farmers and farming in the Mekong Delta, and, in so doing, utilize both written records—government records, scholarly studies, scientific reports, and the like—and interviews as well as our own fieldwork conducted in 2009.

Farming in general --and rice farming in the densely populated Mekong Delta in particular --has rarely been easy, seldom been secure, and never been risk-free. Deltas in general are fluid and dynamic environments that are both rich in ecological energy and highly unstable. The conditions that make the Mekong Delta and other deltas richly productive areas for agriculture also make for instability and precariousness. Floods that deposit upstream topsoil sediments can also sweep away efforts to cultivate them. The tidal currents that create dynamic swirls of energy at river mouths can also create conditions too saline for most agricultural crops. The hugely productive agricultural zone (about 40,000-45,000 sq. km.) of the Mekong Delta – the rice basket of Vietnam – is also a region of often unpredictable environmental change.

Year-to-year fluctuations in growing conditions in the Delta by themselves are enough to render farm life precarious, and certainly broad social forces, especially those growing out of power asymmetries of one sort or another—those growing out of exploitative landlord-tenant relation, for example--have also played historical roles.<sup>2</sup> For a variety of reasons, though, over the past two decades uncertainty, instability, and insecurity have risen dramatically for many farmers in the Mekong Delta.

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<sup>1</sup> See, for example, Arne L. Kalleberg, “Precarious Work, Insecure Workers: Employee Relations in Transition,” *American Sociological Review* 74 (February 2009): 1-22.

<sup>2</sup> Charles Robequain, *L'Évolution Économique de L'Indochine et du Vietnam* (Paris: Centre D'Études de Politique Étrangère, 1939), pp. 201-270 esp.; Robert L. Sansom, *The Economics of Insurgency in the Mekong Delta of Vietnam* (Cambridge: The MIT Press, 1970), pp. 18-52; David Biggs, “Problematic Progress: Reading Environmental and Social Change in the Mekong Delta,” *Journal of Southeast Asian Studies* 34 (February 2003): 77-96. On the earlier history of the region, see Nola Cooke and Li Tana, eds., *Water Frontier: Commerce and the Chinese in the Lower Mekong Region, 1750-1880* (Singapore: National University of Singapore Publishing, 2004).

In most explanations of the rising precariousness of work in the Delta, the 1986 market reforms in Vietnam--and the concomitants of such reforms for agriculture-- figure prominently. In this regard experts point in particular to the transformation of land tenure patterns since 1986; to increased competitive pressures; to the growing vulnerability of many agriculturalists to powerful “middlemen” and to the vagaries of world commodity prices; to increased rural inequality; and to the dismantling of the socialist welfare network, which led beginning in 1989 to steps towards privatization and to an attendant reduction in access for many in the countryside both to adequate health care and to tolerable disability/pension schemes. Some experts point as well to the declining status of Delta farmers, particularly rice growers, as the agricultural sector becomes more diversified and Vietnam as a whole moves into higher value-added economic activities of one sort or another. Although the market reforms have obviously brought numerous benefits to the Delta as well—Vietnam is now consistently number two behind Thailand as a rice exporter and, largely as a result, mean household income in rural parts of the Delta has risen significantly--such benefits have not been distributed evenly among the region’s vast rural population.<sup>3</sup>

None of this is to suggest, however, that the increased precariousness of rice farming in the Delta is due solely to the market forces unleashed in 1986. Delta rice farmers, like fellow agriculturalists in many parts of the developing world, also face an array of “legacy” problems resulting from history, as it were. The “path” taken by the Delta—a path marked by colonialism and exploitation, wars, and inefficient and often inept state economic policies—resulted inexorably, if not inevitably in deficiencies in and/or malfunctioning of key infrastructural supports and institutional arrangements necessary for equable and sustained growth. In the rice sector—still the most important sector by far in the Delta--any short list of such problems would include the dearth of modern transportation/communications systems; milling/grading/inspection capabilities of uneven quality; inadequate crop-storage facilities; insufficient (and often expensive) mechanisms of agricultural finance; the absence of “income-smoothing” tools such as crop insurance and futures contracts; inefficient, non-transparent land markets characterized by high transactions costs; rudimentary provisions for rural education; underfunded agricultural-research infrastructure with limited capacity to disseminate research; and oligopolistic agricultural middlemen/ intermediaries. Some critics also point to corruption in the private sector and public sector alike.<sup>4</sup>

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<sup>3</sup> See, for example, Benedict J. Tria Kerkvliet and Doug J. Porter, eds., *Vietnam’s Rural Transformation* (Singapore: Institute of Southeast Asian Studies, 1995); Judith L. Ladinsky, Hoang Thuy Nguyen, and Nancy Volk, “Changes in the Health Care System of Vietnam in Response to the Emerging Market Economy,” *Journal of Public Health Policy* 21 (2000): 82-98; Susan J. Adams, “Vietnam’s Health Care System: A Macroeconomic Perspective,” Paper, International Symposium on Health Care Systems in Asia, Hitotsubashi University, Tokyo, January 21-22, 2005 [<https://www.imf.org/external/country/VNM/rr/sp/012105.pdf>]; Martin Rama, “Social Protection and Labor Markets in Vietnam,” Paper, Commission on Growth and Development, Labor Markets and Growth, October 15, 2007, Washington, D.C. [<http://www.growthcommission.org/storage/cgdev/documents/LaborMarkets/Rama.pdf>].

<sup>4</sup> Interview, Vo Tong Xuan, February 3, 2009, Ho Chi Minh City, Vietnam; Interview, Senior Staff, Mekong Delta Development Research Institute (MDI), February 4, 2009, Can Tho, Vietnam; Interview with Nguyen Xuan Lai and Luu Hong Man, Cuulong Delta Rice Research Institute, February 5, 2009, Thoi Thanh, Vietnam. Also see Hien

Exacerbating--and in some cases growing out of--the concerns mentioned above are another set of problems related to rice cultivation regimens and practices in the Delta. Holdings are generally tiny in the delta (generally about a hectare or two per farm household), which inhibits mechanization. When mechanized equipment is employed in rice production in the region—and more is being used each year—such equipment is all too often still rudimentary, cheaply made, and of questionable quality. For the most part, agriculture in the delta, as in the rest of Vietnam, is still labor intensive—almost 56 percent of the country's labor force is still engaged in agriculture—but labor productivity is low. Indeed, despite the fact that more than half of the country's labor force remains in the agricultural sector, that sector constitutes only about 21.4 percent of GDP. By way of contrast, in the U.S. agriculture accounts for about 0.5 percent of the labor force and 1.2 percent of GDP. Moreover, though many agriculturalists are largely idle in the Delta for long periods during the year, during the busy harvest season labor shortages invariably arise in various parts of the region.<sup>5</sup>

Several research institutes in the South have collaborated with farmers in the creation of a range of seed varieties, and rice growers in the Delta have largely escaped the expensive trap of hybrids, but seed is nonetheless expensive relative to other costs, and variety and seed choices are often a lottery where farmers bet on unpredictable future markets. Fertilizer use—generally bio-fertilizers of one type or another—is common, and pesticides and herbicides are widely used—often indiscriminately. It should be noted for the record, though, that a growing cadre of progressive farmers in the Delta attempt to practice IPM at least to some degree, and agricultural researchers are actively promoting a more responsible use of pesticides and herbicides in general.

Agronomists and soil scientists in the Delta and other parts of Vietnam --as well as outside of the country at institutions such as International Rice Research Institute (IRRI) in Los Baños, The Philippines-- are doing important research on soil reclamation and rice-varietal improvement, but the results of such research often fail to reach Delta farmers or are viewed with skepticism by them. Consequently, rice yields in the Delta, though rising, remain far lower than in leading producing/exporting regions, including nearby Thailand, the world's leading exporter. And the quality of Vietnamese rice remains open to question, too, at least in the minds of most consumers in wealthier markets, forcing Vietnam to sell most of its rice cheaply, mainly in poorer developing countries in Asia, Africa, and other parts of the world.<sup>6</sup>

For decades now, development experts, agricultural policymakers, and research scientists in the Delta have been pushing hard to get the region's farmers to modernize, to consolidate plots into bigger holdings, to diversify production and move, at the margins, out of rice and into mixed farming systems and the cultivation of value-added crops. Many farmers have also contributed to the swelling ranks of laborers in urban industrial zones inside or outside the Delta and

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Nguyen Thi Minh and Tsunemasa Kawaguchi, "Overview of Rice Production System in the Mekong Delta—Vietnam," *Journal of the Faculty of Agriculture, Kyushu University* 47 (2002): 221-231; W. Smith, I. Williamson, Tran Kim Chung, Nguyen Thi Vinh Ha, and Hoang Xuan Quyen, "The Impact of Land Market Processes on the Poor in Vietnam," *Survey Review* 39 (January 2007): 3-20.

<sup>5</sup> See the sources cited in footnote 4 above. Also see <https://www.cia.gov/library/publications/the-world-factbook/geos/vm.html>; <https://www.cia.gov/library/publications/the-world-factbook/geos/us.html>.

<sup>6</sup> See the sources cited in footnote 4.

indirectly thwart efforts at reform by doing so. Reformers have promoted these and other changes with limited success, but much more work needs to be done before the Delta's agriculture takes off and begins to reach its formidable potential. Small farmers in the Delta, particularly poorer, less educated ones in more isolated parts of the region, continue to struggle the most. And the legacy of past environmental instability and of population growth in the Delta, in combination with the potentially dire threats posed by climate change and Chinese dam-building initiatives on the upper Mekong, will pose further impediments not just to these farmers but to everyone calling the Mekong Delta home.

Not surprisingly, over time attempts to stabilize and structure the fluid balance of water and soils in the Delta so that rice can be cultivated intensively—two and sometimes three crops a year—has in turn made this cultivation unsustainable in some locations. Soil fertility is declining in parts of the Delta, for example, especially in those areas where diking and dams have thwarted annual silt-laden inundations. In other places (such as the Plain of Reeds) the release of acids by the digging of new canals or by attempts to cultivate soils that are already acidic have compounded the problem that is a perpetual one for irrigated agriculture – of soils that become too acidic for rice. Wetlands that are important buffers to rice lands have also shrunk as rice cultivation has expanded and biodiversity in general has suffered the same fate in the Delta as it has everywhere that monocultures have expanded. Facilities for water and waste treatment are minimal in the Delta, and problems arising from pesticide run-off are mounting. Similarly, as manufacturing production increases in the Delta, the industrial pollution of air and water has become a recognizable problem. Each of these problems is amplified by neglect; the government, lacking both capacity and capability, has not yet developed comprehensive land-use plans for the Delta, nor in spite of a couple of highly publicized cases demonstrated much vigor in going after, much less attempting to eradicate the sources of environmental degradation.<sup>7</sup>

All of the above problems are amplified by changes in the very foundation of Delta agriculture – in the environmental conditions that make it possible. The threat to the current configuration of people and environments in the Delta by climate change is especially striking. Climate, as one scientist tagged it, is a “chaotic beast,” and scientific efforts to make predictions about where climate change will take us is therefore not precise. There is still much uncertainty about, and thus disagreement over the most likely climate-change scenario for the Delta. That said, given the ecological fragility of this low-lying region and its vulnerability to sea level rise, saline intrusions and changes in flooding patterns, it is no wonder that the effects of climate change, both the effects already experienced and those projected for the future, are sources of considerable anxiety in the Delta today.

With most of the region just a few meters above sea level, even small increases in sea level due to climate change –in this case global warming--can have profoundly dislocating and disruptive effects. A rise in sea level of just one meter could displace millions and cause untold harm to millions of agriculturalists in the Delta, while perhaps providing smaller numbers with new economic opportunities. For example, with such an increase, salt water would intrude further upon the Delta, increasing soil salinity to levels that would make considerable swaths of the Delta unsuitable for rice production. The global warming trend we have seen over past decades is already endangering rice cultivation in the Delta, as increasing night temperatures cause

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<sup>7</sup> Ibid.

increased plant stress and thence lower yields. If rising sea levels and increased salt water intrusion in lower reaches of the Mekong might help some inhabitants in the region—people employed in aquaculture or growing rain-fed rice—such benefits would hardly compensate for the millions of rice cultivators adversely affected by climate change.<sup>8</sup>

Further complicating the environmental difficulties posed by rising sea levels and climate change are the problems posed by Chinese dam-building upriver, which has considerably reduced the flow of water into the Delta from the north. According to a recent report by the Mekong Delta Commission (MDC), water levels in the Mekong River are today at record low levels, endangering the livelihoods, if not the lives of scores of millions in a number of different countries in mainland Southeast Asia. While low levels of rainfall across the region in recent years have contributed to the problem, many experts place the burden of the blame on China's aggressive dam-building campaign on the upper Mekong over the past decade.<sup>9</sup> Thus, with problems arising from both rising sea levels/salt-water intrusion *and* from reduced amounts of water flowing into the Delta from source streams in the Himalayas, farmers of the Mekong Delta face both upstream and downstream environmental challenges.

Rice cultivation in the Delta has always been a balancing act with the environment – and when population levels are relatively low and farmers are producing mainly for household use on lands that are flooded regularly and have good soils, it's a balancing act that works. But the shift to extensive and intensive production of rice for markets, and the diking of lands to add a third crop of rice or of vegetables or maize for cattle feed, along with vulnerability to the extraordinary fluctuations of forces not environmental, but social and political – from people and markets rather than water and soils – has made the work of growing rice in the Delta increasingly.

## **Analysis of Migration Flows in the Mekong Delta of Viet Nam** **Huynh Truong Huy<sup>\*10</sup>, Le Nguyen Doan Khoi<sup>1</sup>**

### **Abstract**

Migration occurs as a response to economic development and social, cultural, environmental factors as well. This paper has explored the pattern of migration in the Mekong Delta (MD)

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<sup>8</sup> Ibid.

<sup>9</sup> *The Straits Times* [Singapore], "China Help on Mekong Sought," March 7, 2010 [http://www.straitstimes.com/BreakingNews/SEAsia/Story/STIStory\_499145.html]. On the broader problems posed by Chinese dam building, see Kenneth Pomeranz, "The Great Himalayan Watershed: Agrarian Crisis, Mega-Dams and the Environment," *New Left Review* 58 (July-August 2009) [http://www.newleftreview.org/?view=2788].

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region of Viet Nam by using the information of the VHLSS in 2004 and 2006. The main purposes of the paper are following: (i) to give an enough insight of situation of migration flows in the MD region and (ii) to identify the determinants of the migration flows concerning commune-related variables. From the description and the multivariate analysis, there are several interesting findings: First, the number of migrants of the MD region has been increased in recent years and their destinations are the leading industrial and commercial cities in Viet Nam, including Ho Chi Minh and Binh Duong. Secondly, the “push” factors such as poverty and challenges in farm production are the key causes of migration flows. In addition, policy makers should take advantage of economic development programs as an adjustment tool of migration matter.

*Keyword:* migration, migrant, origin, destination.

## **1 Introduction**

### ***1.1 Migration and development***

Until recent, migration’s role in economic development has been widely recognized. Migration and particularly internal migration are seen as one of the essentials of growth and a crucial strategy to escape from poverty for many poor and rural families in developing countries. As widely known, the economic transition towards expansion of urban centers and manufactures has strongly attracted a large number of labor force from surrounding regions with less developed condition; as a result, the rural migrant laborers gradually engage in urban labor market, as included by Lewis (1954). Simultaneously, an expansion of manufactures in urban areas has created employment opportunities for rural migrants to improve their livelihoods and well-being. Therefore, on economic aspect, migration and development are complements: development induces migration and migration contributes development. In comparison with international migration, internal migration is likely more important in developing countries where a majority of population live in rural area and have a limitation of human capital. In the update report of human development 2009, the UNDP estimated that there were about 740 million internal migrants in the world, four times as many as those who moved internationally (UNDP, 2009). Additionally, data gathered from some countries of Asia by Deshingkar and Grimm (2005) presented that nearly 120 million people move internally in China against about 450 thousands of international migrants in 2001. In Viet Nam, during the period of 1994-1999, 4.35 million people were estimated to migrate internally, while the number of international migration was fewer than 300,000 people. In the literature we can find that relationship between migration (particularly internal migration) and development is widely recognized. This pattern of migration does not only contribute to economic growth in destination, but also has positive effects on livelihood strategy and poverty reduction in origin. More specific, contributions of migration to development are usually summarized in a number of the following aspects: For the destination, migration can affect the average level of human capital, both quantity and quality, for example: making increase of urban labor force and high-qualified migrants, the so-called “brain drain”. For the origin, remittances from migrants as an additional source of income improves livelihoods of people who left behind at origin, stimulate consumption and maintain financial ability to cope with vulnerabilities.

For internal migration of some countries in Asia, there is a gradual change of migration from rural - rural to rural – urban. As formerly, a majority of people often moved from one village to another village within country to seek an availability of fertile soils for their farm work. In the

latter, economic transition took place in most countries in Asia towards manufactures and exports that has strongly effects on the trends of internal migration; especially, a large number of rural migrants to urban areas is increasingly recognized. For example, the share of rural to urban migration in Thailand increased from 14.3% in the period of 1975 – 1980 to 18.4% in 10 years later; while, the share of rural to rural migration decreased from 52% to 40.9% in the same period (Guest, 2003). In Viet Nam, rural to rural migration took place after the reunification of country along with the planned migration programs. That aimed to reclaim an abundance of fertile soils in Highlands, but low density of population. According to statistics of the GSO<sup>11</sup>, the number of rural to urban migration was 1.18 million people, accounting for 27.2% of total all migrants in the period of 1994 – 1999. Although, recent estimations of this migration is not known yet, the pattern of rural to urban migration has been dominantly recognized. According to estimated data of GSO in 2006, five cities such as Ho Chi Minh, Binh Duong (in the Southeast), Ha Noi, Quang Ninh (in the Red Delta) and Da Nang (in the Central coast) are the most destinations for migrants. These cities are seen as the leading centers of industry and commerce in the whole country. In addition, Deshingkar and Grimm (2005) also documented that this pattern of migration in Laos, China and Cambodia also has been increasing in recent years along with the development of industrialization and urbanization in these countries. Therefore, it can infer that rural to urban migration plays a crucial role in economic development and has been an interesting concern to many researchers in domain of human economics.

### ***1.2 Commune-related factors affecting internal migration: a review***

As already known, reasons of migration are usually interpreted by a combination of “push” and “pull” factors. Especially for rural people with low qualification, the “push” factors of origin such as high populated density, poverty, unemployment and damages from natural disasters seem more important to induce them to migrate than “pull” factors of destination. In both literature and empirical evidences, commune-related factors that determine internal migration flows may be classified into main categories, as following:

- Principal factors
- Economic factors
- Policy factors
- Environmental factors

*Principal factors* refer to variables those are the density of population, geographic location (remote area) and ethnicity. More specifically, relationship between high populated population and migration has been long seen as a dual phenomenon: rural to urban migration leads to high populated density in urban areas where has employment opportunity. Otherwise, high-populated density is often associated with lack of availability of employment and productive land in rural areas. It is apparent that in rural areas, high populated density may induce people to migrate due to labor surplus in agriculture. Meanwhile, scale of non-farm work is usually so small that unable to absorb that labor surplus. Further, basing on a review of determinants of internal migration, Ivan (2008) also highlighted that the density of population in origin has positive effect on internal migration and this variable is usually seen as the “push” factor of migration.

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<sup>11</sup> General Statistical Office of Viet Nam

Because of the variety of ethnic groups and geographic locations in most countries of Asia, researchers often examine on how the pattern of migration across ethnic groups and geographic regions takes place. For example, the study on decision of rural to urban migration in China by Zhao (1999), the authors found that minorities tended to less move out of their villages. Evidences on migration suggests that poor villages or remote villages also tend to have a higher number of migrants (Deshingkar and Grimm, 2005), because migration is long seen as a tool to escape from poverty. However, people living in remote areas, far from the central of province or district, can be less migratory for lack of availability of information, weak road and high costs of migration. In the study of seasonal migration and improving living standards in Viet Nam, Brauw and Harigaya (2007) also mentioned policy suggestions on encouragement of migration for people in remote areas and minorities in the Northern Uplands and the Highlands.

### *Economic factors*

By the earliest literature of migration, Ravenstein found that major motivations of migration are economic and demographic reasons. In the latter, few of many researchers such as Lewis (1954), Lee (1966) and Todaro (1969) also examined economic variables (mainly gap of wages) as a key determinant of migration decision.

Empirical evidence on internal migration in some countries of Asia by IOM (2005) was shown that gap of income among sectors is usually regarded as the key factor of migration flows, including migration away from agriculture to non-agriculture or migration from rural to urban areas. More specifically, migration flows engaged in non-agricultural sectors is seen as a result of the economic transition along with the concentration on industrialization. As already known, it is apparent that the economic transition often causes disparities in development and income across regions in country. Certainly, a higher wage of non-agricultural sectors in urban areas is a magnet which absorbs rural people to come. Meanwhile, agricultural work is often seen as low-paid employment due largely to backward technology and frequent negative impacts of climate changes that stimulates people to seek a another employment out of agriculture. As for China, scholars and policy makers predict that there are still 150 million of surplus laborers in agriculture who will be moved to non-agricultural sectors in the next one or two decades.

Additionally, rural to urban migration has been viewed as a positive livelihood strategy for the poor in rural areas. Because of limitations of access of land, capital and education, many of those households often choose migration as an ultimate option to survive. Throughout the study of internal migration and poverty in Asia, Skeldon (2003) highlighted that poverty may be a root cause of migration. A large number of people moved from least developed area (dominantly agriculture) to more developed areas (mainly manufactures).

As for agriculture production, there are numerous and diverse of constraints to farmers, ranging from events related to changes in agro-product prices, access to market, capital to farming techniques, and from diseases to climate changes. It is apparent that farmer's income from agriculture are usually more vulnerable from those constraints and risks; for example, a majority of farm households in Viet Nam, with small scale of farming<sup>12</sup>. In order to overcome those constraints, farm households often tend to diversify sources of income by reallocating laborers and sending members to urban areas for non-farm working. According to the empirical evidence

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<sup>12</sup> According to the survey result of GSO in 2006, Vietnamese farm households had an average area of 0.77 hectare.



on migration in Bangladesh, Hossain (2001) reported that 25.6% of the migrants had engaged in agricultural sector at the origin before migration. After the economic crisis in 1997, Thailand, a farming-based country, had over 1.2 million people who left away from agriculture to manufactures, construction, commerce and services. Another evidence on internal migration in Viet Nam, IOM (2005) indicated that rural people, who engaged in agriculture and fishery, often face sharp seasonal fluctuations and long slack periods. Therefore, returns of agriculture only provides enough for basic needs of food, while other costs of living are quite dependent on remittances from migrants.

#### *Policy factors:*

Migration occurs as a response to economic development of each country, each province and each commune. A rapid increase of rural to urban migration has made many challenges to policy makers in maintaining agricultural sector. Therefore, a set of policies on job creation for rural people are very essential in present condition, especially non-farm rural employment ranging from traditional local industries (handicrafts) to services (repair of farm equipment). On the other hand, such activities may increase an attractiveness of employment in rural areas and consequently reduce the pattern of migration towards urban areas (Turnham, 1994, Rhoda, 1983).

#### *Environmental factors*

Apart from socio-economic factors that determine the trends and levels of migration. Until recent, external effects of environmental changes are taken into account and seen as one of the key determinants to explain pattern of internal migration (mostly rural to urban migration). Cited from the reports of international organizations in 2005, Brown (2008) revealed that 50 million people in 2010 will be forced from their home and off land by a range of serious environmental effects, including pollution, land degradation, droughts, flooding and natural disasters.

As for Viet Nam, it is one of the most disaster-prone countries in the world. According to the study of flooding in the MD of Viet Nam, Ninh (2007) warned that flood and inundation have the most effects on agricultural production of the region (mainly rice crop). Annually, flooding season usually last between September and mid-November, but inundation tends to be longer and deeper due to the rise of level of seawater. Undoubtedly, land degradation and damages from natural disasters are currently the most popular cause of rural to urban migration in almost agrarian economies like Viet Nam.

### ***1.3 Empirical evidences on internal migration in Viet Nam***

As for Viet Nam and particularly the MD, the internal migration has increasingly recognized since the introduction of economic transition. As already described, the unbalanced development and inequality in living standards across regions of Viet Nam and rural and urban areas are the key cause of rural to urban migration during the last decades. According to the Viet Nam's population census in 1999, nearly 4.35 million people changed their place of residence between 1994 – 1999, accounting for 6.5% out of 6.9 million population. While, this share was only 2% in the period 1984 – 1989. It is apparent that internal migration is not a new phenomenon in Viet Nam and it has been become an interesting concern of researchers and policy makers in the field

of migration and development. Therefore, in this paper, several studies on the pattern of internal migration (macro-data analysis) in Viet Nam are summarized, as following:

Many of previous studies used the census data of GSO to examine the pattern of internal migration across provinces and regions in Viet Nam, for example: Anh, *et al*, (1997), Phan and Coxhead (2007) and Loi (2005). In other words, migrants in the census are defined as the number of persons, over 5 years old in the survey period, who changed their place of residence during the last 5 years.

In the study of internal migration in Viet Nam, Anh, *et al*, (1997) also used the census data in 1999 to describe the trends of migration and identify the determinants of number of migrants across provinces. The authors indicated that the Highlands and the Southeast were the most promising destinations for migrants from other regions in Viet Nam due to many advantages of fertile land and development of manufactures and commerce. In addition, they used a range of macro-data variables of the origins such as density of population, industry sector, distance and policy to explain the trend of inter-provincial migration. More interesting, two of many important findings were found that additional increase of living standards and distance between origin and destination have negative effects on the number of inter-provincial migrants. The authors explained that distance is seen as an intervening obstacle in migration process, because of lack of availability of information and transportation across provinces or regions in Viet Nam. However, they also presented limitations of macro-data in the analysis that we have no further information of migration concerning motivations, employment and consequence of migration.

Similarity to the earlier work of Anh, *et al*, (1997), Phan and Coxhead (2007) also used the census data in two periods of 1984-1989 and 1994-1999 to investigate pattern and determinants of inter-provincial and inter-regional migration in Viet Nam; then measure impact of migration on inequality in income across provinces. Gravity equation is a popular model to estimate a spatial movement of people between origin and destination. In the model, the authors applied the Ordinary Least Square method to measure a number of inter-provincial migrants (with the logarithm transformation); besides, they defined inequality in income as a ratio of per capita income between the richer province (destination) and the poorer province (origin). Throughout results of estimation, they indicated that the migration flows tended to increase during two periods of the census. The trend of those migration flows can be explained significantly by different levels between the origin and the destination including per capita income, bus distance. Not surprisingly, the Highlands and the Southeast were still the most destinations of most migrants. While, The MD and Central Coast were the most origin in the 1990s. The authors illustrated that provinces with a higher per capita income tend to attract more migrant. As estimated, additional increase of 1% per capita income of destination province leads to an increase by 1.5% of migration rate. Furthermore, they also revealed that migration seems as a tool to mitigate inequality in income across provinces, for example 1% increase in out-migration rate leads to a decline in inter-provincial inequality in income by 0.01%.

In contrast with the previous existing studies on internal migration, Loi (2005) used the method of case study to explain the pattern of rural to urban migration across regions in Viet Nam. The author highlighted three important aspects causing rural people to migrate. First, pressure of population and employment is seen as one of the key reasons of migration. More specific, share of population in the working age of 15-59 was steadily increased from 47% in 1979 to 57.5% in 1999 and 65% in 2009, equivalent to 1.37 million persons per year between 2004 – 2009. Simultaneously, the additional increase of working aged persons mostly took place in rural areas

where had a agricultural sector with low returns. Therefore, migration flows from rural to urban areas has become a common phenomenon in the recent decade. Secondly, like to some countries in Asia, industrialization and urbanization process in Viet Nam has also played an important role in attracting a large number of rural people to come. Thirdly, the author indicated that stagnant development of traditional rural industries (mainly traditional handicrafts) in most villages of Viet Nam caused a mass of people to leave for urban areas to seek another job. It is found that recession of traditional industries is mainly caused by the severe competition of modern industrial products with low price.

In short, throughout the existing studies on internal migration of some countries in Asia and of Viet Nam, we can find that this pattern of migration is generally investigated underlying the macro-data variables of both the origin and the destination. Until recent, there nevertheless has been an absence of specific study on internal migration for regional level, for example the MD. Therefore, the main objective of this paper is to investigate those factors that are associated with the rural to urban migration in the MD region. More specific, this paper attempts to exploit the VHLSS<sup>13</sup> series in 2004 and 2006 with the commune-related data and examines whether or not this region has relevant aspects of migration to recent findings in Viet Nam.

The remaining part of this paper is organized as following: Section 2 presents an overview of internal migration flows of the MD region between 2002 – 2007. Section 3 provides an explanation of the data of VHLSS series and commune-data variables. Section 4 shows model specification and determinants of migration of the MD region. Finally, some conclusions are drawn in section 5.

## 2 General migration flows of the Mekong Delta region

Internal migration in Viet Nam, particularly the MD region, is increasing over time due to a variety of reasons such as uneven economic development, demographic imbalances, living standards etc. According to the census of GSO in 1999, the MD was one of two the most origins of Viet Nam, after the Red Delta in the North. Economic transition of Viet Nam and particularly of the MD plays an important role in the trend of migration of the region; of which, regional disparities are one reason. As a result, a massive number of people left out their rural area to urban areas with desires of a better employment and a positive livelihood. Data of census between 2003 – 2007 of GSO showed that the rate of out-migrants of the MD region increased steadily from 0.23% in 2003 to 0.79% in 2007, compared to the rate of country was respectively 0.75% in 2007, rose up from 0.25% in 2003. Among those flows, migration away from rural areas and agricultural sector were seen as a major pattern in this region. As a result, declines in share of rural population and labor force in agriculture was taken place in the same period (see appendix 1).

Table 1: Population and migration of the MD region

Year	Population	In-migration	Out-migration	Rate of In-migration	Rate of Out-migration	Net migration rate
	person	person	person	%	%	%

<sup>13</sup> Viet Nam Household Living Standards Survey

2003	16,713,700	9,359	38,943	0.06	0.23	-0.18
2004	17,047,579	9,617	48,248	0.06	0.28	-0.23
2005	17,221,063	46,612	76,657	0.27	0.45	-0.17
2006	17,389,927	50,720	121,476	0.29	0.70	-0.41
2007	17,420,195	56,507	137,788	0.32	0.79	-0.47

Source: GSO, 2007.

The most popular questions in most studies on migration that researchers expect to investigate are (i) why did people move and (ii) where are their origins and destinations? In the section, we also use secondary information of the GSO to interpret partly the pattern of migration of the region in recent years. Some socio-economic indicators such as density, income per capita, share of farm income and poverty rate are incorporated in the analysis.

Since nearly 80% population of the MD lived in rural areas and mainly depended on agricultural sector, it can be inferred that the pattern of migration of the region has almost related to pressure of population and of employment in rural area. With the population growth rate of 1.01% a year in the recent decade, density of population of the region increased steadily during the last 15 years, from 383 persons per sq. km in 1994 to 436 persons per sq. km in 2008 (GSO, 2008). Additionally, the region has about 110,000 persons entering labor force in annual. Therefore, pressure of population and new employment of laborers (just engaged) has become the concerns of policy makers in the MD.

Besides, economic transition away from agriculture to manufactures and services has made considerable effects on labor force in rural areas, as previously shown. More specific, a proportion of rural people must be forced away from their agricultural sector due to expansion of industrialization or urbanization. Meanwhile, traditional industries in rural areas are in stagnant situation and gradually eliminated out of local economy mostly due to low capacity of competition and relatively small scale of production and local market. Undoubtedly, it can state that the pattern of inter-provincial migration out of agriculture is a primary phenomenon of the initial period of economic transition. More recent findings of rural to urban migration in China also illustrated this (Zhang and Song, 2003), because this process usually takes a lot of time of development of infrastructure and changes of legal institution.

Table 2: Socio-economic indicators by regions in Viet Nam

Year	Density	Monthly income per capita	Share of monthly income per capita from agriculture	Underemployment rate <sup>14</sup> in rural areas	Poverty rate
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<sup>14</sup> According to GSO, this rate is defined as the percentage of underemployed persons in total employed population; in which, underemployed persons refer to those who worked less than 35 hours a week and they are willing to work more time.

	Person/km <sup>2</sup>	1,000 VND	%	%	%
Red Delta	933	653	19.0	8.2	10.1
Northeast	} 118	511	32.4	} 2.5	22.2
Northwest		372	45.9		39.4
North Coast	} 207	418	30.4	} 6.3	26.6
South Coast		550	21.0		17.2
Highlands	92	522	45.9	5.6	24.0
Southeast	543	1,064	11.1	3.7	4.6
Mekong Delta	436	627	37.7	7.1	13.0
Whole country	260	636	24.8	6.1	15.5

*Source:* GSO, 2006-2008

Basic information displayed in table 2 provides us comparisons of several interesting indicators across regions. These information plays an important role in interpreting the pattern of migration to the MD region. It is apparent that the Southeast region, with a higher level of income per capita, is still the most interesting destination of migrants from other regions of the country, as known in previous studies between 1994-1999. In addition, as for the MD region, 37.7% income per capita of residents was dependent on agricultural sector, compared to 24.5% of the country. Simultaneously, the rate of underemployment in rural areas of this region was also higher than the average level of the country. Therefore, we can find that rural people would face challenges of employment in rural areas if as they had to be forced away from the agricultural sector. Although poverty rate has a rapid decline in recent years, monthly income per capita of the MD region was still lower than an average level of the country, especially compared to the Southeast region. Therefore, it can give an initial subjective evaluation that the pattern of migration the MD region is associated with the socio-economic indicators.

To answer the second question: where are migrant's origins and destinations? We use data of out-migration from the census of the GSO in 2006<sup>15</sup> to describe flows and magnitude of migration of the MD region.

#### Where are their origins?

According to the census of the GSO in 2006, Hau Giang was the most origin of the migrants in the MD region, with its net migration rate of -0.73%. The followings were Soc Trang and Vinh Long. Not surprisingly, these origins likely had less monthly income per capita than an average level of the entire region; besides agriculture, a low-return sector, played an important role in economy of those provinces. It is worth noting that high rate of migration tends to be closely

<sup>15</sup> The abrogation of notification procedure to local authority when leaving out of the commune has led to lack of statistical information of migrant's destination since 2007.

associated with poverty circumstance and agrarian economy of the origins. As earlier shown, most rural households engaged in agricultural production, but at small land per household. As a result, they are often more vulnerable and trapped into poverty from economic shocks and natural disasters, because social security and unemployment compensation are virtually absent and savings are too low to cope with constraints for period of no income. Consequently, Viet Nam and particularly the MD region are good locations to illustrate the relationship of agriculture, poverty and migration.

Table 3: Socio-economic background of the origins

Origin	Net migration rate <sup>a</sup>	Monthly income per capita <sup>b</sup>	Share of income from agriculture <sup>b</sup>	Poverty rate <sup>b</sup>	Economic feature <sup>c</sup>
	(%)	(1,000 VND)	(%)	(%)	-
Hau Giang	-0.73	609	42.9	15.0	Pure agriculture
Soc Trang	-0.68	495	50.3	19.5	Agriculture
Vinh Long	-0.63	580	36.3	11.0	Agriculture and industry
Ben Tre	-0.62	614	38.8	16.2	Agriculture and seafood
Can Tho	-0.61	780	23.6	7.5	Industry and service
An Giang	-0.45	691	33.1	9.7	Service and agriculture
Dong Thap	-0.39	609	39.6	12.1	Pure agriculture
Bac Lieu	-0.32	610	45.7	15.7	Seafood and agriculture
Long An	-0.30	627	32.8	8.7	Agriculture and industry
Tra Vinh	-0.28	509	40.6	21.8	Pure agriculture
Tien Giang	-0.27	630	34.2	13.2	Agriculture and industry
Ca Mau	-0.25	666	47.8	14.0	Seafood and agriculture
Kien Giang	-0.03	675	39.0	10.8	Agriculture and seafood

Mekong Delta	-0.41	627	37.7	13.0	-
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Source: GSO, 2006: <sup>a</sup> Census, <sup>b</sup> VHLSS and <sup>c</sup> VCCI-Can Tho<sup>16</sup>, 2006.

### Where are their destinations?

It is clear that a number of migrants left out of the region are dominant in the flows of out-migration, accounting for over 73%. As expected, the Southeast region is still the most promising destination for most migrants of the MD region. In which, Ho Chi Minh city and Binh Duong province are the most attractive destinations in the Southeast region. Meanwhile, the inter-provincial migration within the MD region is only around one-fourth of the total out-migrants. However, due to lack of availability of information concerning motivations of migration, it is best to use basic information of socio-economic background of those destinations as the key “pull” factors of migration.

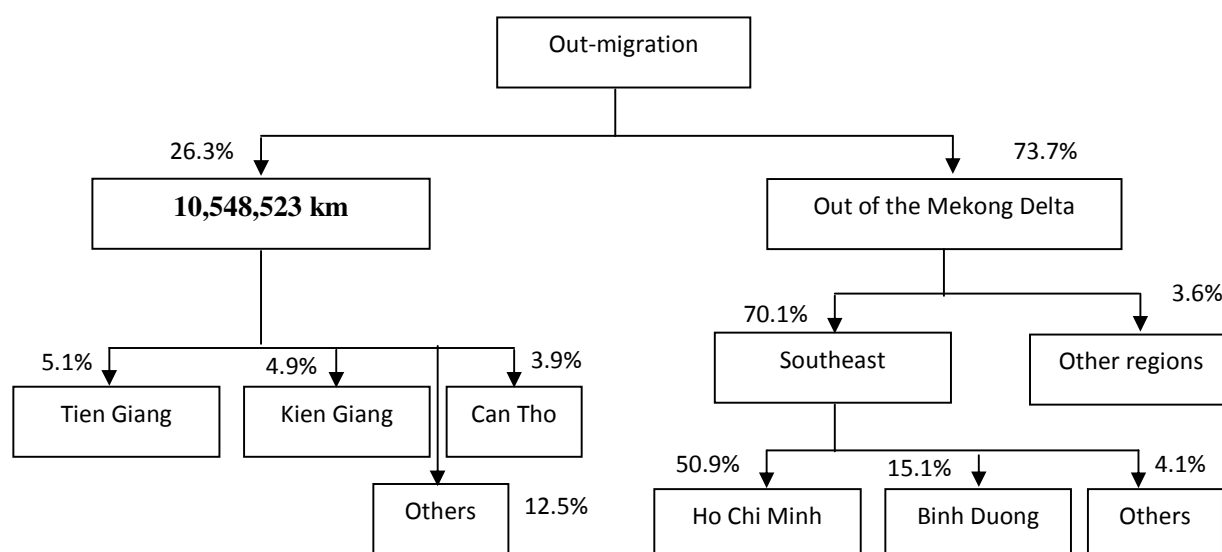


Figure 1: Out-migration flows of the Mekong Delta region.

### *Migration within the MD region*

It can presume that migrants within the region are those who first engaged in migration and mainly female. Because, according to a previous study of Loi (2005), the authors indicated that most respondents who were found in short distance of migration are the first migrants or seasonal migrants. Additionally, female migrants tend to move in short distance for main reasons: first, female migrants often find work more slowly than do male migrants (UNFPA, 2007). Therefore, those female migrants (mainly a initial movement) usually move to closer destinations to save on costs. Secondly, for married women their movement also has become more constraints due to care of family and children.

<sup>16</sup> Viet Nam Chamber of Commerce and Industry – Can Tho Branch, available at

[http://www.mekongdelta.com.vn/mekongdelta/Solieu/GDP.htm#B?ng\\_2.2:](http://www.mekongdelta.com.vn/mekongdelta/Solieu/GDP.htm#B?ng_2.2:)

### *Migration out of the MD region*

Information of migration displayed in table 4 shows that Ho Chi Minh city, as mentioned earlier, is the most attractive destination for most migrants from other regions and from the MD region as well. It absorbed over 50% of total migrants of the MD region. Based on census in 2004, a number of migrants accounted for over 30% of total population of this city. Among those migrants, migrants from rural areas made up around 80%; especially, 31.5% of those migrants were from the MD region and 17.7% came from the Red Delta region. Therefore, it is apparent that rural migrants from the MD region have played an important role in labor market and economic development of the most dynamic city in Viet Nam.

Next, Binh Duong is also one of the most economic developed provinces in the Southeast region, where has the rapid speed of industrialization with a large number of industrial zones. According to statistical data of FDI attraction between 1988-2008, Binh Duong was the second leading province in this region relating to absorption of FDI projects in terms of number of projects and capital (after Ho Chi Minh city).

Table 4: Basic information of some destinations of migrants from the MD region.

Destination	Share of migrants from the MD in destinations <sup>a</sup>	Monthly income per capita <sup>b</sup>	Share of income from non-farm <sup>b</sup>	Proportion of business units in the region* <sup>c</sup>
	(%)	(1,000 VND)	(%)	(%)
Ho Chi Minh	50.9	1,480	30,6	79.0
Binh Duong	15.1	1,215	33,1	7.7
Tien Giang	5.1	630	23,5	11.3
Kien Giang	4.9	675	20,4	14.0
Can Tho	3.9	780	27,7	11.8
Mekong Delta	-	627	22.2	-

*Note: \*Ho Chi Minh and Binh Duong are compared in the South-Eastern region. While, Tien Giang, Kien Giang and Can Tho are compared in the Mekong Delta*

*Source: GSO: <sup>a</sup> Census 2006, <sup>b</sup> VLHSS 2006 and <sup>c</sup> Survey of enterprises between 2000 – 2007.*

In short, important features of the internal migration in the MD region are: rapid increase of rural to urban migration has obvious effects on distributions of population and labor force in rural areas; a majority migrants tended to move to industrial and commercial cities where have higher living standards and better economic condition.

### **4.3 Description of the VHLSS**

Like most developing countries, access of data on migration in Viet Nam is a remarkable challenge to researchers in the field of migration. As a result, many of studies in this topic has primarily relied on multiple-purpose surveys, especially the VHLSS series.



Returning to the main objective of the paper is that we will use the commune-based data of the VHLSS series in 2004 and 2006 to examine whether the pattern of migration of the MD region is associated with the general picture of migration in Viet Nam, as previously described. Therefore, first of all, an explanation of the VHLSS dataset and its commune-related variables is worth to be done in this section.

The VHLSS series were conducted every 2 years by GSO in collaboration with the World Bank, the VHLSS is a comprehensive nationwide survey comprising two parts: commune and household. For commune survey, it includes a variety of aspects such as: population, number of people moved out and moved in, economic condition, education and public infrastructure. Meanwhile, the household survey collected information on multiple aspects of living conditions such as demography, education, health, employment, income, expenditure, physical capital and so on.

The strength of this dataset is a nationwide survey with a large number of observations, 3063 communes and 9189 households in the survey 2006. The VHLSS is nevertheless not a specific survey of migration which results in some limitations in this analysis, as following: First, information of destination of migrants who left out of the commune is not available; as a result, we can not examine “pull” factors of the destination. Secondly, average income indicators of commune level, a key determinant of migration, is also absent in this dataset. Thirdly, bus distance, as an intervening obstacle of migration, is not available. Therefore, an alternative measure in this analysis is the remote commune, because it is defined as the least economic developed commune due to far away from center of city and weak infrastructure.

Generally speaking, data of inter-provincial migration in Viet Nam and particularly in the MD region is quite scarce. More recent, the VHLSS series are seen as the most useful data source to most studies of migration in Viet Nam. In this paper, we only use the samples of the MD region to investigate the pattern of migration along with the commune-related variables such as density, wages in agricultural sector, poor household rate, economic condition, constraints of agricultural production, geographic feature and policy.

#### **4 Determinants of migration: an empirical analysis**

##### ***4.1 Model specification***

An interesting review on inter-provincial migration in developing countries presented by Lucas (1997) is still valid and highly empirical for recent studies. On the other hand, the pattern of internal migration is generally interpreted by a range of macro-related variables throughout the gravity equation. The most strength of the gravity model is its generality which is possible to make tests of a number of issues of migration theory. Therefore, it has been a widely used model to study on internal migration, especially across locations, regions in the country.

As previously shown, the VHLSS is not a particular study of migration which leads to lack of availability of information on differences in income, unemployment rate and distance between origin and destination. Therefore, pattern of migration flows in this analysis can only be explained by a range of commune-related variables of the origins; those are socio-economic factors and policy. In various macro studies on migration in Viet Nam, the number of migrants measured by the aggregate data is often treated as a dependent variable. Few of those studies were done by Anh, *et al*, (1997), Phan and Coxhead (2007).

However, to avoid differences of the population scale across origins, the pattern of migration is measured by a ratio of the number of migrants to 10,000 population at each commune.

Here, a general model is shown as follows:

$$M_i = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + e \quad (1)$$

Where,  $M_i$  is the out-migrants rate of commune;  $\beta$  are unknown coefficients of independent variables;  $X_{1..n}$  are independent variables, those are main categories such as principal, economic, policy and environmental factors; and  $e$  is error term.

In this analysis, the equation (1) is transformed into the logarithmic model. In fact, the popularity of the logarithmic transformation (or semi-logarithm) is due to the following reasons: First, the logarithmic model often obtains higher R square than the common linear model, especially when the relationship between variables of the model is nor linear. Secondly, logarithmic transformation is one of the most widely used techniques which not only has the effect of making the distribution of the transformed variable closer to the normal distribution, but also stabilize the variance (or remedy for heteroskedasticity), together with obtaining the Robust standard error of the model (Wooldridge, 2009 and Chatterjee, *et al*, 2000).

Consequently, we obtain the transformed model of migration (in the equation 4.2), as follows:

$$\text{Ln}M_i = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + e \quad (2)$$

Where,  $\text{Ln}M_i$  refers to the natural logarithm of rate of out-migrants in the commune.

In this analysis, three estimated models are separately analyzed to examine on how the relative effects of each category of factors on the pattern of migration in commune. In other words, the first model estimates the contributions of principal factors to the movement of population left out of commune, including density (1,000 person/km<sup>2</sup>), farm wage (1,000VND per day), poverty rate (ratio of poor households to 100 households), remote area (classified as remote commune by the Government's regulation) and ethnicity (1 for the Kinh, 0: otherwise). The second model will be added economic factors to seek whether the relative effects of these variables (mostly dummy) on the pattern of migration, including economic background of commune (agriculture, industry and service), qualitative assessment of increase in income of residents for recent 5 years (living), whether or not economic units in commune attract local labor and the presence of four among the most constraints to rural people in agricultural production, such as lack of capital, frequent influence of price fluctuation of agro-products, impossible to access market, lack of farm technique. And, the last model will comprise additional factors of policy and impacts of disaster, such as the presence of projects on job creation and local economic development in commune and rate of households granted supports due to impacts of natural disasters in commune.

In short, the main goal of proposed models is to test the hypothesis whether or not principal, economic, policy and other factors affect the migration flows of commune. Table 5 provides a description of variables and their direction of expected effects in the models.

Table 5: Description and expected sign of variables in the models

Variables	Description	Expected effect
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Principal factors		
Density	Population density of commune (1,000person/km <sup>2</sup> )	+
Farm wage	Farm wage a day (1,000 VND)	+, -
Poverty	Poverty rate (by 100 households)	+
Remote	Commune classified as remote area (see appendix 2)	-
Kinh ethnic	Kinh is a dominant ethnic group in Viet Nam, accounting for 80% of the total population.	+
Economic factors		
Agriculture <sup>a</sup>	Agriculture as the main sector of commune (coded by 1)	+
Industry <sup>a</sup>	Industry as the main sector of commune (coded by 1)	-
Fishery <sup>a</sup>	Fishery as the main sector of commune (coded by 1)	-
Living	Increase in income of resident in the last 5 years (coded by 1)	-
Labor attraction	Economic units in commune created employment to local laborers (coded by 1)	-
Lack of capital	Farmers face lack of capital in production (coded by 1)	+
Price fluctuation	Farmers face frequently influence of price fluctuation of agro-products (coded by 1)	+
Access to market	Farmers face difficulties of access to market (coded by 1)	+
Lack of technique	Farmers face lack of farm technique (coded by 1)	+
Policy and disaster factor		
Job creation	There are programs of job creation in commune (coded by 1)	-
Economic development	There are projects of local economic development in commune (coded by 1)	-

Disaster                      Rate of households granted supports due to                      +  
impacts of natural disaster

## 4.2 Descriptive analysis

Table 6 below presents summary statistics of main variables in the estimated models. At statistical level of 5%, there are quite no differences of migration flows and density between 2004 – 2006 in the selected communes. While, a parallel increase of farm wage and poverty rate took place during this periods that results in significant differences of these variables. It is also surprising that the poverty rate in the analysis tended to be increased in the two periods; meanwhile, poverty situation of the country and the MD region has been decreased overtime, as previously shown. However, this indicator was still appropriate with an average poverty rate of the country, respectively 18.1% in 2004 and 15.5% in 2006 (GSO, 2008). Additionally, some other factors used in the models are shown more detail in appendix 3a and 3b of this paper.

Table 6: Descriptive statistics of main indicators at commune level

Variable	2004		2006		Mean difference between 2004-06 at 5% level
	Mean	Std.Dev.	Mean	Std.Dev.	
Ln(migration rate)	3.82	1.21	3.74	1.27	n.s
Density	0.56	0.34	0.56	0.46	n.s
Farm wage	31.93	5.86	38.90	7.85	***
Poverty rate	9.71	8.37	17.58	10.70	***

Note: n.s, \*\*\* denotes not significant at 5% and significant at 1% level.

Throughout the descriptive results of the independent variables in the models and a review of relationships between migration flows and factors of the origin, it is really necessary to give hypotheses in order to test whether those factors have the same effects on migration flows in this analysis. Several hypotheses are proposed, as following:

1/ Whether or not the increase of poverty rate does induce people to migrate? In the literature of migration, migration is seen as a positive livelihood strategy for households to escape from poverty situation.

2/ How does an increase of farm wage has effects on pattern of migration: positive or negative. Because, on theoretically an increase in wage of a certain sector is possibly to absorb people to engage in that sector. In fact, whether or not that sector can pulls laborers is importantly depended on how different wages across sectors are.

3/ Do the difficulties of farmers in production drive them to move out of their commune? Because their living are almost depended on agricultural sector which is seen as low-return and more vulnerable work concerning economic shocks and natural disasters.

## 4.3 Estimated results and discussions

Table 7 displays the empirical results of three models through the OLS estimation methodology, together with the Robust standard error. In general, these models have expressed the statistical significance in correlation between migration flows and explanatory factors of the origin. More

specific, a majority of the estimated coefficients in three models for 2006 are likely higher than those for 2004. In other words, migration flows in 2006 would be explained with higher relative effects by the factors of the origin. In short, it is more important that we will examine every model to have clearer insights of impacts of each group of factors on the pattern of migration in this analysis.

Table 7: Estimations of migration flows of the MD region

Variables	Model 1		Model 2		Model 3	
	2004	2006	2004	2006	2004	2006
Principal factors						
Density	0.129 (0.07)	0.206 (1.48)	0.098 (0.51)	0.118 (1.14)	0.093 (0.48)	0.126 (1.14)
Farm wage	0.002 (0.16)	0.022** (2.47)	0.007 (0.62)	0.021** (2.20)	0.006 (0.56)	0.021** (2.18)
Poverty	0.005 (0.69)	0.018*** (3.09)	0.003 (0.38)	0.017*** (2.74)	0.004 (0.52)	0.017*** (2.70)
Remote	-0.025 (-0.19)	-0.325** (-2.36)	-0.014 (-0.11)	-0.258* (-1.87)	-0.008 (-0.06)	-0.272* (-1.95)
Kinh ethnic	0.726*** (2.62)	0.537* (1.62)	0.735** (2.55)	0.659** (1.99)	0.714** (2.48)	0.626* (1.87)
Economic factors						
Agriculture			-0.814** (-2.34)	-1.008** (-2.36)	-0.851** (-2.47)	-0.918** (-2.25)
Industry			-1.137*** (-2.84)	-2.229*** (-3.02)	-1.050** (-2.55)	-2.171*** (-2.98)
Fishery			-1.043*** (-2.68)	-1.805*** (-3.73)	-1.087*** (-2.81)	-1.728*** (-3.73)
Living			-1.433*** (-5.07)	-0.638*** (-3.49)	-1.383*** (-4.06)	-0.624*** (-3.83)
Labor attraction			-0.061	-0.109	-0.057	-0.101

			(-0.45)	(-0.82)	(-0.43)	(-0.75)
Lack of capital			0.183	0.252*	0.185	0.262**
			(1.11)	(1.90)	(1.11)	(1.98)
Price fluctuation			0.205	0.278	0.221	0.277
			(1.20)	(1.45)	(1.28)	(1.44)
Access to market			-0.001	0.468**	0.042	0.466**
			(-0.00)	(2.44)	(0.18)	(2.42)
Lack of technique			-0.343	0.292	-0.322	0.275
			(-1.10)	(1.32)	(-1.05)	(1.24)
Policy and disaster factor						
Job creation					-0.160	-0.170
					(-1.16)	(-1.24)
Economic development					-0.212	-0.085
					(-1.46)	(-0.51)
Disaster					1.342	0.997
					(0.97)	(0.43)
Constant	2.978***	2.041***	5.028***	3.640***	5.108***	3.609***
	(6.27)	(3.78)	(8.87)	(5.33)	(8.62)	(5.37)
No of observations	451	480	451	480	451	480
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.02	0.06	0.051	0.122	0.059	0.125

\*\*\*, \*\*, \* significant level at 1%, 5% and 10%.

t-statistics are in the parentheses.

The first model only regresses the principal factors in the communes between 2004 and 2006. As a result, a number of factors with significant effects on the migration flows in 2006 was higher than those in 2004. Those are farm wage, poverty rate, remote area and Kinh ethnic group. While, density of population is not presented its significant effect on the pattern of migration as expected in the empirical review. It is worth noting that increase of farm wage also induce migration out of the commune, but with small effect. In fact, an increase of farm wage may relate positively to the pattern of migration, if as such additional amount is still lower than a gap of wage between farm sector and other non-farm activities or rural and urban areas. Another reason

is that farmers may migrate temporarily in leisure after crop season in order to obtain more money needed to invest in their farm in coming crops (Rhoda, 1983). Therefore, the relationship between migration and farm wage (or agricultural development) is relatively complex and perhaps dependent on a number of other factors.

Undoubtedly, it can state that in this analysis poverty situation is still an important factor driving people to migrate; more specific, the poverty rate has a positive effect on the pattern of migration out of commune at its significance of 1% level. This relationship has been widely known and was found on both theoretical aspects and empirical results in the field of migration.

However, communes those are classified as the remote commune in 2006 are significant and negatively correlated with the pattern of migration which implies that people lived in remote areas are likely less migratory than others lived closer to centers of province. As mentioned in the review and the description, spatial and geographic distance has been long seen as an important obstacle of migration because of limited access to information and road network. Importantly, the effect of this factor in 2006 was much larger than for 2 years earlier. This may be seen as a consequence of the Government's programs on rural development for remote areas and ethnic minorities. The previous studies on inter-provincial migration between 1994-1999 in Viet Nam by Anh, et al, (1997), Phan and Coxhead (2007) also illustrated this.

Furthermore, the Kinh people are likely more migratory than other minorities in the communes of the MD region. There are due largely to main reasons: first, the Kinh people are dominant in Viet Nam, as already shown. Thus, they always play a crucial role in the migration flows. Secondly, other ethnic groups in the MD region such as Chinese, Khmer and Cham have various cultural features and lifestyles that affect the migration matter. For example, the Chinese usually do work for themselves or work for their relatives and other Chinese families at the village. While, life of the Khmer and the Cham is often influenced by cultural and religious concerns. For example, there are many of annual cultural and religious festivals for the Khmer and the Cham that almost forces them to return their origin to join in those activities; as a result, they sometimes face unemployment after each return of the origin. Additionally, ethnic minorities are usually less communicative than the Kinh people because most they live in areas with disadvantaged economic condition. Therefore, a little number of migrants, who are the ethnic minorities, is mainly caused by cultural, religious and social factors.

The second model, which adds economic factors concerning migration, shows that many of those additional variables are significant and they have generally not made changes of the direction and the statistical significance to the principal factors included in the model 1. It is apparent that different economic conditions of each commune have various effects on magnitude of migration; more specific, the pattern of migration out of commune would be much decreased if only the economy of these communes was dependent on industry and fishery development. On the other hand, people in the agriculture-based communes tended to be more migratory than others in the non-agriculture-based communes. That implies a gap of income or wage across sectors in these communes which is also relevant to a general situation of the country.

Besides, socio-economic development of commune, both living standard and employment, plays an important and significant role in making a decline in the pattern of migration out of the commune. Because, there have been a part of laborers, mainly women, who often find a job in the origin due largely to reasons of family and marriage. As shown earlier, farmers seem to be faced with challenges, ranging from investment, technique to selling. There are two potential

explanations for these concerns: first, agricultural production is much dependent on natural factors like weather, water source, and diseases, etc that usually bring farmers to be easily vulnerable. Secondly, a perfection of rural market such as crop insurance and market linkages is almost absent. Such limitations result in frequent failures of farmers in access to market and preventing from economic shocks. In the model 2, lack of capital and access to market are two among the most difficulties of farmers in production, which have significant and positive effects on the pattern of migration out of commune at 5% and 10% level.

In the last model, factors concerning policy and impact of disasters are included in the estimation to investigate whether or not these factors are associated with the pattern of migration out of commune. Although all these factors are not significant, their estimated signs are quite relevant to both theoretical literature and empirical results. More specific, the presence of rural development programs by the Government and NGOs has played an important role in generating employment and reducing migration in rural areas. Meanwhile, impacts of natural disasters are also seen as a cause of migration.

In sum, the determinants of migration of the communes in the MD region are fairly relevant to both theoretical literature and empirical findings in most recent studies of Viet Nam and of some countries in Asia as well. Undoubtedly, “push” factors of the origin are closely associated with the pattern of migration, including poverty, disasters, failures in production and market, socio-economic background and even ethnicity in the commune.

#### ***4.4 Diagnostics of the model***

An econometric model is usually underlying its assumptions; regression diagnostics are common techniques for exploring problems in the analysis and for determining whether certain assumptions are accepted. Although basic techniques used in the estimated models to improve the goodness to fit of the model, including logarithm transformation and Robust standard error, checking other assumptions is also worth to note. Therefore, several methods are used for checking main assumptions of the estimated model; those are normality of residuals, homogeneity of variance and multicollinearity as well.

Checking normality of residuals is a necessary work in the regression analysis which aims to examine whether the residuals are close a normal distribution. We can use graphs of histogram of residuals from the estimated model to make an inference of this matter. Another alternative is a test written by Lawrence, called inter-quartile range (IQR) to examine the symmetry of the distribution. In this analysis, only the third model in 2006 is used for testing assumption due to its full representative for all factors. The result of testing shows that value of IQR is in a range of low inner fence and high inner fence which can conclude that the distribution seems fairly symmetric and the residuals are close to a normal distribution (see appendix 4).

Checking for multicollinearity and homogeneity of variance is worth noting in a regression analysis and especially to the cross-sectional data. Of which, variance inflation factor (VIF) measures the impact of collinearity among the independent variables in the estimated model. Estimations displayed in table 8 present that mean VIF in all models is not so high that to drop them out of the model. However, these indicators tend to be increased when we add more variables in the model (e.g. model 2 and 3). Such increase is mainly caused by two dummy variables (agriculture and fishery) with their VIF of 28.4 and 25.9 respectively in the model 3 of 2006. Therefore, we finally have to drop two these variable out of the model 3 and as a result, the mean VIF of the modified model (model 3\*) is strongly reduced and only remains 1.21.



Table 8 Diagnostics of multicollinearity and heteroskedasticity

	Model 1		Model 2		Model 3		Model 3 <sup>*</sup>
	2004	2006	2004	2006	2004	2006	2006
Mean VIF	1.21	1.17	3.66	5.35	3.25	4.66	1.21
White's test Prob > Chi2	0.790	0.228	0.159	0.075	0.117	0.019	0.080

Note: <sup>\*</sup> this is the model 3, but excluded two dummy variables of agriculture and fishery.

Additionally, there are two widely used techniques to test homogeneity of variance. The Goldfeld-Quandt test and the White's test; of which, Goldfeld-Quandt test assumes that heteroskedasticity has a linear relationship with one of the independent variables; while, the White's test is more general without specifying the nature of the heteroskedasticity. This is the most important reason why the White's test was used for this analysis. Generally, the White's test has the null hypothesis of homoskedasticity (or no heteroskedasticity) and against the null hypothesis: heteroskedasticity. In short, most the p-values of the White's test are not significant at 5% level (except for Model 3 in 2006). It means that there is not sufficient evidence to reject the null hypothesis at a 5% significant level. In other words, the errors of the model have a constant variance. It is apparent that using the semi-logarithm transformation seems fairly appropriate to measure the determinants of the pattern of migration. Finally, the most relevant model of pattern of migration for the MD region is the model 3<sup>\*</sup> of 2006 without two dummy variables (agriculture and fishery) which is not only representative for all explanatory factors, but also meet the assumptions of a regression analysis.

## 5 Concluding remarks

This paper has explored two main questions: what are the determinants of the migration flows out of the commune and whether migration flows of the MD region are relevant to a general situation of migration in Viet Nam.

Regarding the first question, it is apparent that migration flows of this region has been steadily increased in recent years. More important, migrants moved from the disadvantaged economic areas (e.g. low income and agriculture-based economy) to advantaged economic areas (e.g. high income and manufacture-based economy). Ho Chi Minh city and Binh Duong province are the most attractive destinations for migrants in the country, including in the MD region. Additionally, the determinants of migration flows expressed some interesting issues: First, most "push" factors such as poverty and challenges in farm production are the main reasons closely associated with the migration flows of people in the commune. As mentioned in the literature, the result of estimation also shows that spatial distance is seen as an obstacle of migration in this analysis; besides, the improved living standard may cause to reduce migration. Secondly, policy makers can take advantage of tools involving economic development to adjust the pattern of migration out of the commune.

In comparison with the previous studies of inter-provincial migration, the determinants of migration flows in the MD region also have many relevant points concerning the "push" factors of the origin. However, there have been different levels of effect among these studies due largely to differences in the number of migrants, socio-economic factors, and time and geographic

feature as well. In sum, the findings presented in this paper are expected to bring us a better and deeper insight of the pattern of migration at the commune level in the MD region in present context.

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## Appendices

Appendix 1: Migration, population and labor in the MD. Unit: %

	2003	2004	2005	2006	2007
Rate of out-migrant	0.23	0.28	0.45	0.7	0.79
Share of rural population	80.2	79.8	79.1	78.9	78.8
Share of agricultural labor	61.9	60.1	59.7	55.4	51.7

Source: GSO: 2008

Appendix 2: Summary of Decision No 587 on benchmarks of poor and far away commune issued on 22 April, 2002 by the Ministry of Labor, Invalids and Social Affairs.

A commune is seen as a poor commune, if such commune has some of the following characteristics:

1. A poverty household rate: 25% or above.

2. A public infrastructure that is completely invested up to 3 out of 6 items including road, school, health care unit, clean piped water, electricity, market system. More detailed:

- Less than 30% of households provided with clean piped water.
- Less than 50% of households using electricity for living.
- No paved road to the center of the commune by car.
- Less than 70% of total required class room for schooling.
- No health care unit in the commune.
- No market for consumption demand.

Appendix 3a: Summary statistics in 2004

Variables	Obs	Mean	Std. Dev.	Min	Max
Mig-Rate	451	86.735	154.878	0	2147.56
LnMig-Rate	451	3.826	1.217	0	7.67
Density	451	.565	.341	.03	1.96
Farm Wage	451	31.933	5.860	5	50.00
Poverty	451	9.707	8.375	0	62.99
Remote	451	.372	.484	0	1
Kinh Ethnic	451	.942	.233	0	1
Agri	451	.878	.327	0	1
Indus	451	.002	.047	0	1
Fish	451	.108	.311	0	1
Living	451	.993	.081	0	1
Labor absorption	451	.620	.485	0	1
Lack of capital	451	.487	.500	0	1
Price Fluctuation	451	.188	.391	0	1
Access to market	451	.102	.302	0	1
Farm Technique	451	.057	.233	0	1
Job creation	451	.215	.411	0	1
Economic development	451	.255	.436	0	1
Disasters	451	.013	.044	0	.65

Appendix 3b: Summary statistics in 2006

Variables	Obs	Mean	Std. Dev.	Min	Max
Mig-Rate	480	78.775	109.646	0	1008.79
LnMig-Rate	480	3.738	1.273	0	6.92
Density	480	.557	.466	.05	7.86
Farm Wage	480	38.900	7.854	0	60.00
Poverty	480	17.585	10.706	0	74.27
Remote	480	.329	.470	0	1
Kinh Ethnic	480	.947	.222	0	1
Agri	480	.868	.338	0	1
Indus	480	.014	.120	0	1
Fish	480	.113	.316	0	1
Living	480	.993	.078	0	1
Labor absorption	480	.668	.471	0	1
Lack of capital	480	.475	.499	0	1
Price Fluctuation	480	.152	.359	0	1
Access to market	480	.083	.276	0	1
Farm Technique	480	.058	.234	0	1
Job creation	480	.235	.424	0	1
Economic development	480	.173	.378	0	1
Disasters	480	.007	.024	0	.26

Appendix 4: Testing for normality

Mean = 7.2e-10                      std.dev.= 1.218              (n= 480)  
 median= .1155                      pseudo std.dev.= .9994              (IQR= 1.348)  
 10 trim= .0753

low              high

	-----	
inner fences	-2.635	2.757
# mild outliers	18	5
% mild outliers	3.76%	1.04%
outer fences	-4.657	4.78
# severe outliers	0	0
% severe outliers	0.00%	0.00%

## **Impacts of weather variability on rice and aquaculture production in the Mekong Delta**

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## Abstract

Possible solutions to further improve current agricultural systems to adapt to weather and climate variability are necessary to increase livelihoods, food security and adaptability of local people and hence reducing climate forcing in the Mekong delta of Vietnam. This report assesses impacts of short-term weather variability on rice and aquaculture production and subsequently suggests adaptation strategies for improvement the current agricultural systems to well adapt to weather and climate variability in the future. Statistical series data (1990-2008) and information collected from previous projects were analysed. We calculated probability of the occurrence of weather anomalies and applied multiple regression analysis to identify and estimate significant effects of considered weather variables on yields of rice and fish or shrimp in both irrigated and coastal regions. Findings from participatory assessments and statistical data analysis are similar and complementary. Temperature and rainfall are key weather variables strongly influencing rice and shrimp production. Vulnerability level to the weather variability differs with crops, crop development stages, cropping seasons and regions. Rice production has been found to be more sensitive to the weather variability than aquaculture and shrimp production is more directly sensitive than *Pangasius* catfish culture. The impacts become more severe during the early vegetative, flowering and ripening stages of rice crops. The wet season rice crop and the coastal region are more vulnerable to weather anomalies than the dry season rice crop and the irrigated region, respectively. Local people have not fully identified possible adaptation strategies of rice and aquaculture to weather and climate variability. Such adaptation strategies are necessary, particularly for the coastal region.

## 1. Introduction

In the Mekong Delta of Vietnam, rice culture and aquaculture are the principal farming activities of agricultural sector. In 2008, around 1.8 million ha of land is devoted to rice production and around 0.8 million ha of land is used for aquaculture, sharing about 55% and 71% of total rice farming and aquaculture area of the country, respectively (GSO, 2010). Since 1999, the Vietnamese government has promoted diversification in agriculture, aiming to reduce the share of rice to the total agricultural output value while increasing the contribution of aquaculture to economic growth and poverty reduction. In the period of 2000 – 2008, the annual rice growth rate was -0.3% for farming area and 3.0% for production, and the corresponding figures of the annual aquaculture growth rate were 8.7% and 50.4%, respectively (GSO 2010). The main reason of the decline of rice farming area is that farmers have converted rice land into coastal shrimp farming. These figures suggest the trend of intensification of rice farming and aquaculture. Coastal shrimp and intensive *Pangasius* culture have been the main drivers of the development of aquaculture. The long-run sustainability of rice and aquaculture (referred to coastal shrimp and intensive *Pangasius* culture) production in the delta is still challenging. One of major threats is likely climate variability and sea level rise (Carew-Reid, 2008; ADB, 2009; MONRE, 2009). Accordingly, the most vulnerable group is farmer and rural resource-poor people. Recognising this challenge, the Vietnamese government has drafted a national strategic vision to 2030 for rice production and food security. Accordingly, the Mekong delta is recognized to play a crucial role to national food security and about 1.8 million ha of rice land in the delta will be set aside to ensure food security. Recently, numerous studies has focused on simulations to project future changes in weather factors and sea level and their impacts, based on

pre-determined scenarios (Wassmann et al., 2004; Carew-Reid, 2008; ADB, 2009; MONRE, 2009). Knowledge on impacts, directly and indirectly, of climate variability on current agricultural systems in the delta is still limited.

Linkages between climate change and biological systems, including agriculture, have been studied since the mid-1980's and given more attention since 2000 (Figure 1). For instance, Kogen (1986) warned climate constraints to wheat yields and he identified farming technology needs to sustain global wheat production in the long-run. In Vietnam in general and the Mekong delta in particular, this research topic has been studied since the early 2000's (i.e. Wassmann et al., 2004). We therefore hypothesize that climate variability has occurred and caused impacts on agricultural production in the Mekong delta. Possible solutions to further improve current farming practices to adapt to weather and climate variability are of great importance to improve livelihoods, food security and adaptability of local people and hence reducing climate forcing. Through participatory community assessments and analysis of statistical data, this report assesses impacts of short-term weather variability on rice and aquaculture production, and subsequently suggests possible adaptive strategies for improvement the current agricultural systems to well adapt to weather and climate variability in the future.

## 2. Materials and methods

### *Study framework*

This report integrates data from GSO (2010) and information collected from previous projects on improved agricultural water productivity for poverty reduction in coastal areas of Tra Vinh and Kien Giang provinces, which was conducted in 2008 with the financial support from SEI-Asia (Water and food Challenge Program), and natural hazard vulnerability and capacity assessments in flood-prone of Can Tho city, which was conducted in 2009 with the financial support from Challenges to Change. The projects applied the combination of participatory community appraisals with focused group discussions and individual household-structured interviews.

Participatory community appraisals allowed to get a general understanding of the study community and to identify key weather or environmental variables and measures of variability that likely impact on agricultural practices and livelihoods of local people. Subsequently, individual household-structured interviews helped to evaluate impacts of variability of the key weather variables in specific conditions. In addition, the analysis of statistical series data allowed to confirm and to further explain results obtained from participatory group and individual household interviews

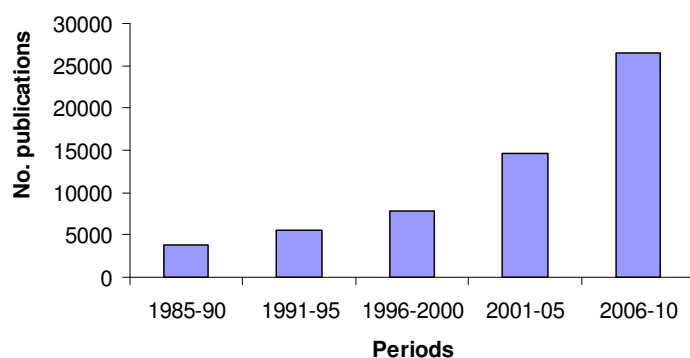




Figure 1: The number of publications related to the linkage of climate change and agricultural and biological sciences by ScienceDirect (drawn with data from <http://www.sciencedirect.com>, assessed on 24<sup>th</sup> March 2010).

#### *Data collection*

The projects were implemented in Tra Cu district (Tra Vinh province), An Bien district (Kien Giang province) and Vinh Thanh district (Can Tho city). For each district, two indicative communes were identified, from where one indicative hamlet (site) was selected for data collection. For each site, focused group discussions were done with different stakeholders (7-10 people per group), including community governmental staff and locally representative people. Subsequently, a sample of 20 – 55 households was taken to collect data at household level.

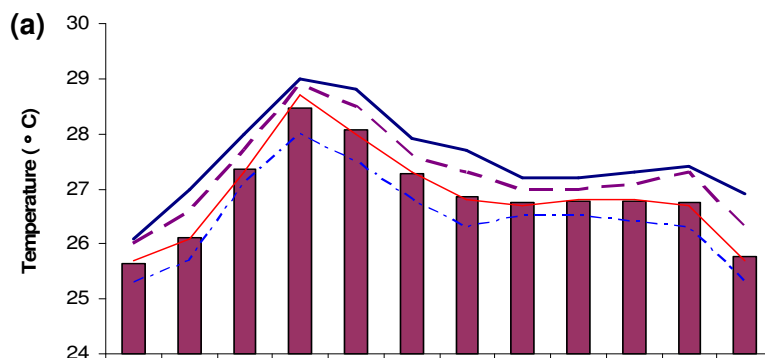
#### *Analysis of statistical data*

Statistical data of An Giang, Can Tho, Hau Giang and Tra Vinh provinces from 1990 to 2008 were employed. The variables included monthly mean, maximum and minimum air temperature, monthly accumulative rainfall, yearly yields of rice and fish or shrimp. We applied multiple regression analysis to identify and estimate significant effects of these considered weather variables on yields of rice and fish or shrimp in these provinces.

### **3. Results and discussions**

#### *Key weather variables*

Results from participatory community appraisals show that the abnormality of air temperature and rainfall significantly influence crop growth and development, resulting in reduced yields of rice and fish or shrimp. Fluctuations of mean and extreme temperature by month with probability of exceedence ( $P$ ) were shown in Figure 2. The air temperature is lowest on days in December or January while it gets highest on days in April. Figures 3 and 4 shows rainfall distribution through out the year. The distributions of rainfall in the irrigated and rain-fed areas are quite similar. During dry months (Jan – Apr), rainfall is general low and some areas would experience drought. Peak amounts of rainfall fall between July and October. Combined with local rainfall, high water discharge from upstream Mekong river causes monsoon floods in the upper delta during August to November, which in turn determines rice cropping calendar, particularly in flood-prone (e.g. An Giang and Can Tho) (Figures 3 and 4).



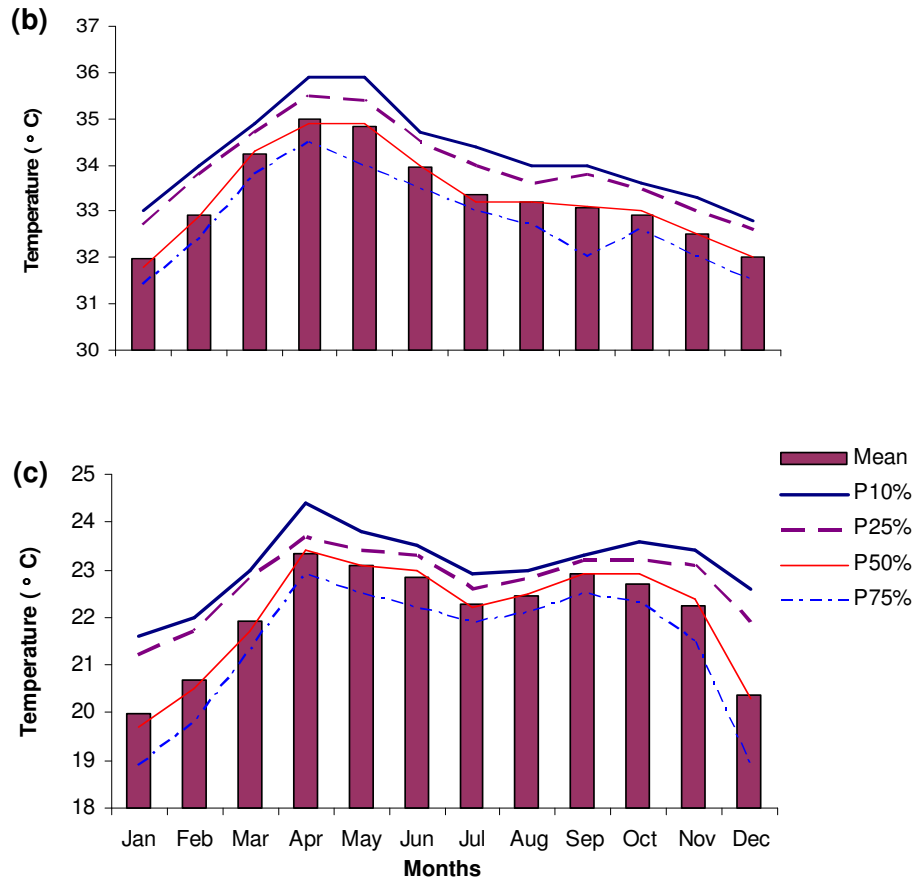


Figure 2: Monthly air temperature with probability of exceedence ( $P$ ) = 10, 25, 50 and 75%: (a) mean, (b) highest and (c) lowest temperature. Data were averaged out from An Giang, Can Tho, Hau Giang and Tra Vinh provinces.

In irrigated areas, according to local people, the occurrence of extremely cold or hot days or of rainfall during tillering, flowering and/or ripening stages (i.e. January-February or May -June) of the rice crop might reduce rice yield significantly. Similarly, the occurrence of low temperature in between December – January would constraints growth rate of intensively culture *Pangasius* catfish. According to evaluation of local people, the impact is little, due to appropriate technological interventions.

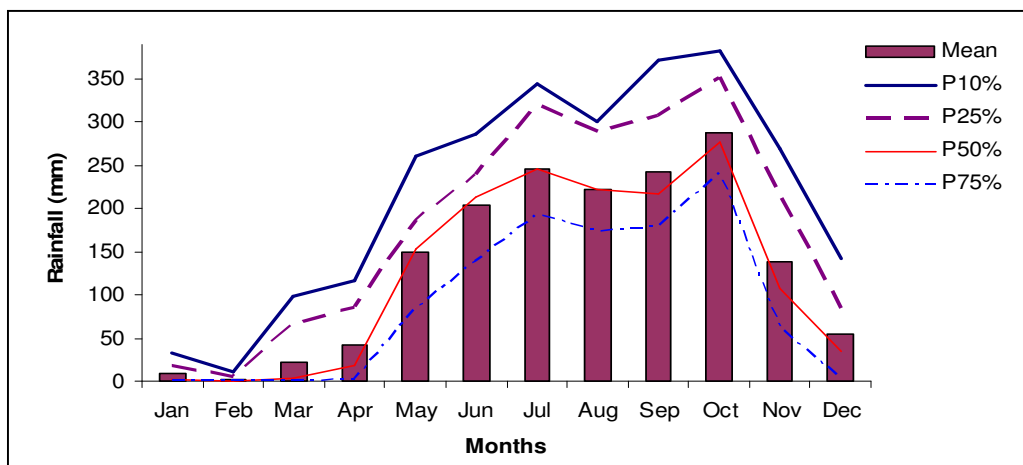


Figure 3: Monthly rainfall with probability of exceedence (P) = 10, 25, 50 and 75% and irrigated rice cropping calendar in Can Tho city and An Giang province. DS (dry season) and WS (wet season).

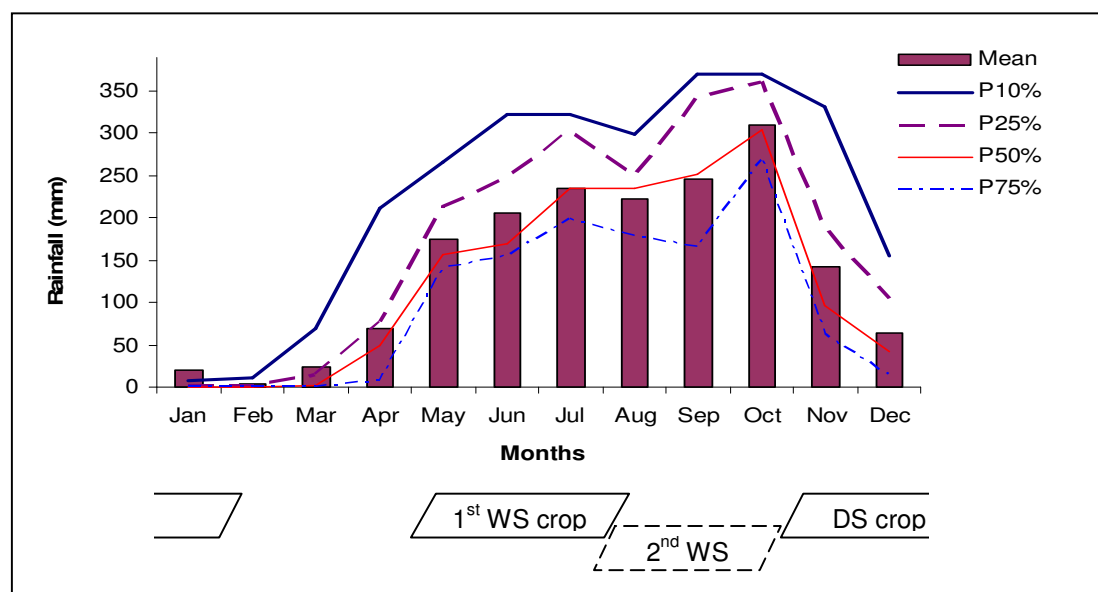


Figure 4 : Monthly rainfall with probability of exceedence (P) = 10, 25, 50 and 75% and rain-fed rice cropping calendar in Tra Vinh province. Two rice crops per year were commonly practiced, except for some areas of high elevation with three crops per year. DS (dry season) and WS (wet season).

Like irrigated areas, in rain-fed and saline areas, the occurrence of extremely cold or hot days or of rainfall during flowering and/or ripening stages of the rice crop might reduce rice yield. Furthermore, rice farming highly depends on rainfall. The occurrence of droughts in between April and June might cause a serious loss of rice harvest. For shrimp production, extremely hot temperature in Mar – June and abnormal rainfall in the dry season negatively impacts on shrimp growth. According to local farmers, this effect is indirectly and less severe than that of intake water pollution and disease dissemination.

#### *Impacts of weather variability on rice production*

Statistical data analysis confirms and further explains findings from participatory assessments on the occurrence and impacts of weather abnormalities on rice production in both irrigated and coastal regions (Table 1). For the dry season rice crop, in both regions local farmers

perceived that the return period of the event of extremely cold temperature or of rainfall during January - February is 3 - 4 years, which causes yield loss of about 10% of the normal yield (an average of 6 tons ha<sup>-1</sup>). Results from multiple regression analysis show rice yields are positively affected by temperature in January and rainfall in January and February. The effect of temperature on rice yield in the coastal region is not significant. The effect on yield losses of abnormal rainfall in February is more significant than that January, suggesting the effect of rainfall during ripening or harvesting stages. The variability of these weather variables explains 15% and 24% of total variability of rice yield in the irrigated and the coastal region, respectively (Figures 5a and 6a). Statistical results reveal that the probability of the occurrence of temperature below 19 °C in January is one-fourth and that in arrange of 18 – 22 °C temperature dropping 1 °C would causes a yield loss of 0.12 tons ha<sup>-1</sup> in the irrigated region. Similarly, the probability of the occurrence of abnormal rainfall above 10 mm in February is one-fourth and that each event of rainy days with 10 mm would result in yield loss of 0.3 tons in the coastal region or 0.4 tons in the irrigated region.

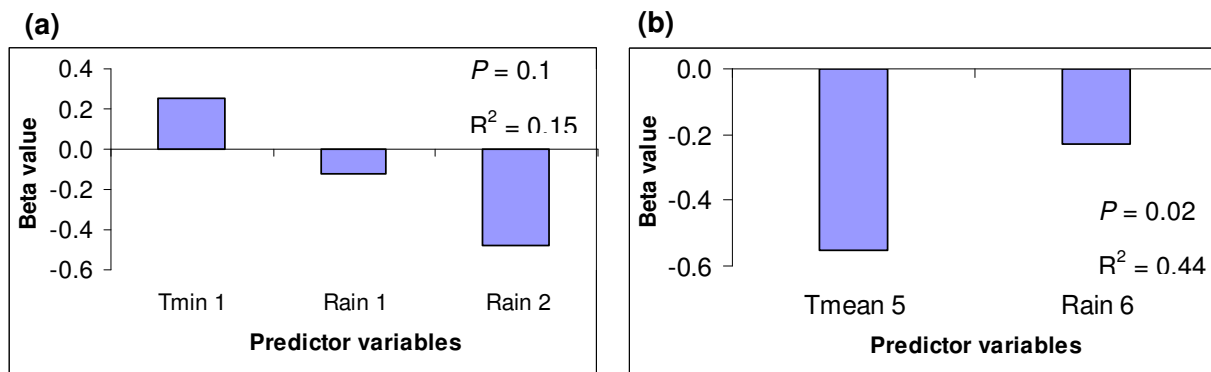


Figure 5: Standardised partial regression coefficient (beta value) for predictor variables of rice yields, model significance ( $P$ ) and adjusted coefficient of the determination ( $R^2$ ): (a) dry season crop and (b) wet season crop in the irrigated region. Rain (rainfall), Tmin (minimum temperature), Tmean (mean temperature) The explanation is also applied for figure 6.

For the wet season rice crop, in the irrigated region local farmers perceived that the return period of the event of extremely hot temperature in May is 3 - 4 years, causing yield loss of 5% of the normal yield (an average of 4.5 tons ha<sup>-1</sup>), and that of highly accumulative rainfall in June is 2 years, causing yield loss of about 7% of the normal yield (Table 1). Results from multiple regression analysis show rice yields are negatively affected by mean temperature in May and rainy days occurring in June would bring about negative effects on pollination in the flowering stage of the rice crop (Figure 5b). In the coastal region, in contrast, water scarcity in early rainy periods is an important problem for the wet season rice. According to local farmers, an extreme drought occurs once in 5 – 6 years, which would damage the rice crop of 1.8 tons ha<sup>-1</sup> (40% of the normal yield). Statistical results confirm this. Wet season rice yields are passively correlated to accumulative rainfall in May and June and negatively affected by mean air temperature in April (Figure 6b). The variability of temperature and rainfall accounts for 44% and 56% of the total variability of yields of the wet season rice crop in the irrigated and coastal regions, respective. These findings suggest that the impact of weather variability on rice production is

more significantly for the wet season crop than for the dry season crop, particularly in the coastal region.

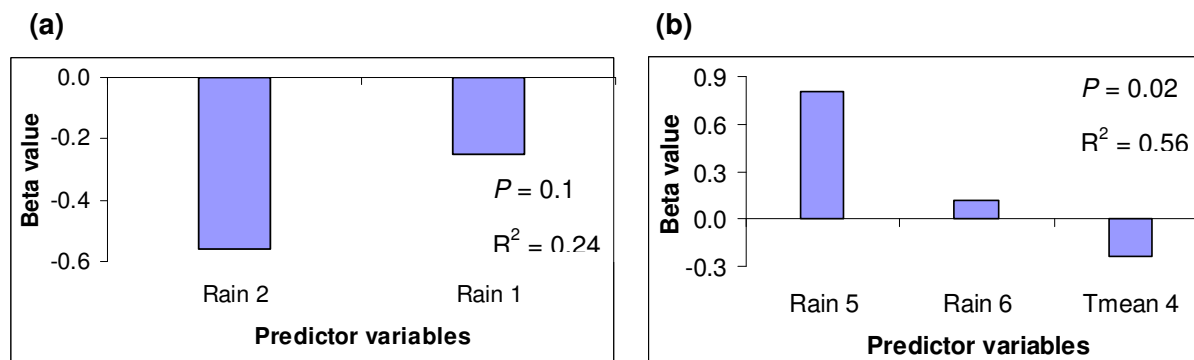


Figure 6: Standardised partial regression coefficient (beta value) for predictor variables of rice yields, model significance ( $P$ ) and adjusted coefficient of the determination ( $R^2$ ): (a) dry season crop and (b) wet season crop in the coastal region.

Table 1: Estimates from farmers' perception and statistical analysis on the occurrence and impacts on rice yields of weather variability in irrigated and coastal regions in the Mekong delta.

Weather variability by crop	Farmers' estimation		Statistical estimation <sup>1</sup>		
	Return period (years)	Yield losses (tons paddy)	Value	Return period (years)	Yield losses (tons paddy)
<b>Dry season crop</b>					
Low temperature in Jan	3 - 4	0.6	<19 °C	4	0.12/1 °C
Rainfall in Feb	3 - 4	0.6	>10 mm	4	0.3 – 0.4/10 mm
<b>Wet season crop</b>					
Extremely hot temperature in May (irrigated region)	3 - 4	0.3	>35 °C	4	0.38/1 °C
Heavy rainfall in Jun (irrigated region)	2	0.6	>250 mm	2	0.2/100 mm
Droughts in May (coastal region)	5 - 6	1.8	<50 mm	4	0.6/100 mm

<sup>1</sup> Estimates are obtained from multiple regression models (figures 5 and 6) and statistical data (Figure 7)

In the coastal regions, where soils mostly are characterised acidic, the effects of droughts, soil salinization and acidification on rice production are mutual. The impacts of the salinization and acidification become more severe when droughts occur. In recent years, shrimp farming development results in soil and water salinization, causing conflicts over water between crops and shrimp production (Nhan et al, 2008b). In addition, during the out-drying of fields as a result of droughts, acidic materials and other heavy metals (i.e. iron and aluminium), which are the products of the oxidation process in acid sulphate soils, move upwards and concentrate at the soil

surface to some extents (Tin and Wilander, 1995; Minh et al., 1997), which would damage the rice plant.

#### 4. Impacts weather variability on aquaculture

The effects of the weather variability on freshwater intensive *Pangasius* catfish and on coastal shrimp culture are less clear-cut than those on rice culture. For *Pangasius* catfish production, farmers perceived the indirect effect on fish growth of extremely low temperature in December – January but they could not estimate the impact level. In addition, the negative effect seems to be low water exchange significant effect interventions (i.e. do not show any

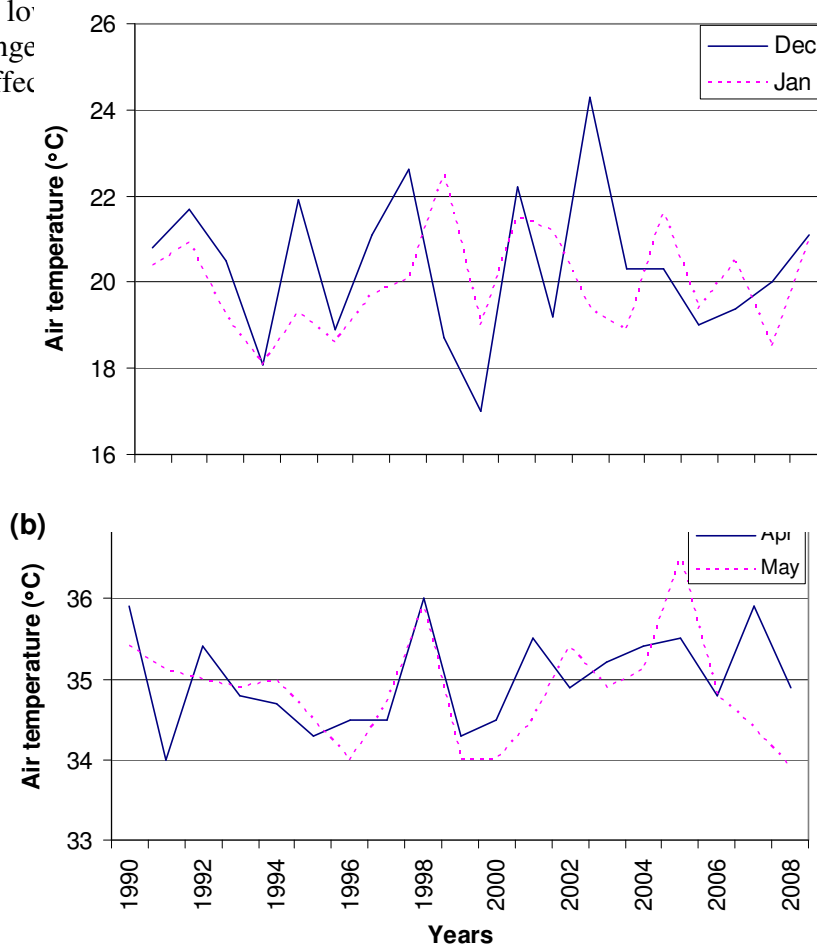


Figure 7: Variability of extreme air temperature by year: (a) low temperature in December and January, and (b) high temperature in April and May (drawn from mean value of statistical data obtained from An Giang, Can Tho, Hau Giang and Tra Vinh provinces).

For coastal shrimp production, local farmers perceived negative impacts of extremely hot temperature and abnormal rainfall in the dry season on shrimp growth and mortality, and hence reducing yields. In reality, farmers have paid more attention to the severe effects of water pollution and disease out-breaks, which could cause the complete mortality of shrimp. Statistical data analysis shows the significantly negative correlation between mean air temperature in March and shrimp yields (Figure 8). According to this relationship, the variability of mean

temperature in March explains about 46% the total variance of shrimp yield in the dry season. Shrimp yield would reduce by 0.7 tons ha<sup>-1</sup> with an increase in temperature by 1 °C. In March, exceedence probability of mean air temperature of 27.7 °C and 28.1 °C is 25% and 10%, respectively.

Local farmers reported that the return period of the occurrence of serious shrimp mortality is 3 years in Tra Vinh and 4 years in Kien Giang province. The average loss of shrimp yield was estimated at 76% of the yield in a normal year, equivalent to about 215 kg shrimp ha<sup>-1</sup>. Shrimp losses are caused by diseases mainly, which results from pollution of canal water. Previous studies reported that coastal shrimp farming is economically risky and that households engaging with shrimp production usually earn lower farming income than those with crop production (Preston and Clayton, 2003).

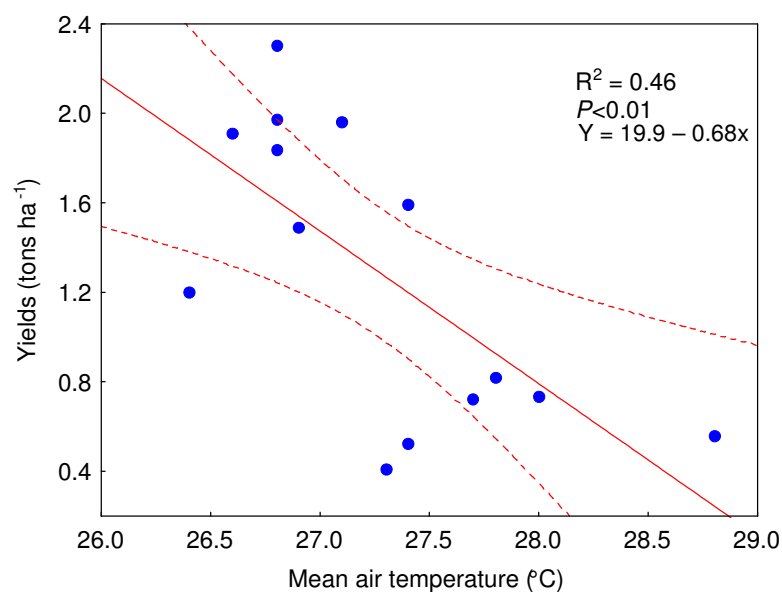


Figure 8: The relationship between mean air temperature in March and shrimp yields in Tra Vinh province. Regression line with the confident level at 95%, significance ( $P$ ), the coefficient of determination ( $R^2$ ) and the regression equation.

## 5. Copping and adaptation to weather and climate variability

### 5.1. Copping measures

In the Mekong delta so far, understandings, perceptions and actions on reducing risks and threats to agricultural production and people livelihoods of water-related problems, weather and climate variability have been limited. Measures of development and improvement of water resources uses by local government and farmers have been mainly land use intensification-oriented. In recent decades, national and local governments have invested money to develop and maintain irrigation canal and salinity control systems mainly for rice and most recently for coastal shrimp farming. Such the structure allows flushing out saline and acidic water in early rain periods while storing rainwater for irrigation and ensuring normal water-transportation

activities. Irrigation system at community level, however, has been poorly developed or maintained. Consequently, conflicts over water usually occur among the same or different water uses within the community (Nhan et al, 2008a), due to inappropriate land use planning, poor management of hydraulic structure and quick organisations at community level (Miller, 2003; Trung, 2006).

Local farmer have had measures at farm level for coping with weather variability. For rice production in irrigated region, farmers have applied an integrated nutrient management to enhance rice plant health to well tolerate to weather anomalies while reducing rice production costs. Earlier maturity cultivars with hard straw have been preferred to grow to minimize risks of extreme weather conditions. In the coastal region, drought occurrence at early rainy periods is considered important. Rice crop establishment is based on rainfall distribution in previous days, soil moisture content and medium weather forecasts by local or national weather centers. In addition, farmers make a modification of rice field with small ditch systems, which function as both surplus water drainage, in case of inundation, and water storage to maintain soil moisture and to prevent acidity moving up from deep soils in case of drought occurrence. Furthermore, farmers have abstracted deep and/or shallow ground water to irrigate crop in the dry season. This measure, however, is not advocated by the government. Rice cultivars that can tolerate to drought, salinity and acidity while yielding high and having high grain quality are still scarce.

For aquaculture, fish pond deepening and appropriate adjustments of nutrient and vitamin inputs and pond water exchange are coping measures commonly practiced for intensive *Pangasius* catfish culture. For shrimp production, farmers have introduced an aquatic plant namely *Scirpus littoralis* (Schrab) into shrimp ponds at appropriate density to help stabilise temperature of shrimp ponds and to use it as a biofilter for reducing water pollution of the ponds.

Nhan et al. (2008), studying improvement of agricultural water productivity in Mekong delta's coastal region, reported that under the same agro-ecological system water use ability and efficiency of resource poor-households is lower than that of richer households, even though more supporting policies given to poorer people by the government. This would suggests that the effectiveness of the coping measures are highly influenced by livelihood resources of households. Coping measures and interventions appear to be not enough to further improve livelihoods of rural poor people.

## 5.2. Adaptation strategies

MacIver (1998) defined “adaptation is an important component of an integrated and balanced strategy to climatic variability. Adaptation is largely a time-dependent, location-specific learning process”. A systems approach, which includes integral components of agricultural production systems, food security, rural people's livelihoods, combined “bottom-up” response and “top-down” policy making, is needed. Such the approach is not new but there is a gap between theoretical knowledge and its application in real situations.

At farm level, local government staff and farmers have identified adaptation strategies. However, application of the strategies to the practice is still limited. Applying the aforementioned approach, adaptive technical measures needs to be integrated to provide farmers a basket of choice of technological packages for specific contexts rather than single component technologies. A technological package would include relevant components like adaptive cultivars, farming practices and integrated farming systems, given special attention to the field of agricultural water management to adapt to weather and climate variability. In addition, crop yield



forecasting and simulation need to be applied to predict crop growth or production from the point of forecast up to the time of harvest, and to identify measures for minimizing vulnerability and risk of crop production due to weather fluctuations and climate variability (Bouman et al., 1997). This activity is still new in the Mekong delta. Moreover, at present weather forecasts only made for lead times of only from a few days to a few weeks are still a constrain.

At household and larger scale, improvement of agricultural production to adapt to weather and climate variability, which is usually conducted at farm scale, need to be put in dynamic and heterogeneous contexts of livelihoods of rural people and food security from household, regional to national and global scale (Ingram et al., 2008). Doing so, adaptation options developed are not only effective in terms of agricultural production but are also environmental, economical and policy-making robust.

The agriculture production have faced increasing challenges from weather and climate variability. This challenge puts more pressure on the government to develop appropriate policies to enhance adaptability of farmers. It therefore necessary to integrate the “top-down” scenario-based approach with the “bottom-up” vulnerability perspective approach (Wall and Smit, 2005). Through assessing impacts of policies and examining adaptability of local people and factors that enhance or discourage it, vulnerability assessments can give responses to policy development. In Vietnam and particularly, the integration of the two approaches seems to be limited.

## **6. Conclusions**

The present report describes the vulnerability of rice and aquaculture to temperature and rainfall variability in both irrigated and coastal region the Mekong delta, and suggest adaptation strategies for improvement the current agricultural systems to well adapt to weather and climate variability in the future. Impacts of temperature and rainfall variability differ with crops, development stages of crops, seasons and regions. The impacts on rice production are more clear-cut than on aquaculture production. Shrimp production is more directly sensitive to weather variability than *Pangasius* catfish production. The impacts become more severe during the early vegetative, flowering and ripening stages of rice crops. The wet season rice crop and the coastal region are more vulnerable to weather anomalies than the dry season rice crop and the irrigated region. So far, local people have had immediate coping measures to the weather variability. Local people have not fully identified possible adaptation strategies of rice and aquaculture to weather and climate variability. Such adaptation strategies are necessary, particularly for the coastal region.

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## **Climate Change in the Mekong River Delta and Key Concerns on Future Climate Threats**

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### **Abstract**

The Mekong River Delta (MD) in Vietnam is the largest agriculture and aquaculture production region of the nation. As the most downstream part of the Mekong River to both the East Sea and the Gulf of Thailand, the Delta is a is very slightly, mainly under 2 meters above mean sea level. Historically and practically, the people of the Delta has settled and cultured densely along the river and canal banks. Human life, agriculture and aquaculture production, domestic water supplies in the Delta depends highly on the meteorological and hydrological regime. This livelihood condition is sensitive and could be threatened by changing climate and hydrological cycle. Future climate projection from regional climate model indicates that the Mekong River Delta region tends to be warmer in the future with longer and drier summertime. Seasonal pattern could be altered under influence of global warming. Moreover, changing in the climate pattern in the upstream region of the Mekong River also affect the flood regime of the Mekong Delta, where the boundary of future flood could expand to wider coverage. These change raised many concerns as there are potential great consequences to various sectors in the Mekong River Delta. This paper presents the potential climate change in the Mekong River Delta and the key concerns on future climate threats, especially to the people in the agricultural sector.

*Key words: Climate change; the Mekong River Delta, flood, threats.*

### **Introduction: Projecting future climate projection for Mekong River Delta using modeling approach**

Climate change, which is induced by global warming effect, has become a global concern as it may have many consequences on various systems and sectors that may threaten human wellbeing (IPCC, 2001). Understanding climate change would be foundation for proper planning on adaptation measures to cope with future risk. However, global warming is a slow process and it would need rather long-term future climate projection to be able to clearly detect the change in future climate pattern (IPCC, 2007), therefore, long-term future climate projection is foundation for assessment of climate change impact on certain sector in specific area. Global circulation models (GCMs) have been developed and are commonly used to simulate future climate. However, most of the simulation results available today from most GCMs are in coarse scale due to limitation in the technology and not quite effective to use for climate change impact assessment at local scale. Therefore, regional climate projection at high resolution has been developed based on various techniques to address the requirement in climate change impact assessment. Typically, there are three types of technique for obtaining high resolution regional climate change projections: statistical, dynamical and hybrid (statistical-dynamical) techniques. The use of Regional Climate Model or RCMs falls into the dynamical category (Jones et al, 2004). This paper discusses the approach in dynamic downscaling of GCM data using regional climate model to develop future climate projection for Mekong River Delta.

A regional climate model (RCM) is a downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global general circulation model (GCM). GCMs

are typically run with horizontal scales of few hundreds kilometers; regional models can resolve features down to much more smaller scale, e.g. 50km or less. This makes for a more accurate representation of many surface features, such as complex mountain topographies and coastlines. It also allows small islands and peninsula to be represented realistically, where in a global model their size would mean their climate would be that of the surrounding ocean. RCMs are full climate models, and as such are physically based. They represent most if not all of the processes, interactions and feedbacks between climate system components represented in GCMs. They produce a comprehensive set of output data over the model domain. This study used regional climate model namely PRECIS for downscaling coarse scale GCM to derive climate change scenarios for Mekong River Delta. (Jones et al, 2004)

PRECIS is a regional climate model that was developed by Hadley Centre for Climate Prediction and Research and is based on the Hadley Centre's regional climate modelling system. It can be used as downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global general circulation model (GCM). It has been ported to run on a PC (under Linux) with a simple user interface, so that experiments can easily be set up over any region. PRECIS was developed in order to help generate high-resolution climate change information for as many regions of the world as possible. These scenarios can be used in impact, vulnerability and adaptation studies. (Simson et al, 2006)

Increasing atmospheric greenhouse gas (GHG) is the key influence to global warming and it is expected that GHG will continue to increase in the future. However, change in level of atmospheric GHG is up to the human activity thus would affect GHG emission in the future. There are projected GHG scenarios, which was developed by Intergovernmental Panel on Climate Change, based change in future socio-economic condition that give different plausible future of GHG emission and concentration. (SRES, 2000).

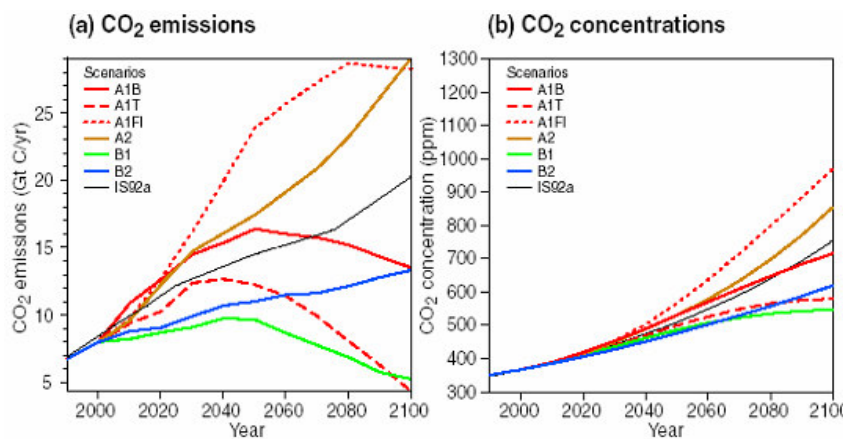


Figure 1: Greenhouse Gas emission and concentration scenarios by IPCC (SRES, 2000)

This study conducted dynamic downscaling based on initial dataset from ECHAM4<sup>17</sup> GCM from Max Planck Institute for Meteorology, Germany ([http://cera-www.dkrz.de/IPCC\\_DDC/IS92a/Max-Planck-Institut/echam4opyc3.html](http://cera-www.dkrz.de/IPCC_DDC/IS92a/Max-Planck-Institut/echam4opyc3.html)) and used PRECIS RCM to simulate future climate for the Southeast Asia region at resolution of .22 degree grid (approximately 25x25 km) with daily timestep.

### Climate change in Mekong River delta

Simulation result from PRECIS regional climate model shows that the Mekong River delta tends to be warmer by few degrees Celsius in the 2030s when compare to the 1980s, which is used as baseline period for comparison. Warming temperature can be seen in both average maximum temperature and minimum temperature. Moreover, the extreme maximum temperature, or in other words the maximum temperature of the hottest day in the year, will also be warmer by few degrees Celsius. See figures 2-4.

Change in warming climate in Mekong River delta also can be seen from the temporal aspect, in addition to the magnitude of change. From the simulation, result shows that it will not only be warmer but also hot period will also be longer. Figure 5 shows that hot period, or as defined in this paper is the number of days in a year that maximum temperature is over 35°C, will extend about 2 months longer in 2030s, when compare to 1980s.

Annual precipitation is likely to decrease by 10-20% in the future throughout the delta area. See figures 6-7.

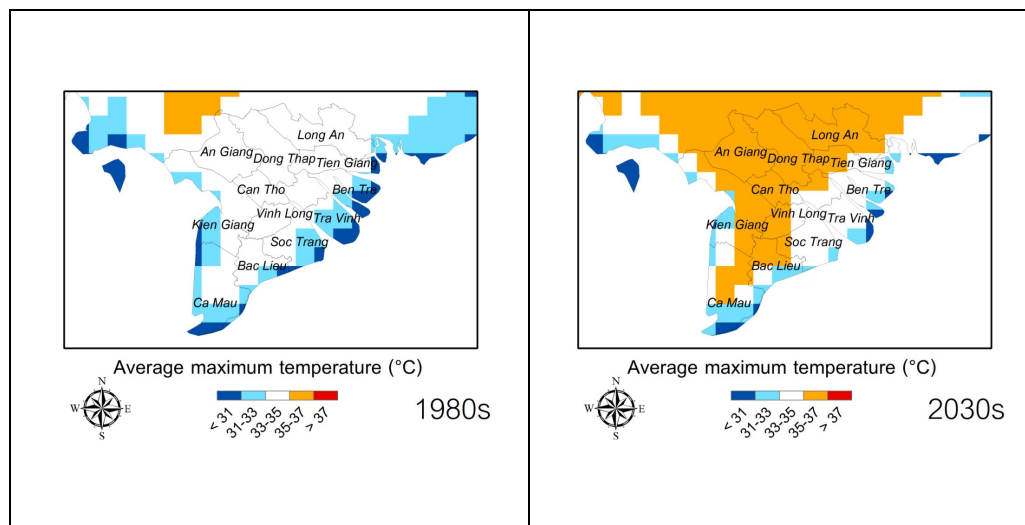


Figure 2: Average maximum temperature in Mekong River delta in 1980s and 2030s (simulated)

<sup>17</sup> ECMWF Atmospheric General Circulation Model coupled with University of Hamburg Ocean Circulation Model ([http://www.ipcc-data.org/is92/echam4\\_info.html](http://www.ipcc-data.org/is92/echam4_info.html))

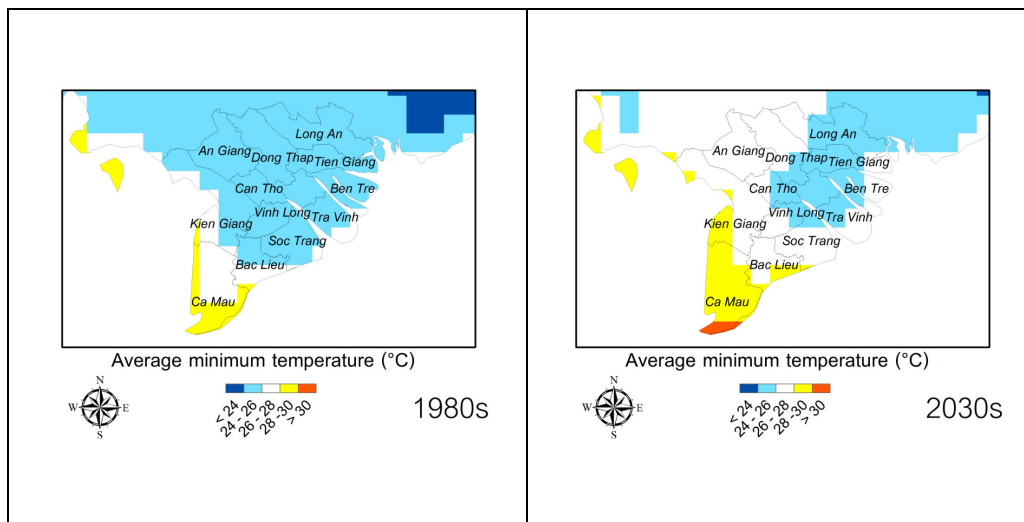


Figure 3: Average minimum temperature in Mekong River delta in 1980s and 2030s (simulated)

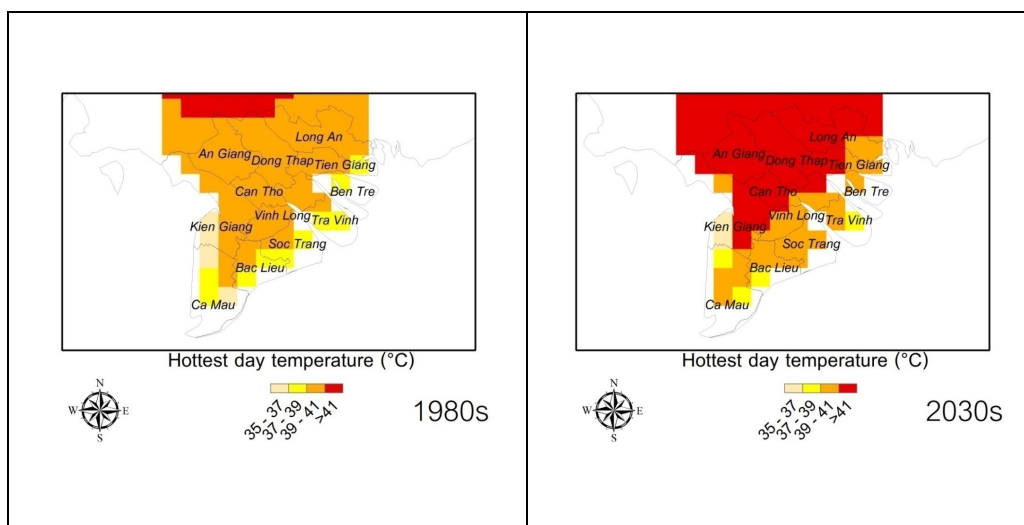


Figure 4: Average maximum temperature in the hottest day of the year in Mekong River delta in 1980s and 2030s (simulated)

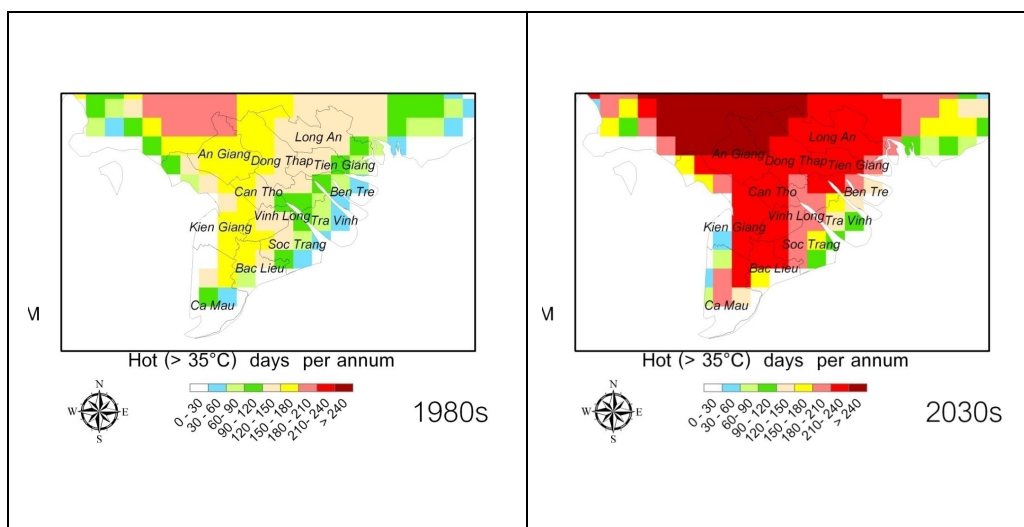


Figure 5: Hot period (number of hot days in a year) in Mekong River delta in 1980s and 2030s (simulated)

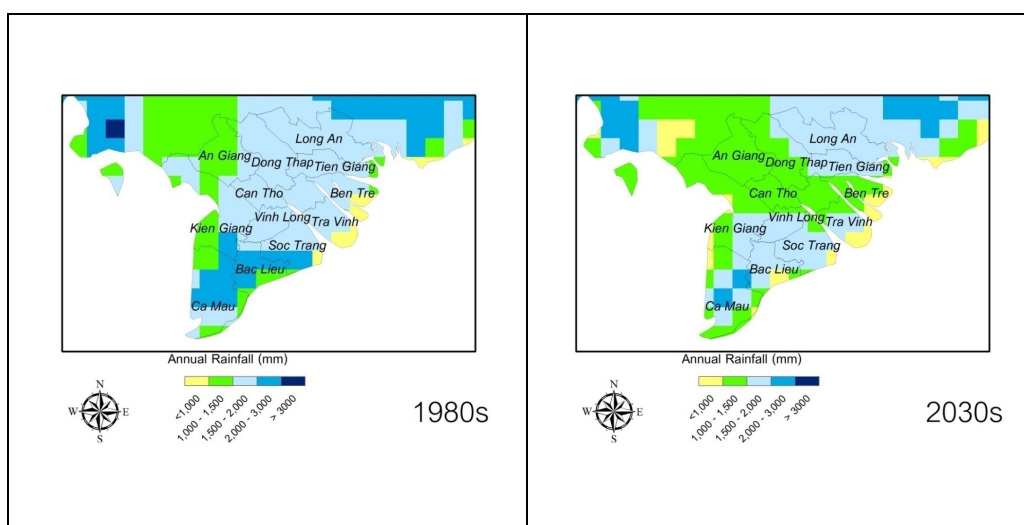


Figure 6: Annual precipitation in Mekong River delta in 1980s and 2030s (simulated)



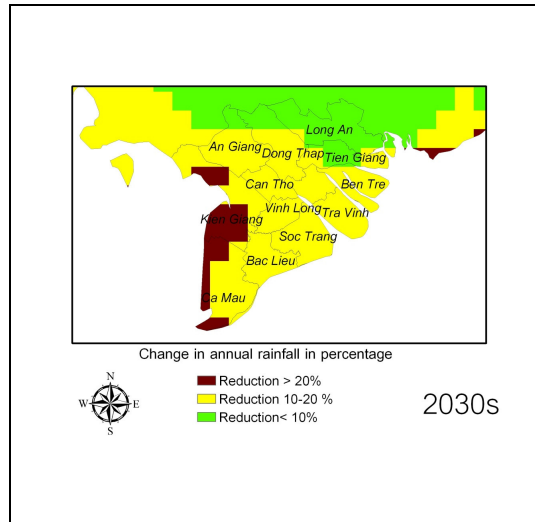


Figure 7: Change in annual precipitation in Mekong River delta compared between 1980s and 2030s (simulated)

### Climate change and impact on flood regime in Mekong River delta

One of the key concerns of impact of climate change in the Mekong River delta is the impact on flood regime, which may affect many economic sectors in the delta area. Flood regime in the Mekong River delta is determined by the regional flow changes that result from climate change's influence in upper parts of the basin, especially the change in annual precipitation. Moreover, sea level rise induced by global warming would also affect the change in flood regime in the delta; in addition to its impacts on salinity intrusion and coastal erosion that has also become major concerns in the delta.

The impact of both of these climate-related phenomena to the hydrology of the study areas were analyzed using modeling approach. The schematic overview on the interactions between climatic, hydrological and hydrodynamic models is presented in Figure 8 (Water and Development Research Group, Helsinki University of Technology, Finland and Southeast Asia START Regional Center (SEA START RC), Chulalongkorn University, Thailand, 2009)

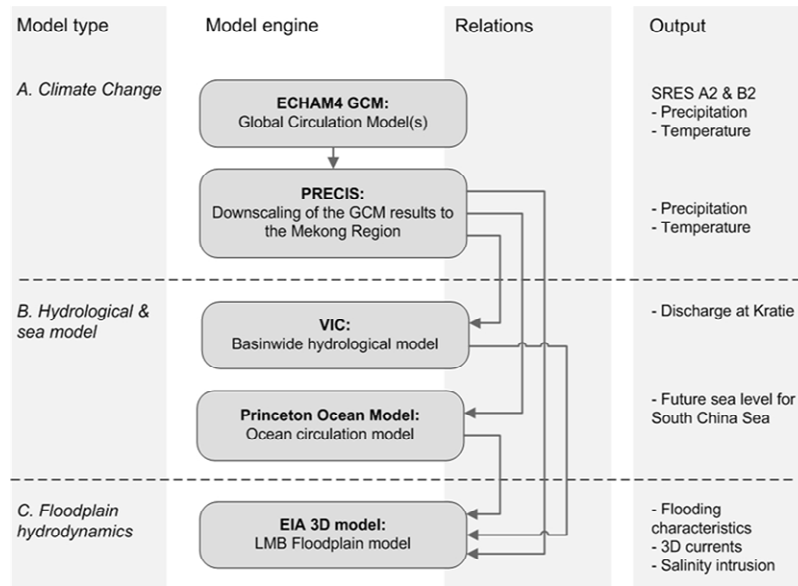


Figure 8: Schematic overview on the interactions between climatic, hydrological and hydrodynamic models.

As explained above, the future climate projection data was simulated by ECHAM4 Global Circulation Model under IPCC SRES A2 GHG scenario and downscaled to high resolution using PRECIS regional climate model, which was used as input to hydrological and ocean circulation model to determine change in future flood regime in the Mekong River delta.

Regional climate projection data was used in the simulation of basin-wide hydrological regime under influence of future climate projection. The simulation was based on the Variable Infiltration Capacity (VIC) hydrological model, which is a macro-scale hydrologic model that solves full water and energy balances, originally developed by Xu Liang at the University of Washington (Liang, et al, 1994). In addition, the regional climate projection data was also used as input to Princeton Ocean Model in the simulation of future sea level at the mouth of Mekong River which may change under influence of changing wind speed and wind direction (Blumberg and Mellor, 1987). Future projection of changing sea level due to direct effect of global warming, e.g. ocean water expansion, as indicated in the IPCC Fourth Assessment Report was also taken into account in the analysis (IPCC, 2007). Results from regional climate model, regional hydrological simulation and ocean circulation model were then fed into hydrodynamic model, EIA 3D model, for more detailed hydrological analysis for the Mekong River floodplain system. The model is able to describe the 3-dimensional characteristics of the flooding, flow, water quality, erosion and sedimentation in the lakes, reservoirs, river channels and floodplains (Koponen et al. 2004)

Result from 3-D hydrodynamic model provides guideline data to determine future change in flood regime in the Mekong River delta, where boundary of flood tends to expand further. The model simulations show an increasing trend in the annual maximum water depth and flooded area during the average and driest water years. Similarly clear trend is not visible in the wettest water years. This change may have significant impact on both the agriculture and aquaculture. See figure 9.

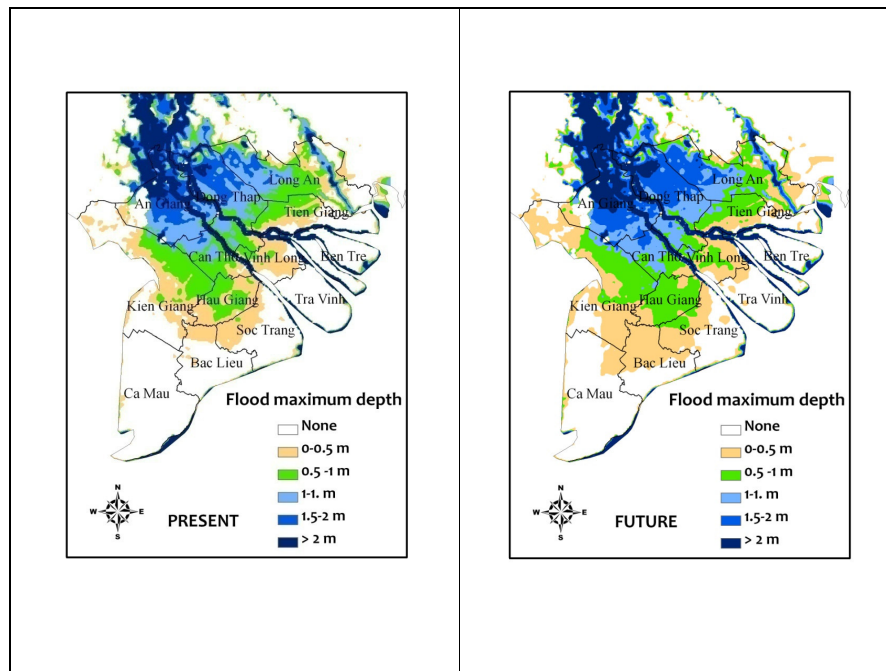


Figure 9: Flood boundary in Mekong River delta in 1980s and 2030s (simulated)

### Concerns on future change in climate and flood regime in Mekong River delta

Many scientists and international organizations have classified the Mekong River Delta as into the vulnerable area of climate change and sea level rise (Peter and Greet, 2008; Dasgupta et al., 2009; IPCC, 2007, UNDP, 2007; ADB, 1994). Climate change will cause complex impacts rural production, nature quality, societies and economic.

The average maximum temperature in dry season increasing in the future will lead the high evapo-transpiration. The salinity intrusion from the East Sea to the land will more seriously. The secondary crop cultivation and freshwater aquaculture will more hardy due to the lack of water supply and irrigation sources. The people will easy to get more weather concerned diseases.

The reduction of precipitation, especial in early and middle rainy season, will affect strongly the Summer – Autumn rice crop. Farmers should pay more money for irrigation and seed rice. Otherwise, the increase of precipitation in late rainy season combined with early flood will threat to their crop harvest.

Flood boundary is projected to expand to the southern part of the Mekong River Delta, toward areas in Bac Lieu and Ca Mau peninsula) will cause threat to aquaculture. The shrimp farmers should pay more cost for the protecting dykes around their shrimp ponds. The inundation periods of flood in the upstream provinces will be lessen; this flood regime changed will cut short the fish catching periods of the poor people in the An Giang and Dong Thap flooding areas.

It can be seen that, the Mekong River Delta in the future:

Agricultural land as rice fields, secondary crop, fruit trees, and aquaculture areas will be narrowed down; the production and capacity will decrease. These will lead the threat to the food security of the nation.

Rice farmers, shrimp farmers, salt farmers and small agricultural businessmen will be significantly impacted due to the lack of essential nutrient sources, land ownership, financial sources and information assessment for adaptation the climate and flood regime change. As a consequence, resources areas of forest, land, water, wildlife, natural minerals... will be encroached, over exploited and damaged.

Many wetland protected areas as Tram Chim, Upper U Minh, Lang Sen, Tra Su, Ha Tien, Vo Doi, Bai Boi, Dat Mui, Lung Ngoc Hoang will be under threats, the sustainability become more vulnerable. Some of the organisms can be extinct while some insects, such as mosquitoes, may increase.

There may be migrations of farmers in coastal areas that are seriously impacted by climate change and sea level rise to the urban areas in the North and the West of the Mekong River Delta (such as Chau Doc, Long Xuyen, Can Tho, Vinh Long, My Tho, Tan An ...). This will make damages to the urban planning and society orders. Urban environment will be degraded due to the mechanical increase in the population.

## **Discussion and conclusion**

The Mekong River Delta is considered to be the most serious impacted are in the South East Asian in terms of ecology, agricultural production, economy and society. This is a critical issue that strategy planners, policy makers, scientists, businessmen, local officers and people have to be aware of. There must be policy on information sharing and measures to mitigate and adapt to the situation. The hesitation, suspicion and irresponsibility will cause consequences to future generations. The phenomenon of climate change and sea level rise has recognized by many scientists while analysis about these is still being continued. It is needed to have a collaboration research on simulating climate change for different time with different scenarios and identifying subjects that are impacted and assessing the levels of impacts.

- Uncertainty of future change – scenario based study. This study is based on single scenario which only represents single plausible future.
- Risk and vulnerability of economic sectors in the Mekong River Delta. Climate change impact is chain of consequences which would affect bio-physical system to socio-economic sectors. However, each sector may be at risk differently and response to future change differently.
- Other long term change under influence from other forces, especially development and globalization, will affect in social and economic context in the future; thus, will also affect interaction among various social and economic sectors and sub-sectors and alter future vulnerability.
- Holistic approach in developing of adaptation strategy in the future will have to take change in social and economic context into consideration by looking into the impact of climate change on various systems / sectors and understand how response to climate change of one sector may affect other sectors in order to come up with appropriate strategy for the region.

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# **Dynamic resilience of peri-urban agriculturalists in the Mekong Delta under pressures of climate change and socio-economic transformation**

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## **Abstract**

Globally and in Vietnam, coupled social ecological systems in the peri-urban fringes are amongst the most dynamic as well as strained areas as they are at the same time drivers and results of comprehensive transformation processes. Based on a literature and policy review, we argue that – globally and especially in Vietnam – there is a neglect of the specific needs and challenges faced by populations in the peri-urban interface. At the same time, the review suggests that, in the Mekong Delta in particular, agriculture-based population groups in the peri-urban areas are at risk of being negatively affected by overlapping trends of (a) socio-economic transformation (including, for example, liberalisation or urbanisation), (b) bio-physical degradation (including, for example, pesticide residues in water-bodies) and (c) climate change impacts. This hypothesis is tested based on empirical research in one of the most rapidly urbanising districts in the Mekong Delta, i.e. Cai Rang district in the peri-urban fringe of Can Tho City. We find that formerly agriculture-based populations in this district are facing substantial decreases in resilience due in particular to the effects of expropriation, relocation and inadequate compensation schemes. On top of this, climate change is in future likely to imply increasing difficulties for those groups which – in view of the already deteriorated baseline-resilience – pose substantial risks of tipping into a crisis situation due to a lack of resources and options for adaptation and coping. This can be true for single households, extended family networks or entire groups (e.g. populations in specific relocation clusters). Yet, the paper argues that resilience effects may not be understood in a functionalistic or deterministic manner, meaning that entire systems *per se* will inevitably move along a given resilience trajectory. Rather, the review of overlaying trends in Vietnam as well as the empirical case study analysis shows that resilience pathways are highly dynamic and depend on rather small-scale factors setting the directions. Resilience, therefore, can be differentiated between households or individuals and acknowledging the importance of those small directive elements within resilience pathways opens up opportunities for resilience management and governance.

*Key words: Resilience, peri-urban, agriculture, transformation, climate change, Vietnam*

## Introduction

Agriculture is amongst the land use types where the most direct and intensive interactions between humans and their bio-physical environment is observable. Over the last decades, various theoretical schools have matured which allow to illustrate the dependencies of humans on ecosystem-goods and -services and which, de facto, focus on sustainable environmental management (e.g. human ecology, political ecology, footprint research; Young 1974; Blaikie and Brookfield 1987; Robbins 2004; Wackernagel and Rees 1996; Millennium Ecosystem Assessment 2005). Land use management plays a key role in these discourses. However, in many studies the regions with most intensive land use transformations are left out from analysis, i.e. the peri-urban interface with its dynamic hybrids of urban and rural land use patterns. Yet, these areas play an increasingly important role. Firstly, they are of substantial quantitative relevance given the strong urbanisation trends, globally and, in particular, in developing countries and emerging economies. Secondly, peri-urban areas in developing countries often suffer from (a) growing bio-physical and socio-economic stress resulting from agricultural intensification, (b) utilisation as dumps for urban wastes and (c) economic and social transformations – often coming along with land reforms or resettlement – which imply significant livelihood challenges for the original (often agriculture based) population.

In addition to these existing stresses, climate change will add to the perturbations in peri-urban areas as negative impacts on both rather rural and rather urban profiles are likely to be felt in those areas simultaneously. As with agriculture in other settings, peri-urban agricultural producers will feel the impacts of climate change in very direct terms due to the fact that changes in temperature-, precipitation- and flooding-patterns directly influence agricultural production. At the same time, peri-urban areas are at great risk with respect to environmental-technical-disasters related to man-made or natural hazards (of which the latter can be induced or intensified by climate change). For example, industrial production units or waste dumps – which bare a substantial risk of environmental pollution if being flooded or destroyed by storms – are often located in the outskirts of cities. In addition, peri-urban areas are likely to be at the forefront with respect to receiving the increasing numbers of migrants who will no longer be able to sustain their livelihoods in rural areas due to climate change and who move into urban areas in search of new income sources, in turn competing for land and increasing both the pressures for the original population and the stress on bio-physical systems.

Despite the high relevance of all the present and future stresses on peri-urban social-ecological systems, the resilience of peri-urban agriculture-based populations and their capacities to respond to existing and future challenges are in many parts of the world not well understood. Yet, a detailed understanding of these processes is necessary in order to allow for adequate policy and decision making which is of particular importance in this context as the reasonable management of those areas can make the difference between achieving a (rather) sustainable coupled social-ecological urban-hinterland system or a unsustainable and highly vulnerable system.

This article, therefore, generates lessons learned from an in-depth, interdisciplinary analysis on the resilience of households in Cai Rang District, Can Tho City, being one of the most rapidly transforming peri-urban areas in Vietnam, which in turn belongs to the countries that are most



intensively affected by overlaying dynamics of socio-economic transformation, ecosystem change, urbanisation and climate change risk.

### **The peri-urban interface: neglected hybrids in an ontologically dichotomous landscape**

In much of the conventional scientific and political discourse, the terms ‘urban’ and ‘rural’ are used to represent mental conceptions of some archetype landscapes and related characteristics (Simon et al. 2006). These archetype conceptions are very often used in a dichotomous and mutually exclusive manner, thereby, constituting the pre-analytic vision for much of the past and current policy making, planning or research – often lacking critical validity- and reality-checks. Yet, in an increasingly urbanizing world – in particular in developing countries – this ill-perceived dichotomy has to be challenged as it systematically contributes to a neglect and misconception of the peri-urban interface, i.e. where the city fringes intermingle with their hinterland to build hybrid mosaics of land use, economic activity, demographic density, socio-cultural dispersion, and bio-physical environments.

The peri-urban interface is thereby at the same time driver and result of cross-scale global change phenomena (comprising ecological, social, economic and cultural dimensions) (Johnston et al. 2002), as manifested in site-selections of social and economic actors as well as in various flows of people and resources. This can, for example, include inbound migration of (rural) poor in search of cheap and accessible grounds for settlements (often informal or illegal). At the same time, there might be urban rich and upper middle-class people who are looking for uncongested sites for housing and leisure activities (often linked to the desire of being ‘surrounded by nature’). In addition, industrial enterprises increasingly choose to build production sites in the peri-urban areas as the infrastructure inside cities is inadequate or land prices might be too high. Moreover, the urban fringes often host critical infrastructure elements such as airports, ring-roads, power stations, transmitter stations, waste dumps or sewage treatment plants.

The above-mentioned aspects make clear that defining the peri-urban interface through static threshold indicators (like, for example, population density or percentage-shares in land-use patterns) would only be of limited use and would be prone to producing a false sense of clear-cut demarcations and uniform entities. Key elements for defining and grasping the complex peri-urban interface and the respective areas rather have to be seen in (a) a continuum understanding and (b) a process understanding (Simon et al. 2006: 10). This implies that, “theoretically, a peri-urban zone may change in width and the steepness of what we might call its rural-urban gradient over quite short periods of time, depending on the nature of pressures within the growing metropolis and of migration towards it” (ibid.).

Despite the fact that this hybrid landscape constitutes the environment for a rising number of people, particularly in the global South, remarkably little attention has been given to the question as to how far it shapes livelihoods in the peri-urban areas. It has been noted that much of the published work on livelihoods focuses on an (allegedly) purely urban or purely rural setting, even though the livelihood framework in general recognizes that many people’s livelihood strategies embrace hybrid activities in rural, peri-urban and urban areas (Simon et al. 2006: 8). In this context it has also been argued that, in developing countries, poor people in the peri-urban interface are particularly vulnerable as they are affected by the ‘worst of both worlds’ (Birley and Lock 1998) since peri-urban interface is subject to the negative externalities of both, the nearby urban and rural areas (Allen 2006: 30). Very often, peri-urban poor depend heavily on

natural resources and ecosystem-services as their livelihoods are in most cases (entirely or partly) based on agriculture, horticulture, animal husbandry, forestry or fishery. Hence, these groups are to a great extent affected by environmental degradation in the peri-urban fringes coming along with urban growth and sprawl. They, thus, often face a double burden from this degradation, i.e. the impacts on the livelihood base in addition to direct health risks (Allen and Davila 2002). At the same time, poor peri-urban dwellers are likely to suffer from steep increases in land prices that can in many parts of the world be observed in the course of urban sprawl and growth. Very often, those dwellers are, therefore, priced out by middle- or upper-income class groups or the business sector or are even expropriated by the government (often with poor and insufficient compensation regimes, in particular in cases of unclear or informal land title). Resulting from this, the affected groups are often forced into temporary shelters and lose their opportunity for subsistence farming or income generation (Allen and Davila 2002).

These problems are aggravated by the fact that peri-urban areas face substantial challenges with respect to policy formulation and implementation. First, the peri-urban interface as defined above usually comprises areas within different administrative units (being typically located in parts within the boundaries of urban administrative units and rural districts, respectively). Hence, responsibilities (e.g. for land use zoning, infrastructure development or environmental management) lay within different authorities, resulting in a fragmented planning and management landscape that hampers integrative planning (Simon et al. 2006: 12). Secondly, Davila noted that in particular environmental management for the peri-urban area is often “falling between the stools” not only with respect to geographical dimensions but also regarding planning and management conceptions and configurations (Davila 2006: 45). Policies with a primarily spatial focus (such as urban or regional master plans) in most cases do not comprise an explicit environmental dimension and are usually designed on the basis of territorial boundaries that do not follow the logic and organisation of ecosystems (ibid.). Many sectoral or macro-economic policies, on the other hand, are lacking an explicit environmental focus, despite having great impacts on the environment in peri-urban areas. Poverty reduction strategies or socio-economic development plans often do not give explicit consideration to environmental issues but rather on the strengthening of market mechanisms, production and trade – which do both depend on and affect environmental conditions in particular in the peri-urban fringe (Davila 2006: 50).

However, although there is a lack of policies directed towards the peri-urban interface per se, it has been argued that the response should not be to call for exactly this. There would be the risk that this only adds an additional layer of actors, new bureaucracy and additional fiscal and regulatory burdens and complicates integrated planning and management even further (Davila 2006: 53). Rather, it should be called for a greater awareness towards the specific needs and challenges faced by peri-urban ecosystems and populations and towards the effects that many spatial and sectoral policies imply for the peri-urban interface. In this context, increased consideration needs to be given to the impact assessment and integration of policies and plans across horizontal, vertical and sectoral divides.

### **Vietnam: dimensions of transformation, climate change and resilience effects**

In the recent past, Vietnam has been undergoing multifaceted transformation processes in the economic, political, social, cultural and environmental domains which influence and cross fertilize each other in multiple ways and which have strong impacts on the specific development pathways and vulnerabilities of different population groups. Those changes and resilience effects

manifest themselves in particular in the country's peri-urban areas given the speed, magnitude and new qualities of overlaying processes in these regions.

In addition to these dynamics, Vietnam is characterized by high degrees of exposure to various future climate change impacts which again are likely to have substantial (potentially devastating) impacts on the resilience of certain population groups, i.e. on the balance between, on the one hand, the level of stress and the magnitude and frequency of perturbations these groups are exposed to and, on the other hand, their capacities to cope and adapt.

The following paragraphs explore the various dimensions of transformation in detail whereby one special section is devoted each to transformations within the agricultural sector as well as urbanisation. Thereafter, climate change risk will be illustrated in some more detail. Finally, the resulting resilience landscape for Vietnam is drawn. The latter will be done in rather general terms here, in order to prepare the grounds for the more specific analysis on dynamic resilience pathways within the peri-urban case study presented afterwards.

#### *Political and economic transformation*

In response to chronic agricultural and industrial underproduction as well as the impending breakdown of the centrally controlled economy coming along with the excessive replacement of the state commercial system through black markets and declines in the purchasing power of official salaries, the government of Vietnam initiated an economic and political reform process in the late 1970s towards a more market-oriented economy (Luong 2003: 8 sequ.; Dang 2007: 10 sequ.). Several plenary sessions of the Party Central Committee as well as Party Congresses during the late 1970s and early 1980s passed directives and decrees that implicitly initiated a shift towards market-based economy. However, the breakthrough happened at the 6<sup>th</sup> Party Congress (December 1986) which embraced renewal (*doi moi*) of the political, economic, social and cultural system as official policy line, including foremost the shift from a centrally-planned command economic model towards a more liberal market economy (Trong 2007: 27). The *doi moi*-process has been continued during the late 1980s and 1990s with numerous additional legislative and regulative reforms, which strengthen the influence and freedom of private economic activity in the fields of, for example, investment, trade, property rights, land title or trade. Resulting from this has been a strong economic growth with an average of 8 percent annually between the years 1990-1997 and with the number of private domestic enterprises rising from 318 to 5,714 between 1988 and 1998 (Luong 2003: 11).

#### *Urbanisation*

In combination with the economic change in the context of *doi moi*, Vietnam has over the last decades been experiencing a strong push towards urbanisation which is expected to continue or even intensify in future. While in 1985 (i.e. shortly before the official commencement of *doi moi*) less than 20% of the country's population was living in cities and towns (equalling some 11.5 million people), the figure has risen to nearly 30% in 2010 (accounting for over 26 million) (UN/DESA 2008). With the average annual urban growth rate only slowly falling from 2.9 percent (for the decade 2010-2020) to 1.7 percent (2040-2050), Vietnam's urban growth is expected to remain substantially above the Southeast-Asian average over the next decades. This means that an expected 42, 49 and 57 percent of the country's population will be urban by 2030, 2040 and 2050 respectively, then equalling some 46, 58 and 68 million people (ibid.). Cities and towns will, thereby, both increase their density of population, buildings and infrastructure as well

as spread in their extent. Regarding the latter, it has been estimated that currently around 100 km<sup>2</sup> of land are converted from agriculture to urban land use every year (Coulthart et al. 2006: x).

Resulting from the combination of densification and sprawl as well as the related effects of resource consumption and pollution, cities will have an increasing environmental impact on their own territory as well as on the surrounding peri-urban and rural hinterlands. At the same time, the concentration of populations and infrastructure can imply opportunities for a more sustainable land-use given the potential scale effects and synergies (e.g. with respect to transportation, cooling of buildings or sewerage infrastructure). Good planning and management in particular in peri-urban and urban areas is, therefore, of increasing importance with respect to overall (i.e. cross-sector and cross-scale) sustainable development of the country.

Urbanisation in Vietnam, thereby, has to be seen in close correlation to the sensitive question of the (normative) role of cities within the social and economic fabric of the Socialist Republic. As with many other non-European socialist governments, the Vietnamese political elite for a long time had an ambivalent attitude towards urbanisation – which, given the specific history of Vietnam, contributed to different urbanisation pathways in the North and South of country of which the effects can be observed until today (c.f. Drakakis-Smith and Kilgour 2001: 220 sequ.). On the one hand, there has been recognition that urbanisation is an important pre-requisite for the promotion of industrialisation which is key to building up an independent economy and strong national defence (Turley 1977: 624). On the other hand, the Vietnamese economy has long been heavily based on agriculture with urban industries playing a comparatively minor role and with agriculture being a major defining element in the national identity. Linked to this, the socialist movement in Vietnam was very much rural-based (Drakakis-Smith and Kilgour 2001: 219) – which is certainly linked to the importance of agriculture in the country's social fabric and national history even before the arrival of socialism. In particular Southern cities (and especially Ho Chi Minh City) were after the reunification seen as “lairs of American imperialism and its puppets”, which has in the early years contributed to an anti-urban bias amongst many carders of the re-unified socialist Vietnam (Turley 1977: 622).

This ambiguity translated for a long time in a somewhat vague and inexplicit handling of urban areas and their specific development challenges. The question whether urbanisation should be rather stimulated or prevented by official policy and how much attention should be given to funding and developing those areas was, hence, not answered coherently for many years. Resulting from this was a poor administrative and legal framework for the planning and management of urban areas which in combination with an overall lack of financial resources (internally as well as regarding foreign investment) led to an “urban neglect” within the first years after reunification, resulting in substantial shortcomings with respect to infrastructure and housing development (Yeung 2007: 272 sequ.; Coulthart et al. 2006). In addition, urban management and planning was outside the large cities like Ho Chi Minh City, Hanoi or Da Nang, often not recognized as profession in its own rights. Hence, medium-sized and small cities were despite substantial (informal) growth and specific urban challenges often administered by political cadres with a background in rural management (if at all).

In 1998, after more than ten years of substantial economic growth following the commencement of *doi moi*, the national government passed an Orientation Master Plan for Urban Development to 2020 which collated an explicitly urban development strategy in response to the obvious

challenges for sustainable development of Vietnam's cities (SRV 1998). The plan sets out the goal of a more balanced urban development in which the growth of the large urban agglomerations shall be slowed down in order to prevent excessive regional disparities and the emergence of mega-urban areas that grow beyond control. At the same time, small and medium cities shall be fostered and specific cities promoted as industrial hubs, constituting locomotives for economic growth. In parallel, competitive elements in the search for national funds have been strengthened, coming along with substantial financial and administrative decentralisations. Those decentralisations have in the following years been further supported through additional legislative reforms, most importantly the Amendment to the State Budget Law (2002), the new Land Law (2003), the new Law on Construction (2003) and the new Law on Urban Planning (2009) (SRV 2002, 2003a, 2003b, 2009, respectively) which all entail shifts of tasks and responsibilities in the domains of urban planning and management from the national government to administrations on Province and District level.

However, albeit the increased attention towards urban areas and development challenges, peri-urban areas with their specific conditions and needs remain to be neglected and still fall through the cracks of rural and urban policy. The Orientation Master Plan, for example, does not give explicit consideration to the peri-urban interface, nor does the new Law on Urban Planning.

### *Agriculture*

Given its high importance for the country's economy, its key role as livelihood basis and, last but not least, its great normative significance within the ideological fabric of the Republic's political system, the agricultural sector is of particular importance for understanding Vietnam's development and renewal process as well as resulting resilience effects.

Agriculture plays a key role in the economy of Vietnam and the Mekong Delta is the most intensively farmed area in the country providing the majority of the production of various commodities (GSO 2009 a,b). Yet, the extent of productive agricultural land is threatened in two ways: first by climate change impacts (see below); second by urbanisation as many rural areas, particularly (but not only) in Can Tho Province, are transformed into peri-urban areas and peri-urban areas become more urbanised.

In rural and peri-urban areas of the Mekong Delta, intensive agricultural production already has impacts on ecosystems. For example, pesticide monitoring programmes that we conducted in 2008 and 2009 at field outlets and in channels used for irrigation, in one strictly rural area in An Long District, Dong Thap Province and one peri-urban area in Cai Rang District, Can Tho Province, indicated that a broad range of recently used pesticides is co-occurring at detectable levels in these systems (Toan et al. 2009). This can potentially have direct negative effects on aquatic ecosystems but more importantly, could have negative repercussions on human health as ongoing studies (Toan et al. not yet published) show that pesticides are detected in drinking water samples from water taken out from canals – which during the dry season are a major source for drinking water.

Going through an urbanisation process automatically implies land use changes. These are not restricted to agricultural land being set aside for urban land uses (e.g. buildings, infrastructures), but because of shifts in access to urban areas, it may also imply shifts in production systems on the land that remains devoted to agriculture. An example could be a shift from rice production to

fruit tree orchards as with improved access to markets, fruits can be sold more easily and provide higher returns to the farmers. Shifts in land use patterns in rapidly urbanising areas such as Cai Rang imply pollution problems too. For example, with the loss of agricultural land, pesticides – as pollutants to the water system -- may be progressively replaced by e.g. bacteriological contaminations linked to inadequate sewerage systems servicing the new infrastructure developments. Aquatic ecosystems and people who rely on these may then progressively be exposed to new pollution problems and the link between ecosystems, the services they provide to communities and the social component of this coupled system can be disrupted, requiring some adaptation from the communities.

Shifts in pollution problems can occur concomitantly with effects of climate change. If we stay with the agricultural sector only, Sebesvari et al (these proceedings) show the various ways in which climate change can affect pesticide pollution problems through the many interconnected processes of land use change, pest occurrences and farmers' behaviour. The concomitant changes however can also take place if pollution problems shift from e.g. pesticide pollution to bacteriological pollution while at the same time populations in maladapted peri-urban areas may face increased flooding problem linked either to the effects of the combination of sea level rise and changes in discharge patterns of the Mekong River or because of changes in rainfall patterns that may overwhelm drainage systems. Here again, communities and ecosystems will have to adapt otherwise the risk of decoupling between the two can take place.

#### *Climate change risk*

A number of recent studies identify Vietnam to be amongst the countries most at risk from climate change impacts (e.g. Dasgupta 2007; McGranahan et al. 2007; Carew-Reid 2008). With its long coastline and large deltas featuring high concentrations of population, agriculture and industry, Vietnam has high degrees of exposure to intensifying natural hazard such as floods or typhoons. In addition, underlying creeping changes in precipitation patterns and temperature but also sea level rise and resulting salinisation of water bodies and soils pose substantial risks especially to agricultural production. In particular the Mekong Delta faces substantial risks given its low-lying topography and its key function in terms of agricultural production for Vietnam and the global food market.

According to the Climate Change and Sea Level Rise Scenarios developed by the Ministry of Natural Resources and Environment, a sea level rise of 75cm – under a medium emission scenario expected until 2100 – would directly inundate 19% of the Delta, based on current protection measures and hydraulic infrastructure (MoNRE 2009). However, indirect impacts such as salinization and changing hydrological regimes would affect a much larger share of the Delta. The same scenario would for the Southern parts of Vietnam imply an increase in the annual mean temperature of 2.0°C by 2100 (ibid.). Overall annual rainfall would increase by 1.5% on average in Southern Vietnam with the amount of precipitation going to decrease even further in the dry season while the rainy season is going to experience an increase (ibid.: 27).

Resulting from a combination of those and other changes on a regional-scale (e.g. monsoon and El Nino patterns but also increased human activity in terms of hydraulic infrastructure for embankments or hydro-power stations), changes in flood patterns have already been observed and are expected to continue to do so, which is likely to increase the frequency as well as magnitude of extreme flooding events (Tran et al. 2008; Wassmann et al. 2004; CFSC 2004).

Moreover, typhoon activity – so far predominant in the northern and central parts of Vietnam (Kleinen 2007; Kelly et al. 2008) – is expected to intensify also in southern Vietnam (CFSC 2004).

### *Resilience landscape*

In combination, the transformation processes described above result in a complex resilience landscape with overlaying, yet differentiated resilience effects for particular population groups. While Vietnam has experienced average economic growth rates of 7,5% over the last years and a general decrease in poverty rates (c.f. Carew-Reid 2008) the market liberalisation reforms under *doi moi* and accompanying land reforms have led to an increase in socio-economic disparities (Taylor 2004; Adger 2000; Waibel 2005) and produced high numbers of landless farmers, particularly in the Mekong Delta (Marsh and MacAulay 2006). Statistical surveys have, for example, shown that the number of landless households has increased from 12.500 in 1994 to around 1,000,000 in 1998 (ibid.: 7). It has in addition been shown that strong correlations exist between poverty on the one hand and land title and size on the other (Tuan 2010). In this respect, Marsh and MacAulay further note, that the general decrease of people living in poverty – which is observed across different measurement approaches – has to be taken with caution as “a high percentage of the population is bunched just above the poverty line and a relatively small deterioration in living standards would be sufficient to push them below the poverty line again” (2006: 8). Many studies emphasise in this respect that poverty is not to be mistaken as equivalent measure to vulnerability or resilience; however, that poverty certainly describes an important factor thereof as it regulates the access to an increasing basket of services and assets within the transforming socio-economic fabric towards market-based economy and the individualisation and privatisation of social security networks (Taylor 2004), including in particular reforms in health care coverage and social insurance schemes (c.f. Ekman et al. 2008; Wagstaff 2007).

A further factor contributing the complex resilience landscape is to be found in the intensifying export orientation and integration in global commodity markets which besides growing export revenues also imply soaring dependencies on global food markets, and, hence, increased vulnerability to price fluctuations therein. In this respect, agricultural producers in Vietnam are subject to what Adger et al. call nested and teleconnected vulnerabilities in the sense that vulnerabilities of people within one place can be linked and influenced through, for example, shifts in policies or market trends originating in other (distant) places (Adger et al. 2009). Lynn et al., therefore, call for a paradigm shift in the sense of focusing on “hot systems” instead of using the conventional and more static notion of “hot spots” (Lynn et al. 2010, forthcoming). Linking in particular the pressures that climate change and globalisation can simultaneously have on agricultural communities, O’Brien and Leichenko introduced the concept of double exposure, meaning that each of those trends may create perturbations that no longer can be considered separately but which interact and overlay to create a new, complex nexus of increased exposure and vulnerability (O’Brien and Leichenko 2000). All these conceptual approaches give fruitful guidance for exploring and understanding the interactions of overlaying processes that create the dynamic and complex resilience landscape that is specific to Vietnam and especially its peri-urban areas.

In addition, the intensification of agriculture can – as shown above – imply substantial risks of ecosystem degradation, putting in particular agricultural population groups at risk which directly depend on the productivity of those services – a problem which has been observed to be of

increasing relevance in the Mekong Delta (Ni et al. 2001). In combination with climate change impacts, those degradations may pose the risk of unexpected feedbacks in coupled-social ecological systems which may cause decreases of productivity and yield, thus, deteriorating livelihood bases of agricultural populations.

Giving particular consideration to natural hazards and climate change, it has further been argued that transformations in the political system and related shortcomings with respect to the layout and implementation of political decentralisation have caused a reduction in collective action for risk management, albeit the emergence of civil institutions which start to shape a new landscape of institutional adaptation (Adger 1999; Tran et al. 2008). As a result, increased vulnerabilities can be observed amongst those groups who do not have sufficient resources to substitute those elements on an individual or household level (Adger 2000). In addition, climate change requires increased efforts and resources for adaptation, which will very likely exceed the capacities of certain population groups, thereby, increasing their baseline vulnerability and their risk of tipping into serious crises in cases of extraordinary natural hazards (Garschagen et al. 2009).

### **Case study: Cai Rang District**

Cai Rang District is one of eight districts within Can Tho City, which is the biggest city and economic centre of the Mekong Delta, located about 180 km southwest of Ho Chi Minh City (compare figure 1). In 2008, Can Tho City had a total population of 1.17 million, of which 80,000 were living in Cai Rang. This district, hence, belongs to the less populated districts of Can Tho, with the neighbouring Ninh Kieu District building the urban core of the Province and accounting for 217,000 inhabitants (compare figure 1). However, Cai Rang has recently commenced the rapid build-up of residential and industrial developments making it to one of the most rapidly urbanising districts in the Mekong Delta over the next years. The development master plan until 2025 envisages developing Cai Rang into an urban-port-industrial zone by 2025 (SRV 2006). This plan includes the development of new residential quarters for 120,000 – 150,000 people (covering an area of 700-800 hectares, in particular in Hung Phu, Hung Thanh and Phu An wards) (ibid.: 5.b). Furthermore, two industrial parks (called Hung Phu I and II) are planned, covering an area of 600-700 hectares. Attached to these, a new port (Cai Cui Port) is being built at Hau River in the south of Cai Rang which is planned to become a seaport, capable of handling large size ocean freight vessels. The port will become the commercial gateway that makes the shipment of goods produced in the Mekong Delta much easier, thereby, improving the competitiveness of the agricultural and industrial producers in the region. In addition to the developments for residential and economic uses, the master plan sets aside 120 hectares for a new cultural centre, as well as land for several other facilities such as commercial centres, hospitals, Golf courses or roads (SRV 2006). One particular characteristic of the district is further that the new bridge for highway number 1 (connecting the Mekong Delta to Ho Chi Minh City) across Hau River lands in Cai Rang, causing many important distributor roads as well as the new parts of highway 1 to run through the district which is likely to have a catalyst effect on its formal as well as informal economic development.

Until the recent past, the majority of Cai Rang's population based their livelihoods on a combination of (a) agricultural activities (for subsistence purposes and as main contributor to income generation), (b) other activities in the industry, service or trade sector (often being located in the urban core of Can Tho, i.e. in Ninh Kieu District or adjacent wards of Cai Rang and Binh Thuy) or (c) on remittances or social welfare (compare figure 1). By and large, Cai



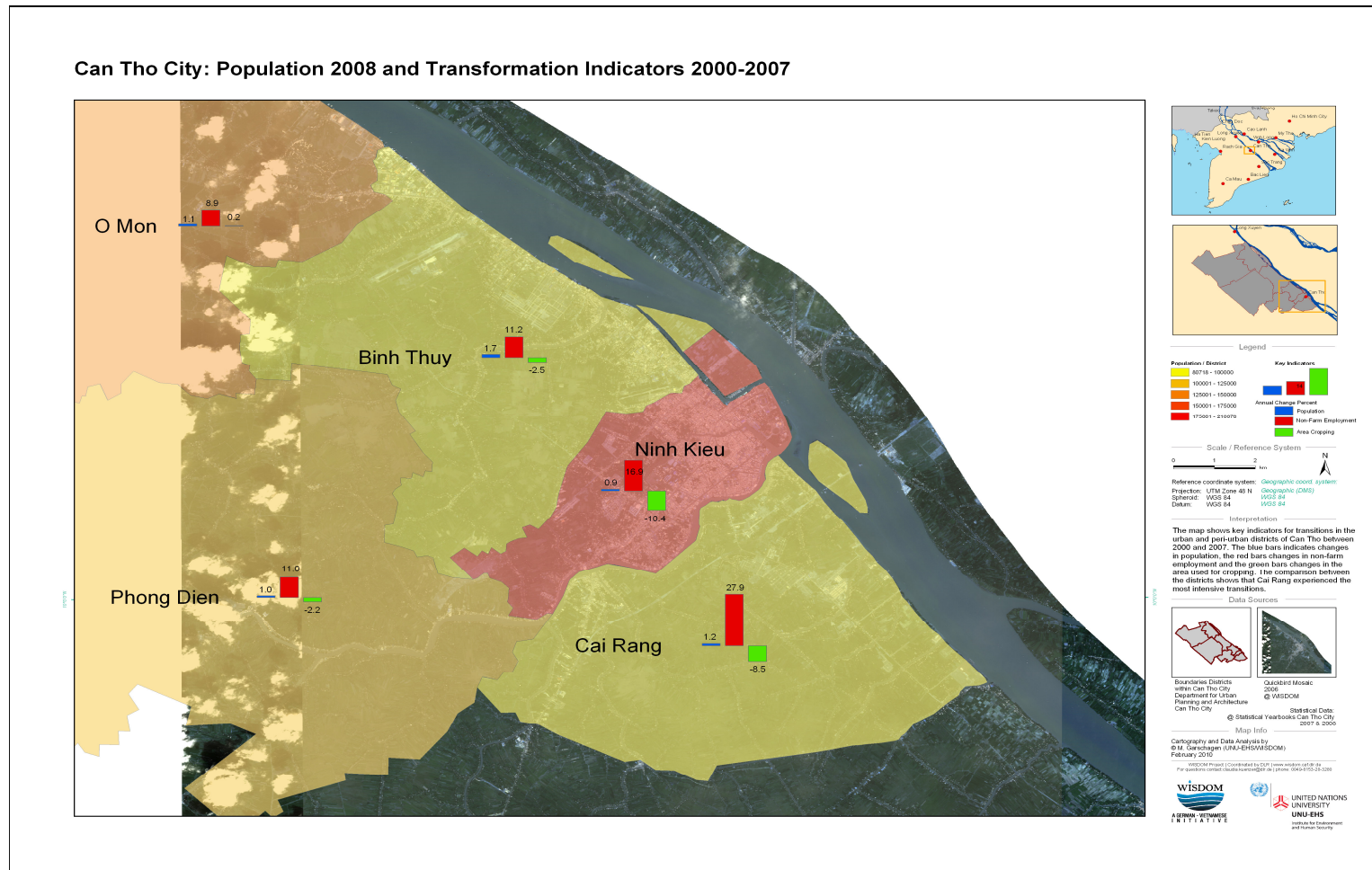
Rang's population is, hence, characterised by the afore-mentioned mixture of livelihood and income earning activities in the peri-urban interface which does not fit into often prevailing archetype conceptions of rural vs. urban livelihood patterns.

Due to the fact that many of the developments are already under construction since a couple of years, transitions in the land use statistics of Cai Rang can already be observed. In particular the area for cropping has been shrinking substantially between 2000 and 2007 with an average annual decrease of 8.5 percent and with a reduction of 26 percent between the years 2006 and 2007 alone (Statistics office Can Tho City 2007) (compare figure 1). Related to this, the number of people being employed in the non-farm sector increased with an average annual rate of 28% percent between 2000 and 2007 with the population showing an average annual increase of only 1.2% during the same period (Statistics office Can Tho City 2007).

These numbers already point towards one of the biggest challenges related to the new developments, i.e. the pressure on former residents in the agricultural sector of which many loose their agricultural land and have to resettle away from their original plot of land. Underlying to this situation is a complex political economy including elements of being priced-out, expropriated, relocated and poorly compensated. Even long before the current construction master plan had been officially approved by the Prime Minister, in September 2006, private property developers and real estate companies started to acquire land plots from farmers and other residents. Many of the households interviewed in 2009 reported that respective transactions with those companies go back six to nine years (i.e. between the years 2000 and 2003).

As all land in Vietnam eventually belongs to the people (i.e. is property of the state), the legislative framework for land transactions in the context of new developments sets out that the government gives right to the developer (either a private company or the state itself in cases of roads, harbours etc.) to build the constructions as specified in the construction master plan. The developer then has to arrange the clearance of the land as well as the compensation in dialogue with the former land holders who under the Land Law are entitled to have long-term individual land use rights including the right to lease, transfer and mortgage land. The clearance and compensation procedure is supported by a site clearance committee with strong involvement of the local government which is supposed to mediate between the interests of the developer and the former residents. In addition, the government publishes a yearly updated price list as a yardstick for compensation rates in specific locations and for different land use categories which in theory should be a close representation of the actual market value of the respective land plots (for a more detailed description of the legal framework regarding

**Figure 1: Map of Selected Districts in Can Tho City and Selected Transformation Indicators**



Source: draft M. Garschagen, own calculations based on statistical data from Statistics Office Can Tho City 2007, 2008

compensation refer to the Land Law of 2003 (SRV 2003b), the Circular 114/2004/TT-BTC on determining land prices or HanandVu (2008)).

In Cai Rang, two schemes of compensation have been applied which in many cases are combined to build a hybrid compensation scheme. The first approach envisages that households receive monetary compensation representing the value equivalent of the land as well as of special assets such the house or fruit trees. This scheme is locally referred to as “money for land”. The second scheme in general aims at compensating in kind with a new plot of land and a house within a new residential cluster constructed by the developer (“land for land”). In addition, a very common hybrid form in Cai Rang envisages that households receive monetary compensation and can use this for purchasing a plot of land and/or a house in the new residential cluster to special conditions.

Based on semi-structured household interviews in Cai Rang in 2009, a number of shortcomings in the implementation of the land clearance and compensation can be identified which imply substantial challenges and livelihood problems for the respective households. First, the compensation is considered inadequate by the majority of households interviewed. A commonly reported point of criticism is that the compensation rate is much below the actual prices for land use certificates in the respective area to the given time. Hence, the amount of money received (in the case of monetary compensation) was stated to be insufficient for purchasing an adequate plot of land elsewhere in return. Interestingly, this criticism was also stated with respect to the plots of land and/or houses in the new residential clusters due to a stark difference in the compensation per square meter on the one hand and the price for the plot in the residential cluster on the other. The compensation scheme of one of the private developers, for example, sets out that land plots of 60m<sup>2</sup> are reserved in a new residential cluster for those households that have to be relocated. In the hypothetical case that such a household had a plot of 60m<sup>2</sup> residential land prior to the resettlement, the household can get the exact amount with the new plot in the residential cluster and, additionally, a compensation for rebuilding the house, with the latter rate depending on the type of house in the old location as well as on the rebuilding and construction rates defined by the local authorities under the pricing scheme. However, if the original plot of residential land was smaller than 60m<sup>2</sup>, the household has to pay the difference for buying the new 60m<sup>2</sup> parcel. The price for this was defined to be 2.5 million VND under the given scheme, of which the local People’s Committee contributes 50%. However, the compensation rate for the old land is – under the same scheme – only 500,000 VND, resulting in a difference of 725,000 VND/m<sup>2</sup> which has to be born by the household itself. In addition, the compensation rates rebuilding the house were reported to be by far not sufficient for rebuilding an adequate house of the same size and quality. The compensation of additional agricultural land is handled separately under this scheme with a one-time compensation of 150,000 VND/m<sup>2</sup>. On the one hand, this money can be used in order to support the purchase and construction of the land parcel and house for residential purposes. On the other hand, this compensation was stated to be way to low considering that it served as a basis for long-term income generation in most households and that the purchase of adequate plots of agricultural land would be much more expensive, if available in the close vicinity at all.

Secondly, the vast majority of affected households stated to have experienced substantial delays between the transfer of the land title and the actual payment of compensation as well as the resettlement or the finalisation of resettlement areas – all potentially leading to significant micro-economic problems. As indicated above, most of the households have transferred the official land use title between the years 2000 and 2003. However, much of new residential areas have only been developed (clearance of land plots, construction of roads, drainage and sewerage systems, hauling of electricity connections etc.) years later, in most cases not before 2007. While most of the households affected by this delay were permitted to remain living on their old land until the actual resettlement, the transfer of agricultural land implied that agricultural production was no longer, or only in very limited terms, permitted or possible during those years. This in turn implies a loss of income generation for the affected households, given the lack of alternative income sources. Many of the affected households were, therefore, forced to use up their savings (e.g. first instalments of the compensation money which were in fact meant for constructing houses on the new land or for purchasing new land titles in the first place) or had to go into debts (most often with relatives).

Thirdly, in addition to those hard economic facts, most households interviewed stated an additional dimension revolving around emotional bonds to their original land as well as social networks in the old location. Not only does the loss of the land threaten the continuation of the old income earning activities and, thereby, the foundation of the entire identity (in particular for the case of farmers, but also within the localised service or trade sector). The resettlement also implies in most cases a break up or re-shuffling of social networks and, hence, social capital, be it with respect to, for example, the school of the children, to long-grown neighbourhood and family bonds or the circle of customers in business relations. Many households, for these reasons, stated their strong opposition to being relocated and would prefer to stay in the old place if they were given the choice.

### **Discussion: dynamic pathways in resilience**

The review of large-scale trends resulting from transformation and climate change in Vietnam in combination with the case study analysis of development in the peri-urban areas of Cai Rang reveals the complex interaction of trends and developments at various scales and their particular influence on peri-urban populations, often comprising rather negative effects and challenges for the livelihood regimes of those groups.

However, the case study analysis also shows that shifts in the resilience of the peri-urban population groups towards transformation trends and climate change can be influenced by many small events or circumstances and the combination thereof. Specific resilience pathways of single households are therefore the result of the particular combination of events, decisions, circumstances and access-portfolios that the respective household is faced with. Every single of these factors, thereby, works as a type of switch or changing point setting the direction for another section of the individual resilience pathway. For the analysed case study district, the chain or conglomerate of relevant elements influencing resilience directions would, for example, include the following questions: Is the household at all located within the area envisaged for new projects? Is the developer the state or a private company? If it is a private developer, which company is it, meaning which specific compensation scheme will be applied? Did the household live on a parcel for which it had a land use certificate or not? Is the compensation scheme linked to this title and how big are the compensation differences for those plots with certificate and

those without? Is the household free to choose between “money for land” or “land for land” is only one option possible due to resource constraints? In case the household prefers to move into the new residential cluster, was the old land patch big enough to be able to afford this? Does the compensation and relocation happen fast enough to withstand effects of income loss and inflation? When is a point reached where all savings or compensation instalments are depleted due to inflation and rise in land prices? How high are inflation rates and rises in land prices? How do global food prices change over the same time and how does this affect the revenue ratio of agricultural-based households?

These changing points can be conceptualised as small tipping points meaning that differences which appear on first sight rather small or unimportant may have a comparatively big effect on the overall livelihood and resilience situation of the given household (e.g. for the illustrated compensation scheme, the question whether the plot of land is 20m<sup>2</sup> smaller or larger than the land size in the resettlement cluster may have substantial financial effect and may be decisive for the question whether or not the household can afford to settle in the relocation cluster). The chain of critical elements exemplified above, further, illustrates that households are at risk of steering into significant crises situations if they experience an accumulation of circumstances implying that direction points are set towards negative developments (i.e. for example, if they do not have land certificate and, at the same time, happen to be located within the project area of a developer who strictly only compensates for those households who do have such a land title).

Yet, at the same time, the notion of direction points and dynamic pathways in resilience evolving from this analysis challenges and advances much of the conventional thinking in resilience and tipping point discourses. Resilience is often thought of as a rather monolithic characteristic of one particular system or group in the sense that, for example, farmers in *the* given area share the same resilience characteristics and are parts that are coalesced in one binding system. This pre-analytic vision often implies strong (implicit or explicit) deterministic, functionalistic or mono-causal notions in the sense that, for example, certain population groups that have similar socio-economic characteristics and share the same bio-physical landscape (and hazards) will move along the same development pathway and eventually end in a similar (often deteriorated) situation. While this observation might be true for certain empirical cases, regions or systems, it is certainly not true for many of them, as the analysis of very differentiated and dynamic resilience pathways in Cai Rang has shown. Hence, the conceptual thinking of resilience and tipping point regimes has to be broadened and advanced towards integrating those dynamic notions and towards challenging the often prevailing implicit notions of determination and functionality.

Further, the notion of overlaying and interacting processes that affect resilience has so far mainly focused on researching and conceptualising those cases where all the interacting processes work in the same direction, i.e. towards a deterioration in resilience, mainly in the sense of cascading effects which eventually lead to the collapse of a given system (Abel et al. 2006; Kinzig et al. 2006). Intermediate options where only some elements are negative and others point in positive directions, are under-represented in the prevailing conceptual discourse.

An additional – and in the view of the authors highly important – point in this context has to be seen in the relevance and applicability of resilience thinking for policy making. It has been noted that resilience thinking is widely considered to be conceptually and analytically appealing, however, that by and large it so far gives little concrete and applicable guidance for decision

making, i.e., for example, on how to avoid tipping into crisis or collapse in a given coupled social-ecological system in which overlapping power relations and actions are at work (Garschagen 2009; Renaud et al. 2010). In this context, it is also of relevance that tipping points are so far predominantly discussed with respect to rather big systems – with the discussion originating from the analysis of global systems in the domains of climatology and ocean streams. The threats of tipping points in those large-scale systems, however, seem to have been overwhelming with respect to finding and implementing policy responses on the ground – let alone regarding the identification of responsibilities.

The notion of small-scale tipping points, more in the sense of turning points in the trajectories household-level resilience pathways, as presented here, however, allows for the quite clear identification of cause-effect relations and, therefore, of responsibilities for specific elements in this resilience landscape. This conceptual and analytic notion, therefore, has a much stronger and more direct relevance for developing concrete response options and counter-measures as it breaks up the big block of resilience into small pieces which are much easier to manage and for which concrete solutions can be found comparatively easily. In this context it also helps to uncover responsibilities of different actor groups as well as options and capacities for solutions amongst these groups (e.g. the time frame for the implementation of compensation and issuance of new land titles lays within the responsibilities of the developer; however, the local government has through the clearance committee can – in theory – take strong influence on the those decisions). It has been noted in this context that the analysis of those questions always has to keep at least three levels in mind, i.e. first, the national level of policy formulation and paradigm definition; second, the local level of policy implementation; and, third, the personal level of everyday power relations, entitlement and livelihoods (Kelly 1998).

Identifying and explicitly analysing turning points and potential tipping points in those resilience trajectories surely can not be seen as a panacea for solving all the problems related to issues of power struggles, influence and fairness in the complex political economy or political ecology at work. However, it is argued here, that explicitly uncovering these turning points and their potentially negative effects is a first very important step towards the strengthening of the domains conventionally understood as defining elements of good governance (i.e. transparency and accountability in particular). This way, the notion of dynamic resilience pathways and the analytical guidelines coming out of it, can have a guiding function for the fostering of integrative planning and management approaches in the sense of comprehensive good governance focusing in particular on the mediation of changing rights and responsibilities in an rapidly transforming and diversifying actor landscape.

## **Conclusions and outlook**

This paper brought together elements from different schools of thought and disciplines with respect to conceptual approaches (resilience, tipping points, political economy, political ecology etc.), methodologies (quantitative social sciences and natural sciences) and geographical areas of interest (rural, urban and peri-urban) for exploring resilience trajectories of peri-urban farmers in the Mekong Delta. An emphasis was placed on the dynamic continua as well as grey-shades (as opposed to the often prevailing static “black and white” thinking in research and policy making). This holds true, for example, for the focus on the peri-urban interface (rather than rural vs. urban thinking); for acknowledging advantages and disadvantages of peri-urban developments and resettlement at the same time (rather than having a biased starting point of being totally pro or

contra, for example, resettlement); for exploring resilience effects in both positive as well as negative directions (rather than exclusively focusing on degradations of resilience, possibly related to cascading effects); for acknowledging responsibility and agency of different actors in a transforming actor landscape (rather than proclaiming exclusive responsibility for single actors); and, most importantly, for conceptualising tipping points and resilience pathways as the result of the interaction of many small factors with multiple possible pathways for different agents (rather than a deterministic or functionalistic understanding of a monolithic system moving as a whole into one pre-defined direction).

It is argued here that a strong emphasise on such continuum thinking is necessary for effectively approaching the complex and highly dynamic developments and challenges in Vietnam and in particular within the peri-urban agricultural sector, which is and will be heavily affected by the illustrated, overlaying impacts of socio-economic transformations (including significant urbanisation) and climate change. The paper, thereby, raised particular awareness of the specific dynamics and management challenges in the peri-urban interface in Vietnam which so far have not been sufficiently addressed in research and policy making and which remain to be falling through the cracks of horizontally and sectorally fragmented administration and planning. The comprehensive focus on socio-economic transformation (and related development questions) and climate change impacts, further, calls for increased efforts to link those two spheres which so far often are regarded rather separate domains (being mirrored in fragmented institutionalised responsibilities of planning and management agencies but also in the layout of research initiatives). Lastly, the explicit focus on, what we called, turning or changing points as defining elements of individual resilience pathways advances the conceptual resilience discourse (which, as stated above, is by and large characterised by a rather deterministic system thinking, lacking the individual household focus and differences in household level resilience amongst groups that, on first sight, might be thought of as having the same level of resilience). This conceptually advanced viewpoint allows for concrete guidance with respect to resilience assessment and policy making as it splits up the – on first sight overwhelming and abstract – domain of household level resilience into smaller elements which, therefore, become possible to tackle and manage. The explicit focus on these changing points, thereby, helps to identify responsibilities for the respective action as well as shortcomings or negative effects. Explicitly identifying those shortcomings is the first step for effectively addressing and improving the related problems (with often relatively small changes being necessary to induce large improvements, as the example of compensation schemes has shown). This process deserves increased attention in countries like Vietnam, as the spectrum of actors is rapidly transforming and liberalisation policies are gaining ground, thereby, making mediations of responsibilities more and more important. However, at the same time this last point is likely to be one of the biggest challenges in Vietnam as decision making processes and their transparency and public participation remain highly contested.

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## Climate change adaptation and agrichemicals in the Mekong Delta, Vietnam

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### Abstract

Since the implementation of economic reforms in 1986 the Mekong Delta experienced an extensive transformation process in agricultural sector characterized by agricultural intensification, enhanced use of agrichemicals (fertilizer, pesticides) and emerging concerns for human health and environment. Predicted impacts of climate change such as sea level rise; greater seasonal variability in precipitation and river flows; elevated temperature and CO<sub>2</sub> concentration will all likely also influence the agricultural setting and thus agrichemical use.

Against the background of the anticipated climate change impacts in the Mekong Delta, special attention needs to be paid to the agrichemical dimension of adaptation in the agricultural sector. The paper reviews the main climate change mediated drivers for agrichemical use with special focus on land use changes, changes in pest and disease patterns and resulting changes in pesticide use. In addition, the paper identifies possible adaptation measures that may be implemented by the agricultural sector in the Mekong Delta and explores the potential environmental effects of these adaptation strategies.

Keywords: Mekong Delta, agriculture, climate change, agrichemicals, adaptation

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## Introduction

### *Physical conditions and agriculture in the Mekong Delta*

The Vietnamese Mekong Delta covers an area of 4.06 million ha and is home to 17.7 million people of which 79% lives in rural areas (GSO 2008). It is a flat and low-lying area (< 4.0 m above mean sea level) with a complex network of rivers and channels. The delta's hydrology is influenced by tides from the South China Sea and - to lesser extent - from the Gulf of Thailand. The climate is tropical monsoonal with a rainy season from May to October and dry season from November to April. Average temperature is about 27°C. Mean annual rainfall is about 1,600 mm, of which more than 80% falls in the wet season (Statistical Office Can Tho City, 2000, 2005, 2008). In the rainy season, a large part of the Delta is inundated. In the dry season, the low discharge of the Mekong, tides from the South China Sea and from the Gulf of Thailand and high water extraction rates cause salinity intrusion in the Delta (White 2002).

To date, the hydrology of the delta is largely controlled by sea dykes, embankments, sluice gates and pumping stations e.g. for irrigation purposes. These large-scale hydraulic control structures have been established mainly to control floods in the upstream part of the delta and saline intrusion in the coastal areas resulting in a largely human-regulated water regime. Existing hydraulic control structures, soil fertility and productivity, and - since the implementation of economic reforms in 1986 - agricultural modernization successfully stimulated rice production allowing Vietnam to move from being a rice importer to the world's second largest rice exporter. Similarly, rapid growth of the aquaculture sector enabled Vietnam to become one of the largest fishery export countries in the world (FAO 2008). To date, 63% of the Delta is used for agricultural production which is a very high rate compared with 28% for whole Vietnam and 38% for the Red River Delta (GSO 2008). The region supplies 55% of national rice production (data for 2007, for all three rice seasons) and 82% of the farmed shrimp production (GSO 2009 a,b). In rice production as well as in aquaculture, this rapid growth was a direct result of intensification processes such as the introduction of three annual rice seasons instead of two (Dang and Danh 2008) and the adaptation to the production of exportable goods (e.g. *Pangasius*). This success is based to a large extent on the enhanced use of agricultural chemicals such as fertilizers and pesticides in rice production (Meisner 2005 Dang and Danh 2008); and the use of processed food, animal wastes, pesticides and veterinary drugs in the aquaculture sector (Trong et al 2002). The drawbacks of this development are widely recognized as environmental degradation and pollution (IRIN, 2009), concerns on drinking water and food safety (Holland 2007, Neubacher 2007), failures in meeting international standards of exported goods (Yen 2006) and health concerns (Margni 2002, Dasgupta 2007).

### *Climate Change in the Mekong Delta*

Climate change is an ongoing process in the world as well as in the Mekong Delta. We do not have to look back very far in the recent climate history of the Delta to understand possible impacts of climate change on the delta's agriculture. In the past ten years, the delta experienced high floods in 2000, 2001 and 2002, including the historic high flood in 2000; drought for 4 successive years (especially the drought combined with low river flow in 2004 and early 2005), sea water intrusion into areas which were never before impacted (e.g. in late April 2009 in Hau Giang province).

Hinkel and Menniken (2007) reviewed a total of 18 studies with regard to their forecasts on climate change effects in the Mekong basin. Most of the reviewed studies agree that the major climate change impacts in the Mekong basin likely will be higher temperature and higher evaporation. Moreover, climate change is predicted to alter precipitation patterns (roughly the same amount but enhanced amount in the rainy season) leading to altered flood patterns.

The Ministry of Natural Resources and Environment (MONRE) published recent climate change scenarios for Vietnam in 2009. According to the medium emission scenario (B2) the annual mean temperature will increase by 1.0 °C in South Vietnam by 2050. Temperature increase will be 0.8-0.9 °C during the dry season (Dec-May) and 1.2 °C during the wet season (Jun-Nov). For the same area and period the annual rainfall is predicted to increase by 0.8 %. However, in the dry season (Dec-May) annual rainfall is predicted to decrease by 7.8% while rainfall will increase during September-November by 6.8% leading to enhanced seasonal variability. Sea level is predicted to rise by 30 cm by 2050 and 75cm by the end of the century. Sea water intrusion in the southwest coastal provinces influences already 1.77 million hectares land (45% of the region). Although sea water intrusion into low lying deltas is a natural phenomenon, sea level rise, climate influenced changes in river flow, and human activities such as increasing water extraction from MD aquifers are predicted to enhance the area affected by sea water intrusion greatly. A sea level rise of 75 cm would lead to an inundation of ca. 7,600 km<sup>2</sup> – 19% of the delta (MONRE 2009).

#### *Possible climate change impacts on agriculture in general*

Croplands that occupy about 18 % of the Earth's surface are more and more exposed to threats from increased climatic variability and to climate change. Changes in air temperature and rainfall pattern and resulting increases in frequency and intensity of drought and flood events as well as altered hydrological cycles will all have implications for agricultural productivity (FAO 2007). There is a considerable number of publications discussing important expected impacts of climate change on agriculture such as impacts on the production area, migration of agro-ecosystems, physiological effects on crops influencing yield quantity and quality (Peng et al. 1995, IRRI 2007, Wassmann and Dobermann 2007, Gregory et al. 2009, Padgham 2009,), changes in soil and water resources, changing occurrence and severity of pest and disease outbreaks (Coakley et al 1999, Chakraborty et al. 2000, Chakraborty and Pangga 2004, IRRI 2007). Despite this large number of studies on particular aspects of climate change impacts (e.g. on CO<sub>2</sub> fertilization) our understanding of climate change impact on agriculture is still limited. One of the reasons is that the processes described above all interact with one another through feedback loops. For example, water scarcity causes the plant to be water-stressed and thus more susceptible to pests and diseases. Also, climate change will likely trigger adaptation i.e. changes in agricultural practices (e.g. planting more flood resistant or salt resistant varieties of rice, implementing better irrigation practices, enhancing use of agrichemicals). Some of these adaptation measures will likely impact back on environmental conditions such as increasing water pollution and soil exploitation. Studies with a holistic approach i.e. considering a broader range of changing parameters and possible feedback loops are largely missing. Additionally, there is lack of information on climate predictions on the small scale (field scale), where most of the yield relevant processes take place. Therefore, by predicting climate change impacts on agriculture we face large uncertainties. Being aware of these limitations, this paper aims to review the current knowledge on possible impacts of climate change on the rice production area in the delta as well as impacts on the rice plant and rice pests and diseases with the goal to predict future agrichemical use in the MD.

### **Possible impacts of climate change on agrichemical use**

Climate change may influence agrichemical use in many ways. Temperature and rainfall patterns seem to influence the amount of used pesticides directly as it was investigated by statistical methods for the pesticide use in the U.S. by Cheng and McCarl (2000). Climatic conditions also influence the efficiency of agrichemicals directly by e.g. influencing their retention time on the foliage. Climate change also affects the net area of crop production by inundation and saline intrusion in the Delta.

#### *Possible impacts on the production area in the Mekong Delta*

Production area may be influenced by climate change in direct and indirect ways. Sea level rise and changing flood patterns will result in a direct net loss of arable land in the delta. A sea level rise of about 30cm is expected by 2050 and about 75cm by the end of the 21st century based on a medium emission scenario (MONRE 2009). Inundations in the Mekong delta caused by 20-40 cm of SLR would significantly affect all three rice cropping seasons by limiting the number of rice crops per year (Wassmann et al. 2004, White 2002). Saline intrusion was found to be the major factor leading to regional differences in rice cropping systems and land use patterns in the Delta (Kotera 2008). Sea level rise would also intensify coastal line erosion and saline intrusion into aquifers and surface waters in coastal areas of the Delta. Should there be no implementation of further structural adaptation measures; predicted inundation of ca 19 % of the delta and increasing salinisation of water and soil resources would lead to a significant limitation of land resources suitable for agriculture in the delta. These limitation would likely lead to an enhanced pressure on the remaining arable land in terms of yield per area in order to maintain food security which in turn would likely require further agricultural intensification with corresponding high pesticide and fertilizer use.

However, the Vietnamese Government plans to undertake significant investments into the construction and upgrade of sea-dykes and sluice gates to respond to sea level rise (SRV 2008). Thus, predictions for the impacts of sea level rise on land use and agricultural production need to take into account a considerable amount of technical adaptation measures. Such methods are already applied in large areas of the Delta as a response to existing saline water intrusion. A series of dykes and sluice gates were constructed in the Ca Mau Peninsula (southern part of the Mekong Delta) to enhance the production area of rice since 1993. The establishment of saline intrusion control measures was a response to the Mekong Delta Master Plan (NEDECO 1993) and the Mekong Delta Water Resources Project's six provincial cross-boundary subprojects in the late 1990s (Evers and Benedikter 2009). The impacts of these measures on land use, management practices and resulting impacts on the environment are already reviewable. Reduced saline intrusion and the elongation of the cropping season during the wet season behind the sluice gates lead to progressive expansion of the area suitable for rice production and to intensification of the production by having two or three rice crops per year instead of one (Kam et al. 2001). This level of intensification increases pressures on soil resources and favours pest outbreaks which lead to drastically enhanced pesticide and fertilizer use. Since freshwater behind the sluices is limited and mainly stagnant in the dry season water pollution by agrochemicals likely becomes a threat for human health, aquatic ecosystems and for agricultural production other than rice paddies. Especially aquaculture is affected by water pollution with agrichemicals which add to the existing conflicts on water allocation between freshwater users for crop farming

and brackish water users for shrimp aquaculture (Nhan et al. 2007). Additionally, leaching from acid sulphate soils tends to acidify the water behind closed sluice gates. In saline water protected areas acidic water and water scarcity in the dry season were found to be the limiting factors for rice production (Aizawa et al. 2007). Overall, intensification in agriculture behind water-control structures challenges the environmental sustainability of the Mekong Delta.

#### *Possible climate change impacts on rice plants*

Influence of climate change, especially global warming and elevated CO<sub>2</sub> (ECO<sub>2</sub>) on the growth and development of rice plants has been well documented (Peng et al. 1995). Enhanced CO<sub>2</sub> concentrations alter physiological processes in rice plant such as photosynthetic rate or stomatal conductance. These changes will in turn have positive effects on rice production such as shortening the growth period by 10-12 days due to shorter vegetative phase and increasing the grain yield by 10-70% (Imai 1995, Allen Jr et al. 1995) which process is often quoted as carbon fertilization. In contrast, global warming - without considering other parameters such as carbon fertilization - is likely to influence rice production negatively (Peng et al. 2004, IRRI 2007) e.g. through more frequent occurrence of acute and chronic heat stress events for the plants (Ingram et al., 1995) or due to changes in evapotranspiration and availability of water used for irrigation (Tao et al., 2008). Since global warming and ECO<sub>2</sub> are predicted to co-occur, investigations on the interactions between these two climatic variables are extremely important. Ingram et al. (1995) demonstrated that the interactions between CO<sub>2</sub> and temperature would be specific for rice varieties and production locations. For example, adverse effects of a warmer temperature coupled with enhanced CO<sub>2</sub> environments are likely to be greater for the tropics, as in the case of the MD than for temperate regions. In addition, climate change also affects plant pests and pathogens and agrichemical use efficiency in relations to crop management options and cultural practices and the inter-relationship between these factors make the assessment of climate change on rice even more difficult.

#### *Possible impacts on rice pests and pathogens*

Damage caused by pests and diseases in general is one of the most important limiting factors in agriculture production. Yield losses due to pathogens and pests are estimated at around 6-9% of total worldwide production (Oerke 2006) which is equivalent of around 220 billion US dollars (Agrios 2005). In rice production alone, global potential losses due to pathogens and pests account for 13-25% of attainable yield and the actual losses vary much according to agro-ecological regions (Oerke 2006).

Numerous pests and pathogens cause different levels of damage to rice crop. The most common and important pests of rice are stem borers, brown planthopper (BPH), rice leaf folder and rice thrips (Pathak and Khan 1994). These pests can occur in one, several or all stages of rice growth causing great losses. Diseases with economic importance in rice are blast disease, sheath blight, sheath rot, brown spot, bakanae, bacterial leaf blight and viral diseases such as rice grassy stunt virus (RGSV). In the MD, the most important pests and diseases in terms of economic loss are BPH, rice thrips, stem borer, leaf folder, rice blast and sheath disease, sheath rot, brown spot and RGSV as reported by the Plant Protection Departments (PPD).

Among the various factors affecting pest and disease incidence and development weather conditions play a significant role and influence all stages of growth and development of host plants as well as the occurrence and severity of the disease (Chakraborty et al. 2000). The predicted changes in climate will likely alter the geographical and temporal distribution of plants,



which in turn affect disease infection and development processes. Changes in temperature have significant effects on pest and disease distribution and development in most locations. Higher temperature favours population development of some pests and pathogens by increasing the number life cycles per year. Higher temperature promotes plant growth in cool regions and thus provides more food and nutrient for pests and pathogen whereas the impact is opposite in warmer locations. Thus, the effects will vary among different agro-ecological zones (Coakley et al. 1999). Elevated CO<sub>2</sub> in the atmosphere will alter physiology and morphology of the host resulting in changes in light interception, canopy structure and microclimate which will in turn affect disease epidemiology (Chakraborty et al. 2000; Gini et al. 2008). Interactions between climate, plant host and pathogens will determine the degree of impact on agriculture (Chakraborty and Pangga 2004) but will also be influenced by the effectiveness of applied management strategies (Chakraborty et al. 2000).

Effects of climate change to pests and diseases have been investigated in numerous regions of the world as reviewed in the following sections. However, studies on the effect of climate change on rice pests and diseases in Vietnam are non existent.

#### *Global warming and pests, diseases - examples*

##### *Rice blast disease*

The impacts of global temperature change on rice blast disease *Pyricularia grisea* (sexual stage *Magnaporthe grisea*) in 3 agro-ecological zones: cool subtropics (Japan and northern China), subhumid and warm humid subtropics (southern China) and humid tropics (Philippines and Thailand) was studied using a combined simulation model (Coupling of CERES-Rice with BLASTSIM) (Luo et al. 1998a). The simulations suggested that temperature changes had significant impacts on disease development in most regions. In the cool subtropics such as Japan and northern China, warmer temperature resulted in more severe blast epidemics. In warm/cool humid subtropics, rising temperature reduced blast epidemics significantly. In contrast, lower temperature caused small difference in disease epidemics compared with currently prevailing temperatures. The effect of temperature change in the humid tropics were opposite to that in cool regions where daily temperature changes by -1°C and -3°C resulted in significantly more severe blast epidemics and temperature increases of +1 to +3°C reduced blast severity.

Using a similar simulation method, the effect of global temperature changes on risk of yield loss caused by rice blast disease was analyzed for five Asian countries (Japan, Korea, China, Thailand and the Philippines). It was demonstrated that changes in temperature have significant impact on the disease compared to that caused by changes in rainfall. The influence varied with agro-ecological zones but the disease will become more severe in cool, subtropical regions like Japan while the model predicted disease inhibition in humid tropics and subtropics such as in the Philippines (Luo et al. 1998b). As the MD has similar monsoon climate to the Philippines, a reduction of blast epidemics due to global warming would be expected. However, the interaction of global warming with other production factors such as elevated CO<sub>2</sub>, land use and pesticide use patterns makes it difficult to predict the effect under real conditions.

##### *Rice pests*

Global warming would likely result in a redistribution and altered abundance of rice arthropod communities with a degree of influence depending on pest species and populations. A change in temperature can affect any stage of the life cycle which in turn can affect pest survival,

reproduction and development. For example, adult survival of BPH remained unchanged between 25-35°C but was significantly reduced at 40°C. From this study, it was concluded that warmer temperature would increase BPH abundance in areas with temperatures below 30°C (Heong et al. 1995).

As temperature increases, insects that are directly limited by temperature will be able to expand to temperate regions rapidly. Insects of many tropical and subtropical *species* might *move poleward* from their current locations as long as their cold hardiness allows, because they usually lack diapause in their life cycles (Kiritani 2006). For example, it was predicted that the rice stem borer *Chilo suppressalis* would shift northward in Japan by about 300km if the temperature rises by 2°C (Morimoto et al., 1998). Analysis of long-term insect population in Japan showed that an increase in winter temperature increased population of the rice stem borer and the green rice leafhopper (*Nephotettix cincticeps*) and the degree of change was much larger for the green rice leafhopper than for the rice stem borer indicating a difference in the number of generations per year (Yamamura and Yokozawa 2002). Rice stem borer is an important pest of rice in the MD (DARD Dong Thap 2006) but the effect of global warming on this pest under Mekong Delta conditions has not yet been studied. A study carried out by Kiritani (2006) predicted that rice stem borer may spread northward and will be more prevalent in cooler time of the year, such as during the winter-spring crop (December to March) in the Mekong Delta.

Many rice pests are vectors for some destructive viral diseases. Hence, changes in pest population due to global warming also influence the prevalence of some viral diseases associated with those pests. For example, the geographical occurrence of the rice strip virus disease (RSV) which is transmitted by the small brown planthopper (*Laodelphax striatellus*) could be shifted due to the synchronization of planthoppers with the cultivation of rice plants. The occurrence of this disease therefore is determined by the interactions among three organisms: the rice plant, RSV and the vector. Global warming will change the time when planthoppers occur by accelerating their development. Thus, it is expected that the geographical area that is potentially vulnerable to disease prevalence will shift (Yamamura and Yokozawa 2002).

#### *Natural enemies of pests*

Global warming may work in favour also of natural enemies by increasing the number of generations more than in their host species irrespective of the type of agroecosystem. For example, the attack rate of *Cyrtorhinus lividipennis*, a natural egg predator of the BPH, increased in temperature range between 20-32°C. Thus, it was predicted that in areas with such temperatures there will be an increase in predation on BPH eggs. However, in areas with temperatures higher than 35°C - such as the MD in most time of the year – the ability of *C. lividipennis* to influence BPH population could be reduced (Song and Heong 1997). Biological control utilizing native natural enemies is expected to become a more important control tactic in the future (Kiritani 2006).

#### *Brown planthopper (BPH) and rice grassy stunt virus (RGSV)*

In the last 5 years, the MD has witnessed severe outbreaks of BPH and the virulent disease RGSV. BPH outbreaks occurred in almost all provinces in the MD and caused infection of hundreds thousand of hectares. The percentage of infected area of rice caused by some major rice pests and diseases in the MD in the period 2004-2009 is illustrated in figure 1. There was a significant increase in the areas affected with BPH from 2006-2008. The viral disease RGSV also became prevalent in this period due to an increase in the area infected with BPH, the vector

of the viral disease. Outbreaks of BPH and RGSV were even more severe in some provinces with intensive rice production such as Dong Thap, An Giang and Tien Giang. Figure 2 refers to the percentage of infected area caused by major pests and diseases of rice in Dong Thap province. The area infected by BPH increased drastically and reached 56% in the year 2008. Similarly, the area infected with RGSV increased also significantly.

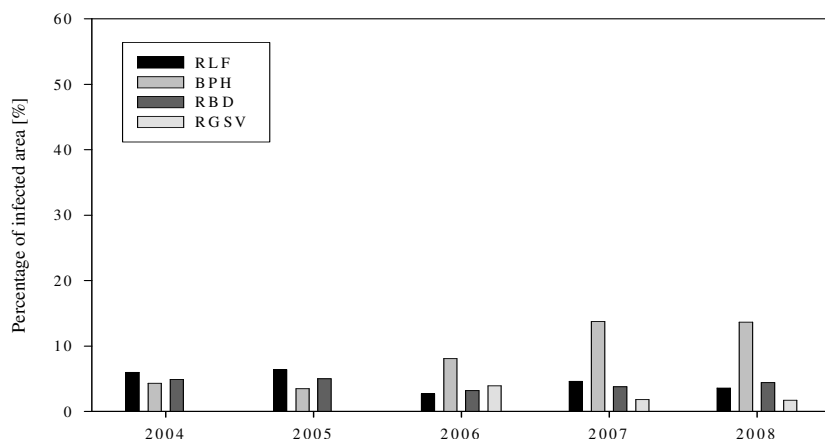


Figure 1: Percentage of cultivated area affected by some important rice pests and diseases in Southern Vietnam in the period of 2004-2008. (Data collected by the Southern Plant Protection Centre). BPH: brown planthopper; RBD: rice blast disease; RGSV: rice grassy stunt virus; RLF: rice leaf folder.

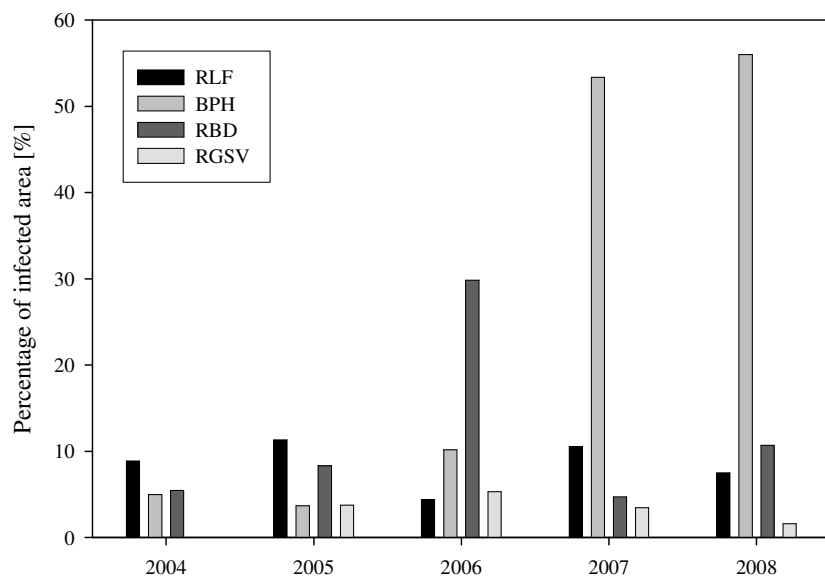


Figure 2: Percentage of cultivated area affected by some important rice pests and diseases in Dong Thap province in the period of 2004-2008. (Data collected by the Department of Agriculture and Rural Development, Dong Thap province). BPH: brown planthopper; RBD: rice blast disease; RGSV: rice grassy stunt virus; RLF: rice leaf folder.

The prevailing hot and humid weather in the MD favours the development of BPH in general. However, severe outbreaks affected the region since 2006. Although climate change has often been quoted to play an important role in the recent severe outbreaks (Dao Xuan Hoc 2009) the reasons are probably manifold and it is challenging to work out the share of climate change on these developments. First of all, the intensive rice production with up to 7 crops in 2 years creates a constant food supply for BPH. Secondly, management practices such as over-fertilization with urea, high seeding density and the use of susceptible varieties favours pest development and distribution (Lam 2007). Thirdly, intensive use of insecticides is common in rice production. Spray of insecticides in early stage of rice development can kill natural enemies of BPH while developing resistance to pesticides and thus decreases the effectiveness of pesticides used. Fourthly, extreme weather events such as abnormally low or high temperatures, severe rainfall or drought periods may contribute to the pest outbreaks (Chakraborty et al. 2000). The more frequent occurrence of El Niño events, warmer temperature with larger difference between minimum and maximum temperature in the MD in general or Dong Thap province in particular in the period of 2001-2008 was considered to play a role in the pest outbreaks (DONRE Dong Thap 2008). The strong northeast or southwest monsoon winds in 2006 also spread BPH to other uninfected areas (Agrivet.com 2008). In addition, interactions between two or more above mentioned factors can also accelerate pest occurrence. For example, global warming can speed up the life cycle of BPH and increase survival of nymphs and adults, fecundity and egg hatch ability significantly along with higher nitrogen content of the rice host (Lu et al. 2005).

Similar severe outbreaks of BPH have been also observed in several rice growing regions of India and China in 2008. According to authorities the recent abnormal weather patterns and the misuse of pesticides may have contributed to the unusual outbreaks of BPH (IRRI 2009). In Thailand, BPH outbreaks have caused significant yield losses in some rice producing regions. Losses were estimated around 7-8 million tons of rice which is equivalent to about 400 million US dollars in 2010 (excluding indirect cost like environmental pollution due to the enhanced use of pesticide) (Heong 2010).

#### *Elevated CO<sub>2</sub> (ECO<sub>2</sub>)*

The impacts on pathogens are not easily determined due to the dynamic interactions between the host, environment and the pathogens (Ghini et al. 2008). In a recent review written by Chakraborty and Pangga (2004), it was reported that of the 26 diseases studied, severity of 13 diseases would increase under elevated CO<sub>2</sub> whereas 4 remained unchanged and 9 would decrease. Lake and Wade (2009) demonstrated that doubled CO<sub>2</sub> concentration facilitated infection of *Erysiphe cichoracearum* on marrow whilst increased the susceptibility of the host to the pathogen infection through changes in stomatal density under controlled conditions. Some diseases such as barley powdery mildew were also demonstrated to cause more severe reduction in yield under high CO<sub>2</sub> level than the normal CO<sub>2</sub> concentration under controlled experiments (Hibberd et al. 1996). Some pathogens expressed higher fecundity or aggressiveness under elevated CO<sub>2</sub> environments (Chakraborty et al. 2000). In addition, elevated CO<sub>2</sub> or changes in temperature would also impact the resistance/susceptibility of the host.

The impact of ECO<sub>2</sub> on some important disease of rice has been demonstrated. Rice plants grown under higher CO<sub>2</sub> concentration were more susceptible to leaf blast than those in ambient CO<sub>2</sub> probably due to their lower leaf silicon content which may contribute to the increased susceptibility to leaf blast. The percentage of sheath blight diseased plants was also higher under

elevated CO<sub>2</sub> condition compared to that under ambient CO<sub>2</sub> concentration. It was probably due to the higher number of tillers observed under ECO<sub>2</sub> concentration which may have increased the chance for the fungal sclerotia to adhere to the leaf sheath at the water surface (Kobayashi et al. 2006). This increase in the disease incidence and epidemics under ECO<sub>2</sub> is probably similar to rice production in the MD.

Therefore, the positive effect of climate change on rice yield caused by carbon fertilization could be bypassed by the negative influence of global warming on rice growth and more abundant and severe infestation of pests and pathogens. Most of the available studies have been conducted under controlled conditions; the effects might be different under field conditions (Ghini et al. 2008). Furthermore, most of the studies have been carried out on the effect of a single meteorological variable on the host or pathogen rather on the interactions between two or more factors (Coakley et al. 1999). Studies considering a combination of more than two climatic factors are not available. Based on the available information on the effect of climate change to rice pests and diseases elsewhere, it is difficult to draw any clear conclusions at the moment for the MD. Therefore, comprehensive research needs to be carried on this topic in the MD.

#### **Possible impacts on agrichemical use efficiency**

Paddy rice production in the Mekong Delta has increased steadily at a rate of 5.1% in the period of 1986-1995, so as did pesticide use at a rate of 5% per annum. National demand for pesticides is around 50,000 tons equivalent to around 500 mills USD (xaluan.com). Pesticide use in rice accounted for 65.5% of total amount of pesticide use in agriculture and insecticide alone shared 85% of the total volume (Dung and Dung 1999).

Climate change will likely affect agrichemical use efficiency in several ways. First of all, warmer temperature and high rainfall may change the dynamics of pesticide residues on crop foliage. High rainfall intensity could reduce retention of pesticide on the foliage by increasing wash-off rates (Schepers 1996). Higher temperature can reduce the effectiveness of certain classes of pesticides such as pyrethroids and spinosad (US Global change research program). The complex interaction between rainfall intensity, temperature, host and disease will determine pesticide use efficiency (Coakley et al. 1999). Statistical analyses of pesticide use in relations to higher temperature and rainfall in the U.S. showed that the effect varied greatly among different crops. For some crop such as corn, cotton, soybean and potato, higher temperature resulted in greater use of pesticide. In contrast, the use of pesticide was reduced for wheat. More rainfall increased pesticide usage costs for corn, wheat, soybeans, and potato (Chen and McCarl 2001).

Morphological and physiological changes in the host plants under changing climate would have also an impact on pesticide use efficiency. Increase in canopy thickness and biomass under elevated CO<sub>2</sub> conditions would reduce the effectiveness of pesticides on the foliage and consequently would increase the amount of pesticide needed. Furthermore, changes in leaf morphology such as thicker epicuticular wax layer on leaves could slow or reduce the uptake of pesticide and thus reduce pesticide use efficiency (Coakley et al. 1999).

In general, the main climate drivers for changing pesticide efficiency would be most likely the predicted changes in rainfall intensity by causing an enhanced rate of pesticides which will be removed from the plant surfaces and increased temperatures leading to faster degradation of the chemicals.

### **The agrichemical dimension of climate change adaptation in the Mekong Delta**

As reviewed in this paper, climate change will likely decrease the area available for rice production in the delta. As a consequence, food security could be only met by increasing yields per unit of land as well as per amount of used water, energy and time (IPCC 2007). This will likely put the remaining production areas under pressure leading to an intensification of agricultural practices – i.e. also via enhanced use of pesticides and fertilizers. This development could be amplified by direct negative impacts on crops and climate driven changes in some host and pest/disease relationships leading to an increase in the occurrence and severity of some diseases and pests by a potentially decreasing efficiency of pesticides at the same time. Our surveys conducted in 2008 and 2009 in the Mekong Delta revealed a strong belief of farmers in chemical responses to any threats to their crops by applying large amounts of pesticides rather than using alternative strategies such as integrated pest management (Toan et al. unpublished data). Thus again, enhanced use of pesticides would be a likely response of the farmers to the expected yield losses. These projections deserve attention since recent pesticide use and management practices in the delta are already not sustainable from the environmental and human health perspectives. Ongoing studies at two study sites in the delta revealed that a broad range of recently used pesticides is co-occurring at detectable levels in field discharges and channels used for irrigation, aquaculture, and personal hygiene throughout the year (Toan et al. 2009). Frequent detection of pesticides in water courses of rural areas of the delta indicates that surface water quality deserves special attention in these land use settings particularly because surface water often serves in rural areas as drinking water source. However, surveys conducted in 2008 and 2009 showed that improvement of water quality requires changes in farmers' practices regarding the use of pesticides and management of pesticide waste (Toan et al. 2009). Farmers tend to increase pesticide use in order to compensate for crop losses due to pests and diseases. This practice is economically not justified due to higher pesticide use costs and resulting pollution in the environment (Oerke 2006). Thus, investments in training and education of farmers will be necessary to promote alternative management strategies and train farmers on effective and safe pesticide use. However, farmer schools and training on integrated pest management are already in place in the delta and strongly promoted by plant protection departments and extension offices. Although farmers usually claim to be aware of and apply these methods their everyday practice shows otherwise. The reasons for the gap between theory and practice are probably deep-rooted and should be overcome to enhance the impact of future training and education programs.

Beside the promotion of integrated pest management via training and education, further improvement of information generation and sharing will be necessary. This includes better seasonal and small scale forecasts of weather together with crop models that can predict yield a few months ahead of the harvest. The information need to reach the farm level possibly also via innovative communication ways such as text messages on mobile phones.

In terms of production area, there is a need for a balance between protection of available arable land by dikes, and sluice gates on the one hand and necessary investment to establish these protection measures on the other hand. Protected areas need to have a long term strategy to deal with the most probably enhanced pressure in terms of expected yield per land area. Soil exploitation and pest outbreaks are likely to occur if no adaptation strategies are put in place.

Concerning crops, development of new rice varieties which adapt better to changing climate (e.g. more drought and/or salt tolerant varieties) and resist better to major pests and diseases such as

BPH and RGSV at the same time would be advantageous with respect to pesticide demand. Also, an improvement in agricultural practices such as crop rotation instead of three rice crops per year would decrease the number of pest outbreaks by creating times where food and host are not available for pests.

For some regions a promotion of organic farming could be also a way to adapt better to climate change and reduce pesticide use at the same time. Organic farming tends to increase soil fertility and water retention capacity on the long run. Organic plants and soils have been shown to perform better under extremely dry conditions than conventional plants and soils (Niggli et al. 2007). However, products from organic farming have usually higher prices and thus the market capacity for these products will be most likely the limiting factor for their planting area.

While some of the above mentioned adaptation strategies will be likely taken up by farmers as a first order response others need to be supported, facilitated or even regulated. Table 1 summarizes most likely climate change impacts, adaptation and possibly facilitation options.

Table 1. Selected adaptation options with a link to agrichemical use

Changing climate parameter	Possible impact	Possible adaptation at farm level	Possible impact of the adaptation on the environment	Facilitation, support, regulation
Increased frequency of extreme events (drought, heavy rains) Increased mean temperatures, changes in rainfall patterns, humidity	Crops more susceptible to pests and diseases Increased incidences of diseases, pests, weeds and vectors carrying diseases Spread of secondary infection for some diseases Increased risk of severe outbreaks	Increased use of pesticides, introduction of new pesticides	Negative impacts on water quality, biodiversity	Training, education on integrated pest management, pest and disease resistant crops Provide seasonal and small scale weather forecasts at farm level Improved pest and disease monitoring and surveillance Support pest predators and competitors e.g. through the use of field margins
Increased rainfall intensity	Reduced top soil quality due to increased runoff and soil erosion. Nutrient and pesticide loss	Increased use of fertilizers and pesticides	Negative impacts on water quality, biodiversity	Use of buffer strips to reduce runoff Consider organic farming
	Reduced efficiency of pesticides (wash up from foliage)			Training on selection of pesticides used, integrated pest management, organic farming

Sea level rise	Inundation or salinization of soils and water resources, loss of arable land	More saline tolerant rice varieties and shrimp farming in the area of saline intrusion	Negative impacts on water quality, biodiversity	Balance the needs for shrimp farming and rice production, flexible water management systems
		Agricultural intensification in the remaining area with enhanced use of pesticides and fertilizers		Crop rotation or rice-aquaculture instead of three crops of rice

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## **Think Global, Act Global in the Mekong Delta? Environmental Change, Civil Society and NGOs**

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The Mekong Delta is experiencing rapid growth in urban development, industry, agriculture, fisheries, foreign investment and trade. With these come the externalities of river flow interruptions, habitat destruction and pollution interacting with climate change to weaken environmental services. Results can be unprecedented livelihood challenges to communities and government in one of the most vulnerable areas of Vietnam. Overcoming the increasing environmental stress and its consequences requires new skills, a forward-looking governance framework and engagement of millions of delta households. Questions therefore arise as how to address the magnitude and geographic scale of challenges by developing institutional and human resources and society's role in this. Civil society initiatives, including national Nongovernmental Organizations (NGOs) in environmental restoration are at an early stage in Vietnam, and studies mostly examine the general societal context of NGOs. Defining the urgent environmental pressures on the Mekong delta, this paper outlines the need for an expanded vision in identifying solutions, widening society's contributions, institutional constraints to society and NGO action. The paper argues that more visible global engagement in management and advocacy are needed given Vietnam's history and position as an emerging, agriculture-based society and its international-linked economy in the delta.

Keywords: Mekong, Vietnam, NGO, environment, civil society

### **Introduction**

The impressive record by Vietnam in reducing poverty and unemployment, improving health, attracting investment, expanding exports, food production, goods and services has been termed a model of development and a success story (Thoburn, 2009). After more than a decade of continuous high growth rates and progressive integration with the world economy, Vietnam's development has however been challenged by multiple international crises in food, finance and health and internal macroeconomic instability (Riedel, 2009). Both national and international agencies have commented on the need to re-examine development strategy and focus on the quality of growth as Vietnam approaches middle-income status (Nguyen Anh Ngoc et al. 2009, Pincus 2010).

Development has come with an environmental cost, and nowhere more than Vietnam's coastal zone have the impacts of development been more pronounced. Most industrial and commercial activity occurs in these areas, and most of Vietnam's major cities, population and its poor people live in the coastal zone and delta areas. Large scale finance and infrastructure investments are

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focused mainly along the coastline and in expanding urban centres. The Mekong delta (including twelve provinces, Ho Chi Minh and Can Tho cities) has been a leading engine of national development and international trade. About 27 percent of the country's manufacturing firms and 29 percent of manufacturing workers are located in Ho Chi Minh city (Dore et al., 2008). The 2009 Provincial Competitiveness Index, indicate that ten of the twelve delta provinces, Ho Chi Minh and Can Tho cities are in the top twenty-two positions (Malesky, 2009), and national production statistics (GSO, 2009) identify the delta as the main business centre, rice and aquaculture producer and revenue earner in Vietnam (Table 1).

<b>Industry, Agriculture and Fisheries Statistics</b>	<b>Mekong Delta<sup>1</sup></b>	<b>Percent in Country</b>
Gross Industry Output (Billion VND) <sup>2</sup>	460,993	31
Net Business Turnover (Billion VND) <sup>3</sup>	1,194,230	35
Planted Area of Paddy Rice ('000 Ha)	3889	52
Production of Paddy Rice ('000 tons)	20,788	53
Number of Farms	58,896	49
Number of Fish Farms	25,770	74
Aquaculture Water Surface ('000 Ha)	762	72
Aquaculture Shrimp Production (tons)	315,691	81
Aquaculture Fish Production (tons)	1,428,972	77
Gross Output of Fisheries (Billion VND)	34,407	69
Production of Fisheries (tons)	2,744,145	60

Source: GSO (2009). <sup>1</sup>Includes Ho Chi Minh city, Can Tho city, and 12 provinces

<sup>2</sup> Current Prices    <sup>3</sup> For 2007

**Table (1). Contribution of Mekong Delta Production to Vietnam's Economy**

Ho Chi Minh city and environs captured almost 30 percent of foreign direct investment (FDI) in Vietnam from 1988-2007 (Athukorala and Tien Quang Tran, 2008). The region is also the major contributor to the country's foreign exchange earnings through exports (including 90 percent of national rice exports) and FDI. Exports have also driven domestic fisheries expansion, making this sector the fourth highest earner of foreign exchange for Vietnam. Malesky (2008) argues that Ho Chi Minh city's high rate of FDI and revenue-sharing with other provinces allows national leverage and greater autonomy in its development. Vind and Fold (2010) further propose that the



city is emerging in international importance as part of a “Global City Network” and “Global Commodity Chain” with extended impact on the country-side through attraction of migrant labor and international connectivity through exports and FDI.

### **The Environmental Situation**

Coastal development trends will intensify, as Vietnam in its strategy to 2020 plans to increase the contribution of its coastal and maritime economy to more than 50 percent of national GDP (CPV, 2007), and the southeast region continues to be attractive to investment (Dinh Thi Thanh Binh, 2010). The future brings both great opportunities and worrying challenges. No longer considered only a biodiversity or conservation issue, environmental threats are now a growing and critical social and economic concern, especially for communities whose livelihoods depend on living resources and ecosystem services. The need to accelerate action to reduce environmental damage in Vietnam and restore ecosystems is being increasingly voiced by government, citizens, international NGOs and donors (Anon. 2008, MPI 2009, Vietnam Development Report 2007).

The Mekong delta spans 39,000 km<sup>2</sup> in Vietnam, with 61 percent in agriculture and aquaculture use, and nine main river outlets exiting the coastline of 350 km. Over 10,000 km of canals and tidal floodgates regulate water flow (Deltares, 2009). Ecosystems in the delta are vulnerable to development through agro-chemical, urban and industrial pollution, eutrophication, sediment fluctuations, dredging, water diversion and habitat damage. At basin levels, Vietnam has lost more than 60 percent of mangrove forests in wetlands and tidal floodplains especially in deltaic areas, with more than 2000 km<sup>2</sup> lost in the last 20 years. Only 21 percent of existing mangrove areas are original forests, the rest being re-planted (VEPA, 2005). A wide diversity of farming, rice cropping cycles and aquaculture systems have displaced delta wetlands (Béland et al. 2006, Phan Minh Thu and Populus 2007, Sakamoto et al. 2009, Joffre and Bosma 2009) and urban and industrial development also leading to reduction in the area of cultivable land (Tran Thi Van and Ha Duong Xuan Bao, 2007). Clearing of coastal forests for agriculture and aquaculture has contributed to ecosystem fragmentation, intensified energy of coastal waves and winds reaching inland, increased flood risk, and facilitated extension of saline regimes inland (Mazda et al. 2004, Seto and Fragkias, 2007).

Pollution loads in the Mekong delta are significant. Ho Chi Minh city is ranked as the first and Can Tho city as the fourteenth most polluting municipality/province in Vietnam (Dore et al. 2008). Pollution is a mix of agriculture and aquaculture chemicals and waste as well as industrial and urban solid, liquid and gaseous discharges. Monitoring of the delta has identified extremely high concentrations of veterinary antibiotics linked to livestock farming (Managaki et al. 2007), and pesticide use is estimated to cost US\$251 million in terms of loss of use of water resources (Dang Minh Phuong and Gopalakrishnan, 2003). A survey in An Giang province identified 77 pesticides in use (Whittle, 2010) and in 1999 health costs of pesticides per farmer per km<sup>2</sup> were estimated at 8,900,000-9,400,000 VND (Nguyen Huu Dung and Tran Thi Thanh Dung, 1999). Solid waste is a growing problem in Ho Chi Minh city and delta areas even though the percentage of collected waste has improved. Because of increasing disposal, uncollected waste increased to over 185,000 tonnes per year from 2000 to 2003 (MoNRE and UNEP 2008).

At a transboundary level, Hart et al. (2001) note that “the data currently available is inadequate to fully assess the risk of transboundary water quality issues in the Mekong river basin”. A biomonitoring program later initiated by the Mekong River Commission (MRC) showed that in

2008 in the Mekong delta of Vietnam, 60 percent of sampled sites were Class 'C' (moderate) and 40 percent were Class 'B' (good). The MRC report (Dao Huy Giap et al., 2010) concluded "the temporal trend of ecological health of the Mekong river sounds a warning that environmental impacts, such as human disturbance and degradation of habitats and water quality are occurring in some parts of the Mekong River". Perhaps, however, the most contentious transboundary issue is the development of dams in the Mekong river. Up to 153 major dams are in various stages of development resulting in changes in hydrology, flow interruption and water quality. Vietnam's delta fisheries are considered as "High Risk" as aquatic biodiversity changes are likely, including species composition, completion of life-cycles, migration, with impacts on the livelihoods of poor households who are the most dependent on capture fisheries (Baran and Myschowoda 2009, Kang et al. 2009)

Declines in catches and sizes of large migratory fish and increase in low-value species in Mekong fisheries have been documented by Baran and Myschowda (2008). Coastal surveys of Soc Trang, Bac Lieu and Ca Mau provinces indicate 70 percent of catches are composed of young and immature fish (Tran Van Viet and Tran Xuan Loi, 2007). Catch rates of the inshore trawler fleets in Ca Mau and Bac Lieu provinces from 1996-2002 showed reductions of 30-40 percent in shrimp catches causing a shifting of fishing effort to small pelagic fish species (Christensen and Dang Van Thi, 2008).

Marine and sub-tidal coastal wetlands which form more than 25 percent of Vietnam's delta wetlands are under stress (Snidvongs et al. 2003). The Mekong coastal ecosystem is ranked the third highest globally threatened in terms of cumulative impact of land-based impacts from nutrient inputs, organic and inorganic pollution, and coastal population (Halpern et al. 2009). But changes to the Mekong river flow and quality may not only have land-based and coastal impacts, as oceanographic studies suggest that the Mekong river plume stimulates phytoplankton growth and oceanic primary production in the western South China Sea (Bombar et al. 2010, Voss et al., 2006). The influence on the Gulf of Thailand is less studied, however the river's plume is known to reach the middle part of the Gulf (Wolanski and Nguyen Huu Nhan, 2005). The downstream ecosystem linkages of these river discharges including possible effects on offshore fisheries or links to harmful algal blooms (HABs) remain to be determined.

### **Climate Change in the Delta**

Superimposed on development-associated changes are the environmental, social and economic impacts of climate change. The planning scenario for Vietnam is a sea level rise of one metre by 2100, modeled to affect 37.8 percent of the Mekong delta and 23 percent of the greater Ho Chi Minh city area. The expected results are inundation and salinization of land, coastal infrastructure, industrial enterprises, critical biodiversity and protected areas. By 2050 about one million persons are estimated to be threatened with displacement (Carew-Reid, 2008, UNDP, 2009). Ho Chi Minh city is projected to be among the ten most exposed cities globally by the 2070's (Nicholls et al., 2008).

The Mekong delta is a complex Land-Water-Atmosphere interface where tidal cycles, coastal currents and changing wind regime interact with wildlife habitats, rural and urban centers. In addition to sea level rise, environmental change will lead to increases in wind energy, air, land and water surface temperature, precipitation, changed currents, ultra-violet radiation, and



acidification of water. Long-term trends will include short-term variability and extremes, but economic and social impacts for example trade, capital flows, investment, savings, commodity prices and services are less well understood and need to be studied (IMF 2008, Nicholls et al., 2007).

Of special concern in the Mekong delta are the climate change synergies with the cumulative and multiple stressors of human development. These include (1) Coastal subsidence caused by excessive groundwater extraction and deforestation (Pham Thi Viet Nga 2008) leading to increased areas and depth of salt water intrusion; (2) Coastal deforestation e.g. mangroves that accelerates erosion, intensifies wind energy reaching the coast, increasing tidal heights, flooding and salt water intrusion and greenhouse gas levels (Mazda et al. 2002, 2004); (3) Water flow interruptions through improper barriers, dikes and dams that may increase the risk of flooding (Le Thi Viet Hoa 2007); (4) Urban and industrial development practices that amplify surface temperature increases due to urban heat island effects, already documented up to nine degrees higher in Ho Chi Minh city (Tran Thi Van and Ha Duong Xuan Bao, 2010); (5) Overfishing that makes recruitment in fish populations more variable and more vulnerable to environmental and climate extremes (Anderson, 2008). How these combine to shape changes in ecosystems and their dependent delta communities warrants special attention, especially to avoid adaptive responses that focus on only on main effects for example sea level rise, but in doing so create other environmental stresses.

### **Environmental Restoration in the Delta -- Pivotal Issues**

Economic progress in the delta depends on restoring environmental capital while advancing economic development. This is a scientific and human challenge, and planning must include a complete valuation of the delta's environment and ecosystems not only as marketable commodities or at present value. Some initiatives have taken place, for example Do Nam Thang and Bennett (2008) demonstrate that a biodiversity conservation program in Tram Chim National Park generates a net social benefit of US\$ 0.15 - 0.96 million, but requires compensating local rice farmers. Timber extraction is forecast to increase at an annual rate of six percent beginning in 2010, the Mekong River Delta being one of the most important timber-producing regions with half a million cubic meters produced annually (World Bank, 2010), however Vu Xuan Nguyet Hong et al. (2007) in comparing the value of forest use in Vietnam estimated conservation oriented forests generate higher values (6 percent) than production/timber forests (3 percent). The impacts of development externalities in the delta (pollution, deforestation, habitat damage, overfishing, river flow interruptions) and subsidies also need to be quantified in financial and social terms and used in decisions on planning, regulation and enforcement. This includes applying the "Polluter Pays" principle and updating fines and enforcement action consistent with total damage effects and restoration costs.

International law and "Soft Law" instruments for environment-related issues are numerous. The CIESIN database<sup>19</sup> lists sixty-two international environment-related agreements to which Vietnam is signatory. These carry obligations and related costs to implement, and are directed by

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<sup>19</sup> ENTRI – Environment Treaties and Resource Indicators. Center for International Earth Science Information Network (CIESIN), Columbia University, New York, USA. <http://sedac.ciesin.columbia.edu/entri/countryProfile.jsp?ISO=VNM>. Accessed 19 December 2009

semi-autonomous international agencies with different styles and rates of implementation and different scales e.g. from climate change being global to disaster programs being site-based and Millennium Development Goals sector-focused (Cochrane and Doulman 2005, Schipper and Pelling 2006). At country level there are also a range of implementation partners and counterparts. In Vietnam, a list of key institutions and organizations relating to the United Nations Framework Convention on Climate Change (UNFCCC) implementation includes seven ministry and ministry-level institutions and thirteen national institutes (MonRE, 2005), and for water resources management nine ministries and eighteen departments (Do Thi Nham 2008). In addition there are academic institutes, provincial and municipality-level departments and university-based institutions. At the regulatory level there are national laws, regulations, decrees, decisions, ordinances and political decisions at national, provincial and local levels. Despite this profusion, there may be overlaps, inconsistencies and loopholes or other inadequacies e.g. a low level of fines or inconsistent application. Across the Mekong delta and basin, harmonizing regulatory components and implementing them is an overwhelming task.

Major projects, planning and research programs in the Mekong operate at scales defined by boundaries as the “Greater Mekong Sub-Region, Mekong Basin, Mekong River, Lower Mekong and Mekong Delta”. While these provide a framework and “big picture” context, these scales inadvertently tend to minimize local focus, where most daily initiatives are aimed at reversing environmental damage and its social impacts. Often however, local action is proposed from a pre-conceived belief in grass-roots solutions, trust in traditional and culturally embedded systems to be effective, inadequate analysis of the local situation and its drivers, or practical limits imposed by short-term and under-financed interventions. Frequently repeated, individual site-specific projects become mainstreamed as a dominant approach. When threats originate only locally, in most cases solutions can be found locally. But in the cases of trans-boundary, regional and international origins as in the Mekong delta, permanent solutions need multi-level management, as well as wider stakeholder and institutional involvement (Berkes, 2007). The technical knowledge or institutional and financial support to sustain changed conditions after short-term interventions may also not be available locally or nationally.

Defining and communicating success with clear and verifiable indicators in environmental restoration are essential if environmental restoration is to progress. A common shortcoming is interpreting success as temporary progress at one or a few sites without knowing or covering the wider scope of interventions, or the mechanism to extend initial achievements. In the context of the Mekong delta two main challenges exist:

- **Connectivity between grand frameworks across provinces and countries and ground work in local communities.** Interaction between local projects also tends to be minimal. These continue to elude donors, development agencies, government planners and organizations operating locally
- **Strategy to up-scale intervention success to other sites in a permanent way.** One option is traditional and direct and based on continuous expansion of organizations to service a wider base, for example larger government and nongovernmental organizations (NGOs). Another option is indirect, multiplying effect by creating new, autonomous organizations or changing behavior in existing organizations so leveraging them to mainstream up-scaling (Uvin et al. 2000).

Combinations of approaches will be needed as well as hybrid solutions, including for example private sector involvement. However a strategy is needed to address these two main development challenges as it is unlikely that a “Business as Usual” approach will be successful in environmental restoration. Success in different approaches will be measured differently, but in all cases communicating success is needed. It is inspirational and energizes communities who have overcome environmental threats, motivates others who need similar benefits, and facilitates the securing of human and financial services. Communicating success is also learning, as it exposes practices and achievements to scrutiny, peer review and improvement.

### **Management Actions – Aquatic Systems**

Water is the life-blood of the Mekong delta, its canals and tributaries are a vast transportation network, a direct source of food in capture fisheries especially for the poor, the means to irrigate agriculture and an input into manufacturing and processing. Aquatic systems are however especially vulnerable to environmental change. Disasters in Vietnam are mostly water-based through extremes of rainfall, flooding or drought, and aquatic areas tend to be the final collection point for pollutants and waste. But effects are not as visible as on land so aquatic areas do not command an equal restoration response. Already a major export sector with a value of US\$ 4.25 billion in 2009 (VASEP 2010), the fisheries sector is planned to be developed as the “leading sector for the course of industrialization and modernization of the agriculture sector” (Prime Minister of Government, 2006a), so investment and development need to be managed to minimize environmental damage. As Vietnam’s economy moves from a production orientation to a market orientation, the tool-box of management policy and intervention has expanded to include a mix of traditional and novel approaches, involving government, private sector and the public, with both obligatory and voluntary options.

Re-building and restoring ecosystems should be the central focus of natural resources management in the delta, not conserving or sustaining degraded ecosystems or their wildlife populations at present levels. This approach needs to be reflected in recovery-oriented plans and not traditional management plans (Pitcher, 2001). It represents a bold vision and one example of shifting paradigms that are attempting to overcome consistently failing management worldwide. New concepts are often constructed internationally in developed countries and introduced through Official Development Assistance (ODA), technical cooperation consultants, training, or grants linked to specific priorities of donors, development agencies and university academics. Evaluation of new paradigms and adoption of approaches require organizational discipline to avoid chasing trends or being aid-driven, but also flexibility to consider promising approaches.

New skills are needed to evaluate and apply new analytical and planning methods, for example since the 1970’s in Southeast Asian fisheries the transition from single-species management to ecosystem-based management (Pauly and Chuenpagdee 2003). To reflect the scale, and inter-dependencies of environmental systems and human actions, integrating physical, biological and social science into “Earth System Science” and “Global Change Science” are being proposed (Lehodey et al. 2006, NRC 2007). New forms of collaborative research also need to be explored using mobile technologies, the internet and community volunteers as citizen scientists in environmental data collection, monitoring and cooperators in research.

Structural changes are planned in Vietnam’s fisheries by the government to address overfishing. These include reducing by fifty percent the number of coastal fishing vessels (Prime Minister of

Government 2006b). Implementation however requires a census of vessels, comparative indicators of fishing effort, selection criteria for exiting vessels, community consultation, alternative employment generation, and the means to enforce regulations and prevent re-entry or “effort creep” (Standal, 2005). There is recognition that while progress has been made in conservation, the number, types, level and scale of management challenges have increased and natural resources management needs new approaches. Market-based and voluntary interventions are increasingly being considered including certification, life cycle and value chain approaches for shrimp and fish aquaculture given the export focus of many products (Vo Thi Thanh Loc et al., in press). A number of consultations and trials have been initiated towards meeting international certification standards for shrimp (mainly *Penaeus monodon*) and finfish (mainly *Pangasius* and *Pangasianodon spp.*) aquaculture products (Vu Dzung Tien and Griffiths 2009, Anon. 2009a). In 2009 a community-level capture fishery for clams (*Meretrix lyrata*) in Ben Tre province received international certification from the Marine Stewardship Council (MSC) – the first MSC certified fishery in Vietnam and Southeast Asia (Tran Truong Luu et al., 2009).

Hybrid approaches are promoting increased community participation through locally based solutions, co-management and integrated coastal zone management (ICZM) that involve the range of stakeholders whose actions either contribute to environmental threats, are affected by them, or whose participation is needed to enable success. Hybrid solutions are expectedly difficult, as they involve different sectors, levels and participation capacities and have to overcome the inertia of habits and historical relationships to create and sustain new collaboration. There has been a significant amount of enabling legislation by government to promote expanded public participation but implementation progress has been slow. In a review of co-management experiences, Swan (2010) comments that “what is required of protected area co-management in Vietnam is to learn, and share lessons learnt, from both international and national experiences. At present, this is not occurring to a sufficient degree: the same mistakes are being repeatedly made, and few projects are critically evaluating, documenting and disseminating achievements and failures”. A similar conclusion can be made of ecotourism promoted for many years in Vietnam commercially through tour companies, at community levels mainly through NGO actions and in protected areas through management boards. At province level concessions are reportedly being provided by local governments, for example Kien Giang province in the delta is reported to be leasing state forest areas to the private sector to develop nature tourism and ecotourism (Stewart, 2010). Ecotourism, as in many countries is however more often being used as a marketing tool than an approach to benefit the environment or share economic benefits with local communities in an equitable manner.

Protected areas are also being developed as part of the management toolbox, and the delta area includes thirty protected areas with nineteen declared of national importance, and four areas of international biodiversity significance (FPD/MARD, UNDP and IUCN 2006). The Mekong delta also hosts 2 international biosphere reserves (Kien Giang and Can Gio) and a further one (Mui Ca Mau) designated as part of the World Network of Biosphere Reserves co-ordinated by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Most of the protected areas however cover relatively small areas and encroachment and fragmentation threaten their viability. Despite at least US\$ 325 million (63 percent being ODA) of financing for major protected areas in Vietnam from 1995-2005, there is also inadequate funding especially for conservation activities and the management framework, especially community involvement, needs strengthening. On average, funding is equivalent to 0.1 - 0.2 percent of total ODA, and 0.1

percent of annual government expenditure. Recommendations have been made to increase efficiency in the use of funding by making budget planning less complicated, flexible and longer-term, improve financial accountability, and provide incentives to individual protected area management to capture, diversify and retain financing (FPD/MARD, UNDP and IUCN 2006). It would seem reasonable that biodiversity areas of international significance and world biosphere reserves in Vietnam should merit higher levels of international funding as well.

### **Civil Society and Vietnamese NGOs**

In the Mekong basin despite the continually growing evidence of environmental damage, top-down management action has been slow and inadequate and environmental threats are increasing. Broadening civic engagement in policy development, decision-making and implementation has been suggested as a new development pathway (Friend, 2009). Vietnam has a history of informal environmental regulation or “community-driven regulation” as described by O’Rourke (2002) where local communities supported by local social organizations respond to local pollution. It was reported for example in 2009 that farmer associations from Ho Chi Minh city, Dong Nai and Ba Ria Vung Tau provinces received nearly 10,920 letters demanding legal action against an industrial river polluter. Cases are also reported in national media, and sometimes involve public responses by academics and government agencies (Phung Thuy Phuong and Mol, 2001, Vietnam Net, 2009). However such community actions tend to be Ad Hoc, local and reactive, often based on immediate and visible economic and health threats, not precautionary approaches to avoid long-term environmental damage. A formal national role for NGOs has been proposed in the Government of Vietnam’s Five-Year Socioeconomic Development Plan (SEDP) 2006–2010 in economic development and management, as service providers in humanitarian activities, addressing poverty, and environmental management of pollution and sanitation. In addition, it encourages civil society to “engage in managing and monitoring some public fields” and planning, implementation and monitoring the SEDP from central to local levels (GOV, 2007).

The study of civil society, civil society linked organizations and NGOs in Vietnam has been undertaken in particular by foreign observers, mainly on the evolution, societal, regulatory and state relations of organizations and minimally with sectoral issues (Thayer, 2009). Following the transition of organizations from their origins to the present day is important to identify their situational constraints and developing capacities as partners in dealing with environment change. Initial attempts to develop VNGOs and operations of International Nongovernmental Organizations (INGOs) in Vietnam are reported as hesitant and challenging (Hannah 2007). Early analyses in Vietnam commented on the closeness of the first organizations to the government, in some cases lateral transfers of individuals from government agencies re-constituting themselves as separate or connected organizations, with a minimal of action-oriented activities (Pednekar, 1995). As late as 2001 it was reported that in Vietnam independent local or national environmental NGOs who performed the role of mobilizing communities, were absent (Phung Thuy Phuong and Mol, 2001). But later reviews (Lux and Straussman 2004) conclude it is “increasingly clear that the forms, functions and behavior of Vietnamese NGOs are more and more similar to non-state counterparts in the rest of the world”. Sabharwal and Than Thi Thien Huong (2005) also identified a broad trend in the “growth of development NGOs essentially different from the organizations that emerged as a product of the retrenchment process during the late 1980’s”. More recently, however, the annual report presented to government by international

donors led by the World Bank still noted that “the processes of creating new civil society organizations are burdensome, and not all are treated equally .... in Vietnam’s devolving system, the devolution of civil society has been approached cautiously” (Vietnam Development Report, 2009).

There nevertheless seems to be a rapid growth of organizations calling themselves NGOs or sometimes VNGOs, whether or not they fit Western concepts. Dang Ngoc Dinh et al. (2006) list a typology of six main types of national organizations with a wide range (mass organizations, umbrella organizations, professional associations, faith-based organizations, VNGOs and informal groups). Kerkvliet (2003) and Nørlund (2007) suggest that useful evaluation criteria to consider are an organization’s origin, affiliation to and dependency on the state, funding source, voluntary membership, governance, work program and non-profit orientation. The numbers in each category are publicly un-quantified but estimate 65-70 million persons are members. Organizations may register under a variety of decrees and regulations with varying rights, responsibilities and geographic jurisdictions. While the diversity of registration procedures and mechanisms facilitates growth in numbers of organizations, it challenges the development of governance and performance standards and accountability. The Vietnam Union of Science and Technology Associations (VUSTA) is estimated to have 1.15 million members across the country (Dang Ngoc Dinh et al. 2006). Citizen surveys in Vietnam indicate 7.6 percent of persons in 1999 identifying themselves as belonging to an environment/conservation organization (Dalton, 2005), a higher percentage than 17 European countries surveyed. However the degree of activity or effect was not determined.

The debate on VNGO performance in Vietnam is on-going, but not informed by comprehensive assessment or public access to information on activities and results. There is some skepticism of aid-imposed “civil society” and “participatory” solutions (Molenaers and Renard, 2009), or exclusive dependence on participatory and community-based derived knowledge and research (Rambo, 2009). Concerns are also expressed whether NGOs are compromised by being aid-driven, government restricted or if their results are really superior to those of government institutions (Gray, 1999). Organizational limitations in VNGOs have been identified as capacities in management, leadership, technical and language skills, networking, communication with government agencies, a narrow geographic focus and staff turnover. On the other hand, noted assets include high motivation levels of predominantly young staff, a more egalitarian approach with communities, ability to mobilize voluntary resources, lower costs than commercial enterprises and minimizing operational overheads (ADB, 1999, AusAID 2000, TAF 2008).

In Vietnam Nørlund (2006) identified civil society organizations (CSOs) among the least influential organizations, yet notes that “all types reach down to the grassroots level better than similar government programmes and policies. In that regard, CSOs have had an impact”. Similarly, Wischermann (2003) notes “there is a widening gap between what society is in a desperate need of and what state and/or the economy can deliver. Civic Organizations are filling this gap and they are filling it in a very specific way”. A novel environmental initiative is the work of “Environment for Nature” a VNGO (Vietnamese NGO) in establishing a “Wildlife Crime Unit”, national telephone hotline and database to track occurrences of illegal wildlife use, consumption and trade (Sumrall, 2009). In terms of socioeconomic impact, an external evaluation for Vietnam commissioned by the European Commission found community-based

organizations in rural areas to be “highly effective in poverty reduction, working with vulnerable groups, etc. Their work is not as visible as it deserves to be” (Particip GmbH, 2009). An even less publicized role for NGOs (especially VNGOs) in Vietnam is their acceptance of volunteers to participate in fieldwork, projects, events, and provide opportunities for student research and theses. While this collaboration is temporary, it provides informal education through “On-The-Job” exposure allowing many citizens (especially youth) to gain a deeper knowledge of society and local communities and in the case of environmental-focused NGOs, of the issues facing biodiversity and natural resources in Vietnam.

### **International NGOs (INGOs) in Vietnam**

International NGOs (INGOs) have been increasingly active in Vietnam, with development assistance growing from an estimated US\$ 20 million in 1990 to US\$ 260 million in 2008 with about 650 INGOs estimated to operate now in Vietnam (Anon. 2009b). Together with twenty-nine bilateral and nineteen multilateral agencies including United Nations organizations they form the international ODA and development community in Vietnam (DFID 2008), in addition to other INGOs not in Vietnam who also provide technical and financial support. According to Fforde (2005) INGOs and donors mainly channel their efforts directly to and through state and mass-organizations, a situation indicated as operating outside the mainstream of social development, compromising both their understanding of Vietnamese society and their effectiveness.

INGOs however still played and play significant roles: (1) by increasingly funding local organizations including promoting grant programs reserved for VNGOs, the level of funding disbursed often limited by the local organization’s technical and management capacity; (2) acting as a bridge between international and local organizations and government agencies, particularly beneficial when the concept of VNGOs was new in Vietnam; (3) facilitating capacity development of VNGOs by providing training and mentoring; and (4) contributing to VNGO leadership through transfers of Vietnamese professionals who previously worked in INGOs.

Records<sup>20</sup> indicate that between 2004-2008 at least ninety-nine INGOs operated in the Mekong delta (including Ho Chi Minh and Can Tho cities) with an apparent increasing trend from seventy-four to eighty-one over this period. Of these, only twelve to eighteen list themselves as having an Environment, Conservation, Wildlife, or Integrated Development focus. Most INGOs (76-81 percent) worked in Ho Chi Minh city, and while all provinces had INGO activity, 90-95 percent of INGOs worked only in four provinces or less. This pattern presents a case to have strong institutional coordination and information exchange so that knowledge on the delta’s environment as a whole can be obtained and consolidated.

### **Information Challenges**

Generally, development-oriented organizations operating in Vietnam do not effectively share information either at professional or at local community levels. There are some systems in place, for example the VUFO-NGO Resource Centre in Hanoi coordinates 20 INGO Working Groups, and twenty-six internet-based Mailing Lists (NGOResource Centre, 2009). VNGOs also have a

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<sup>20</sup> Viet Nam INGO Directories, 2004-2005, 2006, 2007, 2008. Vietnam Union of Friendship Organizations (VUFO) NGO Resource Centre, Hanoi, Vietnam

number of issue-focused networks (TAF, 2008). But the effectiveness of these is limited. While information on NGO activities are reported to supervisory agencies and donors as operating requirements, accessing information on VNGO and INGO activities in Vietnam by the public is time-consuming, information is not easily obtainable and is of variable quality. Institutional and project evaluation reports are rarely made public on an on-going basis or at levels of outcomes. In a survey by the Asia Foundation, 65 percent of VNGOs do not have websites (TAF, 2008), and 55 percent of INGO's working in the Mekong delta also do not have listed websites (VUFO-NGO Resource Centre 2009). There are benefits to INGOs and VNGOs to improve transparency and the communication of information on their programs, not only to be accountable but also for their effectiveness. For example, taking advantage of the strong connections of VNGOs with local communities and INGOs with international communities will extend the geographic impact of their advocacy.

Obtaining information on Mekong content is also challenging. There are basin-scale information initiatives, for example through development and donor agency websites as the Asian Development Bank through its Greater Mekong Sub-Region (GMS) program and the Mekong River Commission (MRC). The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) finances the MekongInfo website hosted by the MRC. A more academic focus is taken by national level organizations as the Mekong Delta Development Research Institute at Can Tho University, Vietnam and the Australian Mekong Resource Centre of the University of Sydney, Australia. There are also formal networks as the Greater Mekong Sub region Academic and Research Network (GMSARN) and the Mekong Program on Water Environment and Resilience (M Power). These initiatives maintain web sites that host information on publications, news, research updates, meetings, links and some with national pages. Mekong information is also embedded in national and international organizations with Southeast Asia programs including NGOs and global databases, and these sources help with identifying information on completed and current research and issues. However, available internet technology is still not being used to share and take advantage of combining individual site content for the benefit of users. Each web site has to be browsed separately, and as new information is added the task becomes more time-consuming. Importantly, in most cases the information contained is not in the main languages of the peoples of Mekong basin countries. Other information and communication possibilities, for example mobile technology are also sparingly used.

In terms of natural resource information, the Mekong River Commission (Campbell, 2005) describes the Mekong as "one of the more poorly studied rivers ... there are very few studies on the geomorphology of the river, very few published studies on any aspect of the ecology of the Mekong...we are limited by the poor knowledge of the biota". This reflects both under-representation of riparian countries in research and in leading research. An analysis of 4579 freshwater biology papers published from 1992-2001 in 9 international journals, showed only 1.6 percent were authored or co-authored by scientists based in Asia (Dudgeon, 2003). It is also the result of "Gray Literature" not being known even within countries generating it. In the case of Vietnam, the greatest information need is national research not being covered adequately even by national databases or library systems. Factors include very local circulation of many journals of institutions and universities, published proceedings and results of workshop and conferences, project reports, theses and dissertations from national Universities. Paradoxically, publications produced by riparian country institutions, or by researchers and students of these countries in foreign institutions or published in foreign journals, are sometimes more easily accessed through



international search engines and databases than national databases or library systems in riparian countries. There are some documentation initiatives in Vietnam as the National Center for Scientific & Technological Information - *NACESTI* ([www.vista.gov.vn](http://www.vista.gov.vn)) and *Vietnam Journals Online* ([www.vjol.info/index.php](http://www.vjol.info/index.php)) that show great promise but are still limited in coverage and need technical and financial support to expand because of the rate of knowledge creation.

Foreign journals, commercial publications and aggregation services as the *Web of Science* still remain the main source of peer-reviewed content, but are increasingly expensive and in languages not usable by all Mekong basin scientists. General internet search engines as *Google Scholar* are helpful and often competitive with commercial services in identifying new knowledge on Vietnam, as are other internet-based thematic aggregating services for example the *Social Science Research Network – SSRN* (<http://ssrn.com>) and *EconPapers* (<http://econpapers.repec.org/>) in social sciences. But not all information can be obtained at no cost. International Open Access journals, Open Archive initiatives and sponsored access to online journals through *AGORA*, *HINARI* and *OARE*<sup>21</sup> are a significant support for life science researchers in Vietnam also, but these sponsored access services are not widely known in Vietnam, even within institutions that have free access to them.

Taking advantage of and contributing to international information systems is becoming increasingly important. Riparian countries in the Mekong basin share a common biodiversity. Identifying the boundaries of this helps to prioritize research, management and save costs, by countries using each other's knowledge and experiences. In the case of fish species for example, there are freshwater species in the Mekong basin ecosystem that Vietnam has in common with its neighbors (from 20 species with Myanmar to 205 species with Cambodia). The common occurrence of fish species for riparian countries is shown in Table (2).

Country <sup>1</sup>	Myanmar	Thailand	Laos	Cambodia	Vietnam
China	12	79	104	64	45
Myanmar		30	26	19	20
Thailand			331	294	169
Laos				325	192
Cambodia					205

<sup>1</sup>Species identified for the Mekong basin ecosystem in each country. Data provided by E. Capuli

(WorldFish Centre) on 1 March 2010

**Table (2) Common Freshwater Fish Species occurring in the Mekong Basin**

<sup>21</sup> AGORA (Access to Global Online Research in Agriculture), HINARI (Health InterNetwork Access to Research Initiative), OARE (Online Access to Research in the Environment)

As riparian countries are highly biodiverse, it is unlikely in the medium-term that any riparian country will have the human and financial resources to research every species. Using international scientific information systems like FishBase ([www.fishbase.org](http://www.fishbase.org)) that are Public Goods, allows countries to take advantage of global knowledge on information of local importance. The value of this is even more important when countries that share natural resources contribute information to such global information systems: when any country contributes, all countries benefit. The urgency and importance to keep track of new knowledge to manage the Mekong basin is underscored by the pace of knowledge creation. In 2009 the Mekong River Commission reported nineteen regional initiatives in climate change (MRC 2009), and since 1993 published literature on climate change impacts on marine systems alone is reported to have increased exponentially (Harley et al. 2006).

## **Conclusion**

Despite incomplete and variable quality of information there are enough indications in Vietnam of a trajectory of progress and increasing potential of organized civil society to work with government and the private sector. VNGOs and local community organizations can lead, partner and support actions to address environmental challenges in the Mekong delta. INGOs can continue to play important roles in bringing international linkages, perspective and advocacy, facilitating application of advances in science, and capacity building of individuals and organizations. At the same time there is much work to be done in improving transparency, accountability, institutional capacities, and the administrative framework under which NGOs and INGOs operate. In terms of capacities, there is widening range of technical skills needed to match new forms of knowledge and technology, as well as soft skills in relationship building, communication and advocacy. It is unlikely any one organization will have all skills, so the need for networks, partnerships, and flexible use of services will increase.

There are objective conditions why solutions to environmental problems in the Mekong delta must incorporate international geographic, economic and technical scales. The forces include increasing participation of Vietnam in the world economy and its effects on the country's macro-economy, the driving forces of foreign investment in the Mekong delta, the importance of foreign markets for its industrial and agricultural products, the obligations under international legal agreements on the environment to which Vietnam is signatory, the presence of sites of international biodiversity significance in the delta, the tighter integration within countries of the Association of Southeast Asian Nations (ASEAN), the position of Vietnam downstream from other riparian country use of the Mekong river, and the need for international technologies and technical knowledge to restore the delta's environment. The situation Vietnam faces in the Mekong delta due to changing global climate also requires international advocacy, diplomacy and securing international support for its mitigation and adaptation campaign.

Effective programs will need a combination of traditional tools and new approaches that match the scales and stresses, that span governments and the international private sector and are both voluntary and regulatory. Despite the progress and potential of NGOs to participate effectively from central government to community house-hold level, NGOs have human, financial and logistical limits. Goals need to be re-defined so that so that communities are not permanently dependent on organizations based in the main urban areas, secondly that local communities can be guided to self-organize, learn from and guide other communities, and thirdly that "success" is

not environmental restoration in individual local sites no matter how spectacular results may appear, but permanent environmental restoration in all communities and sites.

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## **Promotion of organic cocoa in mixed farming system in the Mekong Delta region: a preliminary analysis**

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### **Abstract**

Over the past decades, the Mekong River Delta has become a strategic region for the socio-economic development of Vietnam including the agricultural sector. While the region is nowadays producing most of the exported products (i.e. rice) of the country, the sustainability of its conventional production system using chemicals (fertilizers and pesticides) is challenged. It is known that organic agricultural systems are more sustainable compared with conventional agriculture systems. Certified organic products can receive premium prices in international markets. Organic agriculture also reduces green house gas emissions. To enhance sustainability and fight poverty Helvetas, the Swiss Association for International Cooperation has initiated in collaboration with the provinces and the Nong Lam University in Ho Chi Minh City an organic and fair trade cocoa program. In five years, totally 2000 selected cocoa-coconut farmers (men and women) situated in the 2 provinces of Tien Giang and Ben Tre are expected to produce certified organic and fair trade cocoa for the international market. The support program focuses on the development of appropriate techniques, the provision of training for farmers and fermenters; the support to set-up certification schemes and linking the farmers organisations to the market. In 2009, the first 22 pilot farms converted to the organic agriculture by adopting measures such as composting and bio-control of pests and diseases. These first positive experiences will be used to convince other farmers to convert. In view to set-up an organic purchasing system a first agreement was signed with the biggest cocoa purchaser in Vietnam Cargill. The organic premium has been set preliminarily to 20%, but this is probably slightly too high for the current market for organic cocoa.

**Key words: organic cocoa, organic certification, farmer organization.**

## 1. Introduction

Vietnam Mekong Delta, covering an area of some 40,000 km<sup>2</sup>, and home to some 18 million people, has become a strategic region for socio-economic development of the country, accounting for 50% of the nation's total food production, 95% of rice exports, 65% of fisheries production and 70% of fruit (Truong 2009). However, over the past decades, agricultural production in the Delta has used roughly a million tons of chemicals including pesticides and fertilisers a year (Chanh 2009), bringing about negative impacts on local environments and adversely affecting the sustainability of agricultural production in the region. The recent outbreak of rice brown plant hoppers is a typical consequence of the improper use of pesticides. The improper use of agro-chemicals does not only pollute the water resources but also the soils. This is due to the fact that in general a crop effectively uptakes only 30% of the total amount of fertilisers and the remaining 70% is either washed off or accumulated in the soil (Truc *et al.* 2006).

For developing the agricultural sector in a more sustainable manner the government of Vietnam has made great efforts in applying more environmental sound farming techniques. From 1990s with the support from the international community the government has promoted and successfully applied the integrated pest management (IPM) on rice, vegetables and other crops in 61 provinces nationwide and 97% of villages in the Mekong Delta (community IPM 2001). Recently good agriculture practice (GAP) has been introduced on some crops such as rice, star apple and pineapple. Successful application of global GAP on star apple in Tien Giang is a typical example of this movement.

Under that context, Helvetas Vietnam – a Swiss organization for international cooperation, with its substantial experience in rural development in Vietnam sees the combination of organic farming and fair trade approaches as one of the strategies for poverty alleviation and sustainable natural resources management in the country. This is based on the premise that in organic agricultural production small scale farmers are enabled to have better opportunities to access to contemporary food value chain and stable markets with premium prices of 10-50% higher than conventional products thanks to the added value attribute of organic produce (FAO 2007, FAO 2005). Also, participation in this sector will enable small scale farmers become less dependent on chemical inputs that have to be purchased at a higher price for small farmers due to higher transportation costs in rural areas and higher unit costs for small volumes (IFAD 2003, UN 2008).

More importantly organic agriculture offers sustainable development opportunity and can be used as a powerful tool for achieving the Millennium Development Goals as over the past decades, the organic agriculture sector has been steadily growing, reaching a value of 50 billion US dollars in 2008 (UN 2008). By end of 2008 there were almost 1.4 million organic producers with 35 million hectares of agricultural land certified according to organic standards, 3 million higher than that of 2007 (IFOAM 2010). The organic sector has however, grown at different paces among different continents. In term of global organic production area, the Oceania accounts for the largest share (34.7 percent), followed by Europe (23.4 percent) and Latin America (23 percent) (IFOAM 2010).

Based on those strong foundations, a five year program for the development of organic and fairtrade cocoa in Vietnam has been developed by Helvetas Vietnam, with funding from several international donors including SECO (State Secretariat for Economic Affairs), Rabobank and Helvetas. This program aims to increase the living standards of the rural population in the southern regions of Vietnam via improved social, economic and environmental conditions related to agriculture (Helvetas 2008b). The project is to be implemented through the multi-stake-holder approach: the private sector (Ritter Sport, Cargill), the farmers' organizations, and local public institutions (the Nong Lam University in Ho Chi Minh City, the Ben Tre province through the Department of Agriculture and Rural Development, and the Tien Giang Province through the Department of Science and Technology).

This paper aims to present the rationales for the program interventions and an analysis of program preliminary results which both can serve a useful source of information for any organic initiative to be implemented in the Mekong Delta.

## **2. Description of program interventions as rationales for promoting organic agriculture in the Mekong Delta**

The world organic agriculture sector has been on a tremendous increase over the last few decades (UN 2008). General speaking, organic agriculture is an agricultural production system that sustains the health of soils, ecosystems and people by combining site appropriate traditional farming techniques and scientific innovations that relies on non-chemical inputs and ecologically sustainable techniques such as crop rotation, green manure, compost and biological pest control (UNEP-UNCTAD CBTF 2009). In organic production systems, as chemical substances are mostly prohibited the inorganic fertilizers are substituted with organic nutrient management practices such as crop rotation, compost, mulches, green fertilizers, nitrogen fixation crops in order to conserve and raise the level of organic materials and fertility in the soil (Nilda 2003). In fact, unlike conventional systems, organic production does not focus on the agro-products per se but rather on the whole system employed to produce and deliver the product to the end user (FAO 2005).

However, it should be noted that not all agriculture systems without external inputs can be considered as organic agriculture according to international organic standards. This is because of that fact that purchased inputs such as mineral fertilizers or synthetic pesticides are not used in some agriculture systems simply because the farmers cannot afford them, resulting in low and declining productivity, and eventually environmental degradation such as soil erosion (FAO 2005).

With those principles, for successful promotion of organic cocoa in the Mekong Delta provinces of Tien Giang and Ben Tre, the program has identified five key areas to intervene; they are *development of site appropriate organic cocoa farming techniques, provision of training for local cocoa farmers, organic certification, marketing and enabling policy for organic agriculture.*

## *2.1 Development of organic farming techniques suited to local conditions*

Helvetas has identified the development of site appropriate organic farming techniques as first and foremost important intervention for promoting organic production in the Mekong Delta. The international experience shows that it is difficult to develop a one-size-fits-all organic farming technique and therefore, the principles of organic agriculture only serves as guides for organic practitioners to formulate organic farming practices suited to each individual farming location with specific social, technical and climatic conditions (IFAD 2005, CSIRO 2006). Therefore, before designing and implementing the program, Helvetas conducted a feasibility study on promoting organic cocoa to identify the most suitable regions, and perhaps more importantly understand the opportunities and challenges likely facing the program. The study reveals that Tien Giang and Ben Tre Provinces are the most suitable areas for the program to start organic cocoa due to the low input requirements of local cocoa-coconut farming systems, availability of manure and green materials for compost making, and high commitment from local authorities (Helvetas 2008a).

For conducting experiments to define organic farming techniques suited to local conditions, Helvetas has collaborated with the Nong Lam University (NLU) to conduct studies on management of cocoa pests and diseases and nutrient management via compost using local resources. The research activities to formulate site appropriate organic farming techniques are not one off but rather on-going, and it takes time for the program to define organic farming practices that are technically, socially and economically suited to local conditions. The international experience indicates that it takes time for local farmers to test and learn newly introduced farming technologies and methods (IFAD 2005) and therefore, it would be desirable to promote organic agriculture to a local area gradually, at least during the first few years in order that the program is enabled a correct conversion to organic production, while learning from the practice of implementation (IFAD 2003).

## *2.2 Provision of training to farmers and other value chain actors*

The program has prioritised training activities to make sure local authorities and local farmers have a sound understanding of organic requirements and principles, and that local farmers are able to apply organic farming techniques under their conditions. This is because organic agriculture by international understanding is new to Vietnam. Also, the program needs to make sure that participating farmers fully understand the benefits of organic agriculture. In fact, the likelihood of organic production success will be greater if farmers are highly motivated, particularly by health and environmental concerns other than the economic advantages (IFAD 2003). At the same time, once the organic cocoa farming techniques are developed and defined by the research team, they will be used to train local cocoa farmers and local extension service providers. The training activities by the program will be accomplished using farmer to farmer extension approaches; under which key farmers will be selected and trained to become farmer trainers. These farmer trainers will train their fellow farmers. These approaches will be more cost-effective and more sustainable after the program ends.

### *2.3 Organic certification*

For the organic cocoa to be recognised in the international market, the cocoa produced in the program area must be certified by internationally recognized organizations. This is because of the fact that certification is a must in organic production systems since certification gives the buyers the confidence that an organic product has been produced and processed in according to the organic requirements and standards, and that organic certification enables small scale farmers to benefit from premium prices (FAO 2007). In fact, organic certification systems were developed in the early 1970s and today, there are 70 countries that have a domestic certification organization, and a dozen internationally active organizations offer organic certification services in virtually all countries in the world (UN 2008).

In the Mekong Delta, organic certification has not been done before and thus certification is also a key program intervention. For this purpose, as farmers in the Mekong Delta are small scale farmers and not very well organised, for joining the organic cocoa production, the farmers need to group themselves as clubs. The international experience shows farmer organizations play a key role in the incorporation of small farmers into organic production as groups will enable individual farmers to take advantage of collective marketing, managing volumes, and perhaps more importantly it is easier and more economical for companies to negotiate and implement contracts with one or a few associations than with many individual small farmers (IFAD 2003).

Also, the farmer groups provide mechanisms as internal control systems to ensure the full compliance of organic regulations by participating farmers. This is due to the fact that fraud may be a big challenging faced by small-farmer organizations producing organic products as one or a few organization members may be tempted to obtain premium prices without complying fully with organic methods of production (IFAD 2003). Equally important, group certification will reduce the cost of certification per capita. Financially speaking it is impossible for small scale Mekong farmers to be certified individually. In other words, the program needs to have a minimum number of farmers to convert to organic production because the certification agencies do not need to carry out inspections of all association members, but only of a sample (IFAD 2003, FAO 2005). Also, from marketing aspects, local farmers need to have a minimum volume of organic products in order that a buying company can set up a buying system. In the organic cocoa program, the program needs to motivate at least 2000 small scale farmers to convert to organic cocoa.

### *2.4 Marketing support*

Although over the past decade organic trade has experienced a substantial growth (FAO 2007), in the Mekong context, development of stable markets for the intended organic agro-products is a crucial factor for successfully promoting organic agriculture in the Mekong Delta. For this purpose, organic agriculture developers need to prioritise marketing activities to introduce the organic products from the Mekong Delta to the potential international buyers. This can be achieved by participation in international fairs or other marketing means.

Also, for the sustainability of the program intervention, farmer organizations need to build up their capacities in marketing and contract negotiation to ensure that farmer groups is enabled to have sufficient bargain power in negotiating with buyers during the program life and long afterwards. The international experience indicates that capacity-building at the farmer level



(local farmers associations, local training and advisory services) should be a central aspect of any strategy aimed at using organic agriculture as a tool for poverty alleviation (IFAD 2005), and that marketing of organic products through farmer organizations with direct contacts with buyers is a key to obtaining better prices (IFAD 2003). It should also be kept in mind that it may be too ambitious to turn a farmer into a trader; however a network of organizations can improve bargaining power and substantially lower transaction costs (IFAD 2005).

### *2.5 Enabling policy for organic agriculture*

As with other development initiatives, for effectiveness and sustainability of the organic program interventions, enabling policy environment plays a pivotal in promoting organic agriculture in the target area. The international experience reveals that for developing countries, an enabling environment is required to support institutional development and to set up norms and standards in order for this organic agriculture and market to grow (FAO 2007). Equally important, enabling national laws and regulations will help reduce certification costs, either by stimulating foreign certification bodies to open local offices or by supporting the development of local service providers (UN 2008, IFAD 2003).

## **3. Analysis of program preliminary results**

As an inception phase in 2009, the program activities focused on testing and introduction of organic cocoa farming techniques via demonstration activities along with experimentation on nutrient management and pests and diseases in the light of organic agriculture. The implementation of the activities in 2009 has helped the program with valuable lessons learnt for its activity upscale in the years to come. The below lessons learnt may also be useful reference for any organic initiative to be proposed for the Mekong Delta (Helvetas 2010a).

For successfully promoting organic agriculture in the Mekong region, Helvetas has prioritised the development of organic cocoa farming techniques technically, socially and economically suited to local conditions via research and on-farm demonstration. Accordingly, Helvetas has collaborated with NLU to conduct a number of studies on management of cocoa pests and diseases and compost making, and with provincial partners to implement on-farm demonstration plots to introduce and test organic farming. For effective implementation of on-farm demonstration, meetings with the three partners: the NLU, Department of Agriculture and Rural Development (DARD) in Ben Tre Province and Department of Science and Technology (DOST) in Tien Giang were held to reach consensus on criteria for demonstration holder selection, locations for demonstration plots and procedures for demonstration implementation.

As a result, 22 cocoa farmers have been selected for demonstration, 10 in Ben Tre Province and 12 in Tien Giang Province. The selection was based on first commitment of the demo farmers, on the ability of the farmers to have land, labour and production materials. On average, each demonstration holder has 300 cocoa trees intercropped with mature coconuts. Nearly half of them have animal husbandry, cows or pigs. For successful implementation of the demonstration plots, the demonstration holders were trained on compost making and management of pests and diseases in the light of organic principles.

The introduction of organic farming techniques to local farmers is formulated and evaluated using 3 major factors: technical feasibility, social acceptance and economic viability.

### *3.1 Technical feasibility*

For effective management of cocoa black pod disease (*Phytophthora Palmivora*), Trichoderma species have been isolated from cocoa gardens in the program area, multiplied in the NLU laboratory and tested in the demonstration plots. The Trichoderma species have then been sprayed on cocoa trees to test against the disease. However, the effectiveness of the Trichoderma against the black pod disease has not been clear as it may take longer time for the Trichoderma populations to build up to a level that is sufficiently antagonize the pathogen causing the black pod disease. In the mean time, as fungicide is prohibited in organic production, the conversion should be started at beginning of the dry season (November) when the damage of the disease is lower.

Experimentations by NLU and on-farm demonstration activities also reveal that effective management of cocoa mirids have become a crucial factor for successful conversion to organic production. In the farms with low weaver ant population, the level of damage by this pest is very significant. The experience shows that rearing weaver ants during the rainy season is very difficult and therefore it is highly recommended that the conversion should be started during November, when the dry season comes, and when the population of Mealybugs becomes higher.

For compost making, the research and demonstration indicates that under the local context for harvesting a kg of dried cocoa beans, it is recommended to apply some 20 kg of finished compost. With this recommended dosage, local farmers may find it challenging to collect and chop sufficient amount of green materials for compost making. An option for overcoming this challenge is to introduce N-fixation crops that are suitable under shade conditions in the cocoa gardens intercropped with coconuts in the program areas. The international experience shows that with the use of purchased organic matter, organic nutrient sprays and green manure in combination with traditional techniques such as crop residues and compost can solve the problem of insufficient nutrient for crops when converting to organic production as yield capacity depends partly on the application of organic fertilizers in qualities and quantities that compensate for nutrients extracted by crops (IFAD 2003). Another solution is to select the most suitable time to start conversion. For the ease of compost making, the program experience shows the conversion should be started at the beginning of the dry season (November) when cocoa husk is abundantly available and activities such as material collection, chopping and compost piling are easier. If compost making is started in November, the conversion farmers will have sufficient finished compost to fertilise their cocoa once the rainy season comes, usually at beginning of April of the following year. In addition, the demonstration also revealed that without animal husbandry local farmers may face financial difficulties in buying manure such as cow dung for compost making once the program financial support is no longer provided.

### *3.2 Economical viability*

As with any rural development and poverty reduction efforts, cost-benefit analysis is one of the prioritized program activities; however, due to time constraints the program has not done this systematically. Scientifically speaking, once converting to organic production organic farmers may have lower, equal to or higher yields compared to conventional agriculture, depending on

farm conditions, knowledge and skills of the farmers, and the extent to which synthetic inputs were used before conversion (FAO 2005, IFAD 2003, Nilda 2003).

This is clearly illustrated in the program context. The preliminary results indicate the farmers can have similar yields as before conversion if manures had significantly been used before conversion, but lower yields on the farms which had used a lot of inorganic fertilizers before conversion. However, the lack of sound understanding about the implications of organic agriculture for food production and food security makes it impossible to fully evaluate its importance (Nilda 2003, FAO 2005). This is because meaningful comparisons of the performance of organic and conventional agriculture systems need to be conducted over a long period of time as farmers may experience a decline in yields after converting to organic production, and have a significant yield increase after the agro-ecosystem is restored and organic management systems are fully implemented (FAO 2005, IFAD 2005).

Moreover, it may not be easy to evaluate the benefit of organic agriculture from environmental and health perspectives. Under the local context, organic production can help to mitigate the environmental pollutions associated with animal husbandry. Also, using water hyacinth for compost making may help local authorities to save hundreds of millions VND for clearing local canals. In addition, organic agriculture can help to protect farmers' health from direct or indirect use of chemicals. According to UN (2008), organic production can help prevent the recurrence of the estimated 3 million cases of acute severe pesticide poisoning and 300,000 deaths that result from agrochemical use in conventional agriculture every year worldwide.

### *3.3 Social acceptance*

Besides the technical and economic aspects, the program also learns that gender issues and social networking via group formation need to take into consideration for successfully promoting organic production in the local context. As with other rural development activities the gender issue plays a very important role in promotion of organic agriculture. This is because the conversion of a farm to organic practices influences all facets of the operation, including labour demand, social structures, and decision-making processes (FAO 2005). Once joining the organic program, the farmer owner needs to convert his whole farm to organic farming, not only the target crop. Therefore, both wife and husband need to fully understand and apply with the organic principles. This is because it is likely that when the husband is away the wife may be tempted to use inorganic fertilisers (NPK) to apply to her crops. In fact, women have actively been in compost making such as collection and chopping green materials and cocoa pod harvesting (Helvetas 2010b).

Moreover, though the program has implemented its field activities for 6 months, the importance of social working (eg. farmer organization) in peer monitoring and motivation has clearly been demonstrated. Among 22 demonstration farmers, one farmer attempted to use inorganic fertilisers. The unusual performance of his cocoa crop (very big cocoa leaves) drawn the attention of group members and after several meetings for discussion the farmer had to admit his cheating behaviour and promises not to do that again. Moreover, the group has motivated its members to comply with the organic requirements and regulations. As organic production is more labour intensive than conventional one, organic farmers need to spend more time on compost making. During the past months, some farmers have from time to time felt discouraged to make sufficient compost as recommended. However, with the mental support from group

members, they have successfully applied the recommended organic farming techniques such as compost making and weaver ant rearing.

### *3.4 Stable markets for organic products*

The program has learnt that for promoting organic production in the region, development of stable market for locally produced organic products is a key factor. At beginning Helvetas has made clear to local farmers the stable markets to which they can sell their products as local farmers have had bitter experience with “bumper crop with lower market price”. When designing the program, Helvetas identified potential buyers of organic cocoa such as Ritter Sports and Cargill. Recently, Helvetas has signed a purchasing agreement with Cargill Vietnam to buy conversion cocoa from 1<sup>st</sup> December 2009. Without information on the stable market, local authorities as well as local farmers are reluctant to join the program.

### *3.5 Sound understanding of organic agriculture by local authorities and farmers*

Over the past 6 months, the importance of sound understanding on organic agriculture for all stakeholders has been proved. For ensuring common understandings on organic cocoa and organic certification procedures as well as requirements, standards in organic production, the program has contracted a service provider to organise a 2-day training on organic cocoa for program key stakeholders. However, due to ineffective course delivery, local partners and cocoa farmers did not fully understand the principles and requirements of organic cocoa. Consequently, their negative and passive attitudes towards organic cocoa production have hindered the program progress and expansion in some localities, particularly in Ben Tre Province. Therefore, as with other development initiative, all program stakeholders must fully understand the principles and the requirements of organic agriculture. The international experience shows for successful promotion of organic production, local authorities need to understand the long-term benefit of organic agriculture with due consideration of the pros and cons thereof (IFAD 2003, CSIRO 2006).

## **4. Concluding Remarks**

During 2009, the program has made great efforts to accomplish numerous activities, making good progress towards the achievements of its goals. In general, the program has learnt that key factors for successful promoting organic agriculture in the Mekong Delta include, but are not limited, sound understanding of local authorities about organic agriculture in order to motivate local farmers to join the program, development of site appropriate organic farming techniques, farmer organization for peer monitoring and motivation, development of stable markets for locally produced organic products and the important roles of women in organic cocoa production.

More specifically, the program has learnt that the most suitable time for conversion to organic cocoa production is from November to January of the following year because of abundant availability of local materials and favourable conditions for compost making, lower damage by the black pod disease and favourable conditions for building up weaver ant populations. In the years to come, the program should give priorities to local cocoa farmers with animal husbandry to join the program as the likelihood of successful conversion for these farmers is higher. For

cost-effective analysis, the program needs more time to collect information. It should however be kept in mind that the organic practitioners need to make local authorities as well as local farmers to understand that the meaningful comparisons between organic systems and conventional ones will require efforts and commitment over a long period of time.

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# EVALUATION OF THE LIVING WITH FLOOD POLICY: THE CASE OF THE RESETTLEMENT PROGRAM IN VIETNAMESE MEKONG DELTA<sup>22</sup>

Vo Thanh Danh<sup>23</sup>

## ABSTRACT:

*The Vietnamese Mekong Delta (VMD) is the region affected by flooding. People living in the VMD's increased flooding areas may have to be relocated. Currently, Living With the Flood (LWF) policy is popularly accepted in the VMD. Since 1996 the government has launched an ambitious LWF program. The objective of the program was build dwelling houses to reallocate for residents in the VMD's flooded areas. The program built more than 1,000 resettlement clusters (RCs) for 200,000 households with one million people living in the permanently flooded areas. Total investment capital was about \$US 200 million. There were many reasons that make the resettlement program both successful and unsuccessful. Identifying the factors affecting the effectiveness of the program will help local authorities to have appropriate measures to development the resettlement. The rationale of this study was to make a review analysis and qualitative analysis on the effectiveness of the resettlement program. The policy recommendation drawn from the study is that to cope with floods effectively, in the long run people need to adjust habits, social and economic activities towards living with floods and getting benefits from floods rather than preventing floods. At the national level, planning economic development strategies in the VMD needs to be consistent with the LWF policy. At the local level, authorities needs to persuade people to change the realization towards adapting to the flood and choose the way to live with the flood.*

## I. INTRODUCTION

The Vietnamese Mekong Delta (VMD) consists of thirteen provinces, namely, Long An, Ben Tre, Tien Giang, Vinh Long, Tra Vinh, Dong Thap, Kien Giang, An Giang, Soc Trang, Bac Lieu, Ca Mau, Hau Giang, and Can Tho. The VMD has a natural area of 4 million ha and the population of 18.2 million people accounted for 21 percent of total population of Vietnam. Its GDP contribution is about 18 percent of the national GDP. The VMD is only one meter above or below the mean sea level. Sea level rise (SLR), one of the calamities of global climate change, creates a serious threat to the Mekong Delta of Vietnam (VMD). Reiner et al (2004) used a hydraulic model under two SLR scenarios of 20 cm and 45 cm to compute water levels during the flooding season. The result showed that the average increment in water levels in the VMD is about 14.1 cm to 32.2 cm. GIS result presents the levels of vulnerability in term of flooded area of 0.6 million to 2.3 million ha among 4 million ha of the Delta due to the SLR. Ninh et al.

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(1995) summarized the impacts of the SLR in Vietnam. Firstly, the SLR results in the loss of land, especially fertile agricultural lands in the low-lying areas like the VMD. The SLR could have the bad consequences for the livelihoods and socio-economic development. Regions that previously not permanently inundated by sea water may be suffered and become unsuitable for agricultural production. Secondly, the salinization will increase. Especially, the irrigation of paddy rice may be suffered by the increased intrusion of saline water. Thirdly, the vulnerability to flooding will increase. People living in the VMD's increased flooding areas may have to be relocated.

Half of the natural areas in the VMD is inundated during the flood season. Annually, there are more than two million households with eleven million people living in the flooded area from three to four months. Among 800,000 houses flooded, there are more than 200,000 houses inundated under 2 meters or more. The flooded area in the VMD is approximately 1,828,000 ha with more than 50 percent of population in the region consisting of nine provinces, namely, Long An, Dong Thap, Tien Giang, Vinh Long, Hau Giang, Can Tho, An Giang, Kien Giang, and Ben Tre. The flooded area is the low-lying region with more than 61 percent of the flooded areas lower than one meter of the sea water level. The flood period starts on July and ends on December. The inundation level is from 0.5 to 4.0 meters. In the serious floods, there are more than one million ha under one-meter-above inundation. Economically, the flooded area contributes 67 percent of the VMD's GDP, 75 percent of total agricultural-fishery-forestry production values, 79 percent of total industrial values, 80 percent of total services values, 80 percent of rice export values, and more than 50 percent of Vietnam's agricultural export values. Although the flood causes the serious damages on the death, houses, traffics, schools, hospitals, and infrastructures, the flood has also benefits such as alluvial, fishery, water environment improvement, and cleaning acid soil for the rice field.

In hundred years people in the VMD learned to live with the flood as the adaptation measure to avoid damages and get benefits from the flood. Currently, Living With the Flood (LWF) concept is institutionalized as the LWF policy. According to the LWF policy, the VMD's socio-economic development strategy will be interdependent of the masterplan of the flood controlling. Under the LWF policy, there are two flood-related programs implemented in the flooded areas. These are dyke program and resettlement program. Selecting the program depends on the inundation of the flooded area. Flooded areas in the VMD are divided into two parts: the deep inundated area and the shallow inundated area with the below-one-meter inundation level. Therefore, the LWF measures recommended depends on separate flooded areas and takes into account the time frame of short-term and long-term solutions. In the long term, the main solution for the shallowly flooded area is to maintain normally agricultural production and socio-economic activities via the network of small dyke with the function of opening and escaping the flood-water in the whole year. In the shallowly flooded area, three rice crops are maintained. For the deeply flooded area, main measure is to build a big dyke system in order to prevent the flood-water from the direction of Cambodia border into Dong Thap Muoi region and Long Xuyen Quadrangle and escape the flood water into the West Sea faster. A strategy of periodic flood controlling is recommended in order to slow the flood and maintain the shallow inundation level in the beginning of flood for harvesting a Summer-Autumn rice crop. Furthermore, escaping the flood faster in the end of the flood period enables to harvest Winter-Spring rice crop on time. In the deeply flooded area, Autumn-Winter rice crop is removed. In addition, in the deeply flooded areas, resettlement clusters (RCs) are built to move people to live permanently.



Livelihood in the VMD's flooded area is risky. The allocation of household is dispersed. The house construction is simple and fragile under the flood condition. The preparedness of the people in the flooded area is not adequate. Therefore, the damage of the flood for the human life is unavoidable. To help the people in the VMD's flooded area copes with the flood effectively, since 1996 the government has launched an ambitious livelihood program. The objective of the program is to reallocate the households in the flooded areas. The altitude of the resettlement is built at 0.5 meter higher than the record 2000 flood level (5.06 meter). In the resettlement, the infrastructures as dykes and roads and public welfare system as school, market, clinic, etc. are comprehensively built. In the shallowly flooded area, the dyke system has the specification of 2.5 m top x 4.5 m bottom x 2.0 m height. In the deeply flooded area, the combination of making canal and the resettlement with the large dyke system or house on stilts is recommended. Average area of the resettlement is 300 ha. In 1996, government built five sample RCs at Nhon Hung commune (An Giang), Nam Thai Son commune (Kien Giang), Khanh Hung commune (Long An), Giong Gang commune (Dong thap), and Hung Thanh commune (Tien Giang) with 400 households each. In the masterplan, each commune in the flooded areas will have at least two resettlements. In the period 2001-2005, provinces in the flooded areas proposed to build 1,043 resettlements for 200,000 households (with 1,000,000 people) with the investment capital of 3,200 billion VND (215 million USD).

There are many reasons that make the resettlement successful and unsuccessful. Identifying the factors affecting the effectiveness of the program will help local authorities in flooded regions to have appropriate measures to development the resettlement. The rationale of this study is to make a review analysis and qualitative analysis on the effectiveness of the resettlement program. Based on the results of the study recommendations for the policy and research gaps will be given.

Research questions raised in the study are: (1) What is about the resettlement program? (2) How is the resettlement program successful and unsuccessful? and (3) What actions need to be done further to achieve the objective of the program.

The main objective is to evaluate the effectiveness of the resettlement program under the LWF policy in the Mekong Delta. The specific objectives are follows:

1. to overview of the LWF policy and the resettlement program.
2. to evaluate the impacts and constraints of the resettlement program.
3. to recommend actions in agenda.

## **II. METHODOLOGY AND STUDY SITE DISCRPTION**

### **2.1 Research Methodology**

The study used both qualitative and quantitative methods. Qualitative data were collected by the in-depth interview (IDI) and focus group discussion (FGD). The IDI survey was designed for local authority including three persons: a vice president of the commune who is in charge of administration in all the RCs of the commune, an officer of land management who is incharge of infrastructure management in all the RCs, and an officer of the RC of Long Hoa at the commune level to get subjective evaluation on the resettlement program's performance. Commonly, the

commune authority is delegated in managing and monitoring the RCs located inside the administrative area. The IDI variables were periodic progress of the program, management and monitoring, pros and cons, and self-evaluation. To enable to collect relevant information, the IDI questionnaire was firstly sent to the commune authority during a field trip made two days prior to an official FGD survey at the study site. At the time of official FGD surveys, a group of research team was responsible for a discussion meeting with representatives of commune authority so that the IDI survey was completed. For FGD surveys, respondents were grouped into the two of those who currently live in the RCs and resettlement paths (RPs) and those who live outside the RCs and the RPs. The FGD respondents were selected via the introduction of commune authority. For those who were living in the RCs the criteria selected was that they had lived in the flooded and eroded areas before resettled by the resettlement program. For those who were living in the RPs the criteria selected was that they resettled in the RPs at least one year. For those who were living outside the RCs and RPs criteria selected were that their houses located near the RP and next to the river bank eroded. The FGD variables included ex-post income generation, reasons to live in or out the RCs, pros and cons, opinions about the program, and satisfaction, and recommendation. There were three FGD surveys with one for 15 people living in the RC of Long Hiep village, one for 12 people living in the RP of Long Hoa village, and another one for 18 people living in Tan Hau B2 village outside the RCs. Table 1 represent profile of IDI and FGD respondents in the survey.

Table 1: Profile of the respondents in the IDI and FGD surveys.

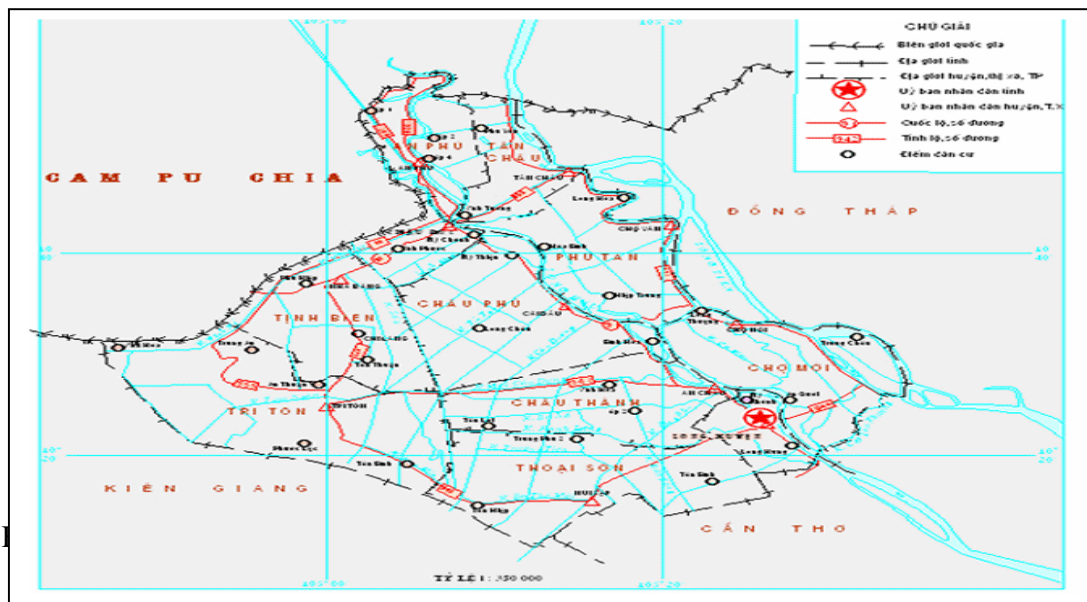
Type of respondent	Profile
IDI survey	1 administrator at the commune level, 1 manager responsible for infrastructure management in the RCs and RPs of the commune, and 1 manager at the RC level.
FGD survey for the RC	lived in the flooded and eroded areas before moving into the RC.
FGD survey for the RP	Lived in the RPs at least one year.
FGD survey for the outsiders	located between the RP and the river bank eroded,

For the quantitative data, there were three household surveys with one for 20 people living in the eroded area along the Kinh Sang river of Long Thanh village, one for 20 people living in the RC of Long Hiep village, and the other one for 20 people living in the RPs of Long Hoa village. Variables collected in the first household survey for people living outside the RCs included the opinion about the impact of the flood on their life, the adaptation on the flood, and the perception about the flood. Variables collected in the household surveys for people living in the RCs and the RPs included changes of income, living condition, and job opportunity. Descriptive statistics were used to make the before-and-after analyses.

## 2.2 Description of Study Site

The study was conducted at Tan Chau district of An Giang province. An Giang province is located at the upstream of the VMD flooded area. The natural areas are 3,424 km<sup>2</sup> with the

population of more than 2.1 million. It has abundance of land resources. There are totally 37 kinds of soil categorized into 6 main groups: alluvial soil with 44.5% of the total area, alkaline alluvial soil with approximately 27.5%, ancient alluvial soil with 7.3%, and other soils with 20.70%. In June or early July the flood from Tien and Hau rivers comes into An Giang's area and inundates the region when water level at Tan Chau station reaches at 3.0 m. At An Giang province each ten years there are 9 years that the peak of the flood occurs in the end of September and the mid-October. According to the observations from 1911, in average, each 7 years there is a serious flood. A flood is considered as a serious one when water level at Tan Chau station is higher than 4.6 m. In 1990s at An Giang province the serious floods happened in 1991, 1994, 1995, and 1996. The dreadful flood in 2000, especially, had a record water level of 5.06 m (compared to the 1961 flood at 5.12 m) and it is considered as a "century" flood with the uncountable damages. Tan Chau district has 15,994 ha with more than 150,000 people. Its administrative units are Vinh Xuong, Vinh Hoa, Phu Loc, Tan Thanh, Tan An, Long An, Chau Phong, Le Chanh, Phu Vinh, Long Phu communes and Tan Chau town. Figure 1 represents the position of tan Chau district in the administrative map of An Giang province. The eastern border is Tien river of Dong Thap province. The western side shares the line with An Phu district of An Giang. The southern side is next to Phu Tan district of An Giang. The northern border is with Cambodia. Tan Chau district is among deepest inundation area of An Giang Province with the average inundation level of 2 meters in the flood season. It is one of the two lowest regions in the VMD<sup>24</sup>. Selecting the study site located in the most flooded area will describe the problem better. Up to the end of July 2007, Tan Chau district had 5,022 households among the total of 6,250 "targeted" households moving to the RCs. All eleven communes of Tan Chau district built the RCs. There were four communes, namely Long Phu, Chau Phong, Long An, and Vinh Hoa having the largest numbers of the RCs with 4 – 5 ones each.



<sup>24</sup> Another inundated area is Hong Ngu district of Dong Thap province.

The study site selected in this study was Long An commune. Figure 2 presents the map of Long An commune and position of the resettlements. There were two kinds of the resettlements, namely the RCs and the RPs, found in the study site of Long An commune. The RC was designed as the residential cluster for those who used to live in the different villages from islands and eroded river banks affected by floods. Those people had to quit their houses to move to the new places in the RCs. The distances from the old places to the RCs were averagely far than 2 km. Currently, there were two RCs adjacent to each other. One cluster was established in 2000 and the other one in 2004. The second type was the RP within a village. It was designed for households in vulnerable areas along the river to move to settle in the same village. The RPs were located along the inter-commune road that also was built as a dyke for the purpose of preventing floods. Resettlers were those who used to live in the eroded areas along the Kinh Sang river next to the existing RPs. The distance from the old location to the RP was not far than 100 meters.

The commune of Long An has five villages, namely Tan Hau B2, Long Hoa, Long Thành, Long Hiep, and Long Thạnh. The villages are located along an inter-commune asphalted road upgraded in 2004. The road is parallel to a river, called Kinh Xang, serving as a dyke to prevent flood from the river. Houses located between the road and the rivers are vulnerable to flood and erosion of the riverbank. In order to adapt to the annual flood situation, since long time all houses here are built on stilts. Currently, there are two RCs at Long Hiep and Long Thạnh villages and two RPs at Tan Hau B2 and Long Hoa villages. Surveys were implemented at Tan Hau B2, Long Hoa, Long Hiep, and Long Thạnh villages.

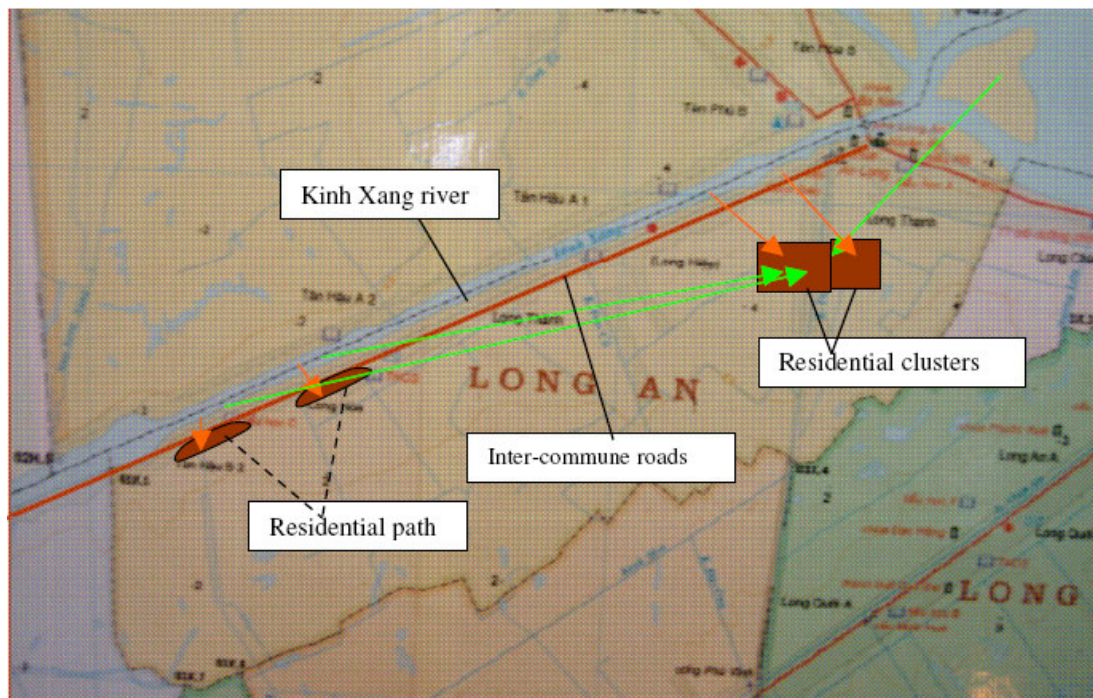


Figure 2: Long An commune and resettlement sites

Moving to whether the RC or the RP depended on where they lived before and the vulnerability of the households to the floods. Those who lived in the isolated island at the rivermouth were affected seriously during the flood season. So, they were firstly in the list of the resettlement program. The authority asked them to move to the RC for safe. Currently, all of them moved to live in the RC since 2005. Those who lived next to the eroded areas along the King Sang river were also selected by the authority to move to the RC. While many households faced with the dangerousness of erosion and the floods, only the households in the worse condition were selected firstly. There were still many households there needed to move. According to the local authority, in the coming years, there will be more resettlements built in the commune to satisfy the need. In the case of the RP, many resettlers lived there before the RP built. When the government launched LWF policy and the resettlement program, an inter-commune road was raised as a river dyke to prevent the floods. Then, the RPs were built along the road. People made the houses in their pieces of land within the RPs. Only a small proportion of resettlers were the newcomers who used to live in the eroded areas along the King Sang river nearby the RPs. Those were selected by the local authority based on the vote of the community. Both the resettlers in the RCs and the resettlers in the RPs selected by the authority could borrow loans for house construction (USD 600 per household) and for income generating activities (USD 550 per household). Term of the loans was 10 years and households had to pay principal from year 6.

### **III. AN OVERVIEW OF LIVING WITH FLOODS AND RESETTLEMENT PROGRAM**

#### **3.1 Flood Situation in the Mekong Delta**

##### **3.1.1 Nature of the flood**

Flooding is an annual natural phenomenon in the VMD. It starts with the fact of water rising at the upstream of the Mekong River due to heavy rains by typhoons and Southwest monsoon. The flood is created when water in the Mekong River inundates Savannakhet and Pakse at South Laos and Kratie at East Cambodia. The stretch of flood season lasts from June to October with 90 percent of total annual flow. Flood in the VMD is measured by water levels of Tien River (Mekong River) at Tan Chau station (An Giang province) and Hau River (Bassac River) at Chau Doc station (Dong Thap province). Annually, affected by Southeast monsoon water levels of Tien and Hau Rivers start to raise at the end of June or early July. The peak of flood is recorded at the end of September or early October. Flood season is usually ended at the end of December or January. The flood in the VMD is called “lu lut”. The “lu” implies that water is rising. The “lut” means the period of inundation.

According to Quang (2000), besides typhoons and Southwest monsoon, there are four causes of the flood in the VMD, namely, hydroelectric dams at China upstream, migration of the human to the flooded areas, deforestation, and network of irrigation dams. It is said that dams at China upstream affect only 2 percent of total water flow of the Mekong River although environmental and ecological impacts for the downstream region are possible. Migration in the plain of reeds in the past and farming practices made the flood more serious and longer. The reason was that the new residents created a canal systems with the high density to desalt the land for rice planting. Deforestation would increase the frequency and danger of the flood. However, the debate of deforestation impact to the flood is still going on. Upgrading old system of canals

for irrigation purpose in 1980s makes the flood come faster and the period of inundation last longer.

To manage the flood, a flood warning system in the VMD is built by the Mekong River Commission (MRC). According to the MRC standard, the “floating” season or without-flood situation occurs when peak water level at Chau Doc station is between 3.8 and 4.2 m. If the peak of water level at Chau Doc station is higher than 4.2 m, the flood happens. If the peak of water level at Chau Doc station is lower than 3.8 m, the drought occurs. For Tan Chau station, the without-flood situation occurs when peak water level is between 3.5 and 4.5 m. Above 4.5 m, it is considered as a serious flood. Above 5 m, it is considered as a dreadful flood. The floods in 1961 and 2000 are considered as dreadful ones with the huge damages for the region. Table 2 represents the flood warning system in the VMD. When the flood starts at the upstream of Mekong River, water in main rivers is rising. As water level at Tan Chau is between 2.8 and 3.0 m, water flow in the Mekong River begins to inundate the plain of reeds and Long Xuyen quadrangle (flood warning at the alarm level No. 1). As water level at Tan Chau is above 3.0 m (flood warning at the alarm level No. 2), flood inundates the plain of reeds, Long Xuyen triangle, and areas between Tien River and Hau River. If the inundation is above 4.2 m, the situation of flood will be happen in that year (flood warning at the alarm level No. 3).

An important nature of the flood in the VMD is the presence of the Great Lake in Cambodia. Great Lake plays a role as a reservoir in reconciling the water volume in the flood season. At the beginning of the flood season, 80 – 90% water volume of the Mekong river discharges into the Mekong Delta, the remaining of 10 –20% water volume discharges into the Great Lake. In October as the water level in the Mekong River reduces by flowing to the sea, water from the Great Lake discharges into the Mekong River’s network up to May next year. This makes water level rises slowly, in average, at 3-5 cm/day. Therefore, the flood in the VMD is named as a “peaceful” flood.

Table 2: System of alarm levels of the flood in the Vietnamese Mekong Delta

Class	Tan Chau station (m)	Chau Doc station (m)
1	3.0	2.5
2	3.6	3.0
3	4.2	3.5 (alarm level)

*Source: Mekong River Commission*

### 3.1.2 Damages of the flood

In the last fifty years, in average, every two years there is a flood with the fact that water level at Tan Chau station is beyond the third class alarm level of 4.20 m. However, there are times the flood occurs 3-4 years in succession as the periods 1937 – 1940, 1946 – 1949, 1994 – 1996, and 2000 - 2002. Observations since 1941 showed that the flood in 1961 was considered as



the biggest flood in the VMD with the fact that the water level at Tan Chau station was 5.12 m. The “century” flood in 2000 with the water level at Tan Chau station was 5.06 m. The flood in 2000 had records of flooded area, inundation time, and water volume. Its economic losses were estimated at US \$500 million.

The flood brings damages for the VMD. The inundation in several months changes the economic activities and the livelihoods of the people in the flooded area. Infrastructures such as roads, small dykes, and canals are under water for several weeks. The flood could generate damage by erosion and landslide. Especially, casualties may happen for people living in several weeks in flooding. Ngoc (2003) applied the VRSAP model<sup>25</sup> to estimate the economic losses of the flood in the VMD. The model used 1996 and 2000 data as the base cases. It predicts the flooding situations with the different return periods. Records of the flood in the past from 1935 to 2000 were used to analyze the flood frequency and estimate the peak discharges for different return periods. Moreover, an inundation map for flood events was made and the flooding durations were estimated. This information was used to evaluate flood damage. Table 3 presents estimated economic losses for the different kinds of damages.

Table 3. Estimated economic losses for the different damages.

Unit: million \$US

Probability of design flood (%)	Residential	Commercial	Agriculture	Infrastructure	Total damages
50	24	0	272	388	684
20	218	48,202	299	538	49,257
10	232	52,830	322	613	53,995
5	243	54,262	341	678	55,522
2	260	61,450	353	749	62,810
1	280	75,235	403	795	76,712
0.2	295	76,072	413	939	77,719
0.1	305	80,610	432	975	82,321

Source: P. Ngoc 2003

<sup>25</sup> VRSAP stands for The Vietnam River Systems and Plains

## **3.2 Description of Living With the Flood Policy**

### **3.2.1 History of Coping with the Flood**

The modern history of coping with the flood in the VMD could be divided into four periods. Prior to the nineteenth century, the pioneers of the new land chose a "natural" adaptation with the flood situation. At that time population density was 10-20 persons/km<sup>2</sup>. Majority of residents lived along the rivers or chose places that are not inundated to be home. In inundated areas, people built houses on stilts. During this time, there was no irrigation infrastructure made to cope with the flood.

In the period of nineteenth century-early twentieth century, as a population density reached 100 persons/km<sup>2</sup>, resettlers created a new network of canals to exploit new land and partly adapt to the flood. Thoai Ha canal in Long Xuyen quadrangle with 51 m in width and 31 km in length was built in 1818. Concurrently, in 1819 Vinh Te canal was built to connect An Giang with Kien Giang with 38.4 m in width and 98.3 km in length.

In the period of 1950-1999, the VMD was exploited for the need of agricultural development. A network of irrigation and dykes for preventing the flood was established for the area with a population density of 415 persons/km<sup>2</sup>. The total length of the dykes system was about 12,000 km. This system was designed to protect 1,200 clusters with 1.3 million ha. In addition, a huge project to prevent the flood coming slower and bring the water in the flood season discharging into the West sea faster.

Since 2000 the concept of living with the flood has been accepted with the fact that besides the damages the flood brings about, it also gives benefits to residents in the flooded area. By coping with the flood actively, people could mitigate the damages and gain more benefits. According to this concept, socio-economic development of the VMD needs to be linked to the strategy of "controlling" the flood. The main objective of controlling the flood in the VMD is both to mitigate damages and live with the flood. Preparing adaptation to the inundation situation and minimizing changes of current flow of the flood are other objectives of this strategy.

### **3.2.2 Living With the Flood Policy**

The perception of the flood in the VMD is unique and different from any other areas of the Mekong Basin. People know that in every year water level will rise in certain months and they prepare to "live" with the flood. It is recognized that positive effects of flood are huge. These benefits include supplying fresh water for irrigation and domestic use, increasing fishery resources, getting natural fertiliser, killing insects in rice fields, flushing acid water caused by sulphate soils, preventing penetration of sea water, etc. In another hand, the balance between the ecological environment and the people's livelihood in the flood season was maintained in centuries. Many economic activities such as aquaculture and fish catching in the flood season bring additional incomes for farmers. For instance, a report of An Giang department of agriculture and rural development showed that in the flood season there are twenty-six of agricultural-fishery production models for improving farmers' incomes.

Historically, prior to the 1978 flood farmers living in the flooded areas appreciate floods and they had learned to live with it. After this disaster, process of building dykes system and new canals aimed to control floods began. However, it is argued that this is a main culprit creating



dreadful floods in the late 1990s. In 2000 the “century” flood caused damages in terms of losses of human life and assets. Many lessons were drawn from the 2000 flood. As a result, the adaptation strategy and response methods to cope with floods were implemented. A system of embankments were newly created and heightened at water level of the 2000 flood as a base level. Under the LWF policy a resettlement program was launched. Many residential clusters were established in the flooded areas to help people have the place to home permanently.

Although the LWF policy is presently broadly accepted, realization on the impacts of the flood to human is changed over time. While the VMD’s residents know the benefits of the flood and find the way to exploit it through activities such as fishing, aquacultures, etc, to earn more income in the « floating water season », policy makers try to find the best measures to eliminate the losses of the flood. Prior to mid-1990s, through an ambitious program so-called bringing the flood into the western sea, new canal system was created with the hoping that the flood can be controlled. However, the flood situation in the subsequent years showed that serious floods in 1996, 2001, and 2002 could be partly because of the negative effects of this program. As a result, in 1996 there is a policy change towards alleviating the negative impacts of the flood rather than fighting to the flood that presently so-called the LWF policy.

The principles of adaptation to floods in the VMD’s socio-economic development strategy announced by Prime Minister’s No. 99 Decision dated on September 2, 1996 are considered as a keystone of a policy so-called Living With the Flood. According to the strategy, the socio-economic development policies are bound up with the irrigation and infrastructure improvement and rural development programs. Next, Prime Minister’s No. 173 Decision dated on November 6, 2001 stated that in the process of growth the VMD needs to exploit the benefits and potentials of the water resources of the Mekong River and strengthen capacities of coping with floods as well. In addition, a permanent resettlement policy is designed to enable that the residents in the flooded area will not migrate during the flood time.

### **3.3 Introduction on Resettlement Program**

*Among measures of the LWF policy, resettlement program is considered as a suitable solution. A resettlement, the RC or the RP, is usually built at a permanently flooded area. Socially, the main objective of the program is to normalize the livelihood condition for the people in the flooded areas. As a requirement, base of a RC is higher than 0.5 - 1.0 m above the 2000 flood’s water level. The construction of the resettlement area includes public infrastructures marketplace, school, clinic, communication system, road, electricity, water supply, etc. The RC may be designed along the river, canal and road conditional on freed flow of floods. However, in reality building the RC is usually linked with dyke system development. In the permanently flooded areas it is required that there are at least two residential clusters built in a commune. For households living dispersedly in the flooded areas, they are able to get preferential treatments in making loans to raise houses or to build houses on stilts.*

*Since 1996 the government promulgated various policies related to building and developing the RCs in the VMD (Appendix 1). The 105 Decision of Prime Minister dated on September 2, 2002 stated that the program’s beneficiaries are households in the flooded areas of An Giang, Dong Thap, Long An, Tien Giang, Kien Giang, Can Tho, and Vinh Long. Those are able to get preferential loans for buying houses in the RCs. Preferential rights include a maximum zero-interest loan of 10,000,000 VND for buying a piece of land in the RCs and a*

*maximum annual 3 percent-interest loan of 7,000,000 VND for buying a house on that piece of land. The time of preferential loans is 10-15 years. Those who are benefited by the program are committed not to sell or mortgage the assets of land and house within 10 years. Regarding standards of house building in the RCs, the 78 Decision of Prime Minister dated in 2004 required that house is not less than 32 square meters in area. For infrastructure constructions of the RCs, the 04 Decree of Ministry of Construction dated in 2004 indicated that a system of roads, communication, electricity supply, water supply, and waste discharge is required to complete. Internal roads enable to connect with road systems of district and province. These roads are limited at 7 m in width. Main roads in the RCs are not larger than 5.5 m in width.*

The program designed to build 1,043 the RCs for 200,000 households with one million people living in the permanently flooded areas in the VMD. Total capital investments for the program are 3,200 VND billion (approximately 200 \$US million). The program began in 2001 and it is proposed to finish in 2005. However, at present all of 8 provinces in the VMD are not able to end it. In 2006 there were only 35 percent of the program's households moving to the RCs<sup>26</sup>. On March 2007 Vietnamese government requested to accelerate the program so that in the end of this year the remains would be completed. To do this, an additional capital investment of 750 VND billion (approximately 47 \$US million) is poured in the program. With this amount of money, it is expected that in this year there are more 184 the RCs for 46,787 households left to move to new places.

Although the resettlement program has been launched, arguments about benefits and consequences were still going on. It is agreed that the most important benefit of the program was to protect the people safely during the flood season. However, the biggest challenge of the program was the change of livelihood condition in the RCs. Ha (2007) raised the paradox of the resettlement program in the VMD. While the government was trying to finish the program so that a smaller group of people affected by floods was able to come to live there, many people expected it coming soon to receive benefits from floods. There already were recommendations on building temporary residential clusters instead of permanent RCs. People will move to residential clusters during the flood season for safe and return their home after the flood.

### **3.4 Results of the Resettlement Program's implementation**

Although establishing the settlement program is the right way to adapt to the permanent flood situation in the VMD, its attraction for people is not as expectation. The success of the resettlement program depends on the development of infrastructures. Many RCs have no waste discharge system and clean water supply. In some cases, there are even no electricity and roads<sup>27</sup>. Public items such as school, kindergarten, clinic, post office, and marketplace were not in progress as expectation. Another concern is the quality of infrastructures of the RCs. To catch up the time frame of the program for the huge amount of works, many constructions do not have the adequate quality. As an example, for about 200 RCs in Long An province constructing and raising the bases of the RCs were done in 2004 while infrastructures such as schools, clinics, water supply stations, roads, etc. were completed in 2005. Consequently, quality of most

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<sup>26</sup> Government inspector office, 2006 report.

<sup>27</sup> It is called the "four no" situation, i.e., no electricity, no road, no clean water supply, and no waste discharge system.

constructions is poor. Through the program the authority of Long An province expects to solve for 37,000 households among more than 99,000 households affected directly by the floods to live in permanent locations. However, to the end of 2005 there were only 26.2% of households registering with the program<sup>28</sup>. This situation could be seen everywhere. Another example is the RCs in Co Do district of Can Tho city. Presently, there is only 34% of households among 2,333 “in-program” households moving to new places in the RCs (Ethnic and Development Newspaper, 2007).

Besides the poor quality of infrastructure, the livelihood condition is another reason of not attracting the people to live in the RCs. Majority of the resettlers are the poor<sup>29</sup>. They have no land or just have a piece of land. Before coming to the RCs, they are employments. Living in the resettlement cluster causes difficulties in getting on-farm employment. Tien (2004) indicated that 45.4% of respondents asked showed that they get less income and spend more expenditures compared to a prior year when they did not move to the RCs. Moreover, the study also showed that poor housing conditions in the resettlement cluster cannot attract people to move there. For the poor a traditional farming model garden-pond-cage (VAC) is commonly considered as a part of their economic activities in generating additional income. Living inside the RCs will not allow them to practice the VAC model.

Financial problem is also a constraint for the program. Many resettlers are the poor. They could not afford for a piece of land in the resettlement cluster. According to Mr. Le Phat Quoi, head of division of science management, Long An department of science and technology, a minimum price to be able to own a piece of land in the RCs ranges at 7-10 VND million. Price of some pieces of land ranges at 30-73 VND million. Moreover, expenses of house building are also a financial constraint for the poor. As a result, they are reluctant to move to live in resettlement cluster.

Regarding livelihood condition in the RCs, Xe, et al. (2006) conducted a study in selected households in the VMD. Objective of the study was to evaluate the socio-economic performance of the resettlement program in An Giang province and Can Tho city. Field survey was implemented for 281 “inside” households (insider) and 81 “outside” households (outsider). Insiders were selected from 28 RCs in the two provinces. Number of the RCs accounted for 30% of total RCs in the study site. Outsiders were defined as the ones who have the same resettlement conditions as the inside households but they currently lived outside the RCs. Results of this study are reviewed as bellows:

**Change in land use.** After lived in the RCs, number of households being land owners decreased and agricultural land area per household, therefore, also declined adequately because generally resettlers sold a piece of land when they move to new places. Reasons of selling the land were financial difficulties (68%), job changes (33%), production capital deficiencies (11%), labor deficiencies (9%), and other reasons (13%).

**Decrease in animal husbandry activity.** It is commonly that animal husbandry activity is main income source besides rice production of the VMD farmers. Before coming in the RCs, there were more than 50% of households having animal husbandry activities. Because of the

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<sup>28</sup> Long An province’s department of construction, 2006 report.

<sup>29</sup> Tien et al (2004) indicated that 64.4% of resettlers are the poor.

regulation of the RCs, these activities are banned. However, a few of households were observed to continue illegally.

**Change in structure of employment.** Resettlement program caused the change in structure of employment towards decreasing employment in agricultural sector relative to non-agricultural sector. After coming in the RCs, number of people getting job in non-agricultural activities and agricultural activities increased 5.8% and decreased 12% respectively. Moreover, the unemployment rate increased at 5.6%.

**Change in sources of income.** The income per household was mostly unchanged in before-and-after analysis framework. However, the structure of income sources changed. Off-farm incomes increased significantly while on-farm incomes including employment activities decreased. In details, per household incomes of agricultural sector, employment activities decreased from 5.5 VND million to 3.7 VND million and 7.4 VND million to 5.6 million, respectively. Meanwhile, per household incomes of non-agricultural activities and wage-earner activities increased from 3.0 VND million to 7.1 VND million and 4.7 VND million to 6.2 million, respectively.

**Improvement in social conditions.** Resettling in the RCs helps people accessing public services better. Especially, proportion of population going to school at all educational levels increased quickly. Rates of children going to kindergarten and primary school increased from 46% to 96% and 67% to 94% respectively. In addition, after coming in the RCs the percentages of households using metered electricity and clean water supply increased from 26% to 84.7% and 12% to 68% respectively. Other public services such as medicine treatment and market activities were also improved.

**Insider and outsider's income comparison.** According to this survey, there were the differences in incomes between the insider and the outsider. Generally, insider's average income per household was 0.8 VND million lower than outsider's average income. Income from agricultural activities such as crop, husbandry, and on-farm employment decreased relatively at 1.7 VND million, 0.9 VND million, and 2.0 VND million respectively. Meanwhile, incomes from off-farm employ and services increased relatively at 1.3 VND million and 3.9 VND million respectively.

## **IV. FINDINGS AND DISCUSSION**

### **4.1 The resettlement program at the study site**

There are three types of stakeholders involved into the resettlement program, including provincial authority, district authority and commune's people committee. The role of provincial authority is to direct the district authorities to implement the policies such as planning the RCs, and selecting the target groups for the RCs. The province is also the one who directly receives the financial source from the central government. The district authority is responsible for designing the RCs such as selecting the place for the RCs and determining the size of the RCs. The district authority is also responsible for managing the investment capital allocated for building the RCs. Commune's people committee takes part in the monitoring and the allocation of the residents plots in the RCs. Once the RC completed, a new administrative unit is established and managed under the commune authority.

Tan Chau district of An Giang province is the most inundated area in the VMD. The average inundation level is about 2.0 m during the flood season. Since 2001 the resettlement

program had been launched to move people living in disaster areas to a safer place. On July 12, 2002 An Giang province's people committee promulgated No. 1706 Decision on criteria of selecting "targeted" households for the program. Four criteria so-called "4 Nos" are successively: (1) those who are below the poverty line, belong to the subsidized group, and have no house, (2) those who have their lands taken over for making the RCs, (3) those who are below the poverty line and live in disaster areas, and (4) those who are below the poverty line but not belong to the subsidized group. All of eleven communes of Tan Chau had the RCs. Table 4 shows the situation of the RCs at Tan Chau district. There were totally 34 RCs built in inundated areas at Tan Chau district. Most of communes had 3-4 RCs. Majority of resettlers belonged to four categories above. Until the end of July 2007, there were 80% among 6,250 targeted households moved to live in the RCs. Numbers of those who paid at the subsidized price (7-10 VND million) were 5,236 households accounted for 85%. The rest of households who did not to the "4 Nos" groups had to pay at the higher market price (30-50 VND million). The reason they had to pay at the higher market price was that the government needed to get more funds to cover the cost of infrastructures that were usually higher than the initial investment capital requirements.

At Long An commune, there were two RCs and two RPs. There were 1,404 households among the total of 3,202 households affected by the flood and needed to be relocated. Up to the end of November 2007, there were 480 households already relocated in the RCs. About 70% of them paid at the subsidized price. It was said that in the period 2008-2015 Long An needs to build 6 new RCs to relocate 924 households. Among these target households, there currently were 224 households living in the vulnerable areas by erosion and landslide along Kinh Sang river and 196 households living in the vulnerable areas by the flood. Table 5 presents results of the resettlement program at Long An commune.

Table 4: Status-quo of resettlement clusters at Tan Chau district of An Giang province

Commune/ Town	Number of resettlement clusters	Number of houses	In which		Number of household s	Proportion (%)
			Subsidized price	Market price		
(1)	(2)	(3) = (4)+(5)	(4)	(5)	(6)	(7) = (6)/(3)
Tan Chau	1	329	280	49	269	81.8
Long Phu	4	530	402	128	398	75.1
Phu Vinh	2	262	178	84	169	64.5
Le Chanh	3	611	456	155	432	70.7
Chau Phong	5	847	793	54	684	80.8
Long An	4	497	480	116	456	75.9
Tan An	3	865	749	116	731	84.5

Tan Thanh	3	622	482	140	480	77.2
Vinh Hoa	4	883	816	67	805	91.2
Vinh Xuong	3	512	412	100	410	80.1
Phu Loc	2	188	188	0	188	100.0
Total	34	6,250	5,236	1,014	5,022	80.4

*Source: Tan Chau district's report on the resettlement program, 31/7/2007*

Table 5: results of the resettlement program at Long An commune

Resettlement cluster/path	Number of houses (designing for....)				Resettle d	% Resettle d	Infrastructure		
	Total	Public	Market price	Subsidie d price			Electricit y	Clean water	Road
(1)	(2)	(3)	(4)	(5)	(6)	(7) =(6)/(5)	(8)	(9)	(10)
Long Thanh	193	0	0	193	181	94.0	Complete d	Comple ted	Comple ted
Tau Hau B2	129	1	37	91	88	97.0	Complete d	Comple ted	Comple ted
Long Hiep	137	3	40	94	88	94.0	Complete d	Comple ted	Comple ted
Long Hoa	152	6	44	102	99	97.0	Complete d	Comple ted	Comple ted
Total	607	11	116	480	456	95.0			

*Source: Tan Chau district's People Committee report (2007).*

#### 4.2 Program manager's evaluation

Management board of resettlement program was an agent belonging to Tan Chau district's people committee. It was a proxy by the provincial authority to manage and monitor the program. It was responsible for technical and financial issues related to the resettlement program. Commune's people committees helped the management board to select the place for constructing the RCs, persuaded and selected the target households to relocate in the RCs. In this survey, Long An commune was selected to describe the situation of resettlement program at Tan Chau district. According to the IDI survey, when the program started there was a few of people selecting to live in the new place. There were some reasons that made people not willing to move. Firstly, at that time, constructing houses and infrastructures inside the RCs was not completed. There was no difference between new place and old place. Secondly, the livelihood

and income earning's ability was not improved as they relocated in new place. Living in one place and going to another place to get the job caused difficulties to the resettlers. That was why many of the poor did not want to joint the RCs in the first phase of program. Finally, living in new place would make life habit change and this was not easily accepted for many people.

However, after constructions and infrastructures of the RCs were mostly completed, the situation changed. Many people now would like to joint the program. Currently, Long An commune relocated 480 households among people affected by the flood and needed to be relocated. To move all of people still living in the vulnerable areas by the flood and landslides, in the period of 2008-2015 it will establish 6 new RCs and paths as the home for more than 900 target households. 70% of houses will be set apart for these target households who are mostly the poor. 30% of the houses left will be sold at the market price for the public. Currently, most of the resettlers did not have agricultural land. Before living in the RCs, they were very poor. After relocating in new places, their incomes and employments were not improved. Off-farm employment generating in the RCs was out of capability of the local authority.

The infrastructures of the RCs including intra-commune road, electricity system, clean water supply network, and waste discharge system were not completely designed. Generally, the infrastructures in the RPs were relatively better than that of the RCs. In the RCs of Long Hiep and Long Thanh villages, the waste discharge system was still bad and needed to be improved. In-house toilet system did not work and it was considered as the most serious problem that RCs had now. Currently, households can get a loan to make their own in-house toilet instead of using a badly in-house toilet system built by contractors. Table 6 summarizes the managers' evaluation on the RP.

Table 6: Managers' evaluation on the resettlement program

Evaluation	Description
General evaluation	<ul style="list-style-type: none"> <li>- Management board was a representative of the Tan Chau District's People Committee in managing and monitoring the RP.</li> <li>- Commune's People Committee had responsibility in selecting the target households based on the provincial authority's regulations.</li> <li>- Most of the target people were the poor.</li> <li>- Majority of resettlers had no stable job. Main income sources were from on-farm tenant activities.</li> <li>- Since relocating in the RCs and paths, livelihood of the resettlers was not considerably improved.</li> <li>- There still were many households affected seriously by the flood that need to be moved to the RCs.</li> </ul>
Reasons that people did not prefer to take part into the program prior to 2005	<ul style="list-style-type: none"> <li>- The poor's financial ability was limited.</li> </ul> <p>House construction and infrastructures were not completed and had poor quality.</p>

	<ul style="list-style-type: none"> <li>- Job seeking was not easy.</li> <li>- People did not want to change the custom and the life condition in the new place.</li> </ul>
Reasons that people preferred to take part into the program	<ul style="list-style-type: none"> <li>- The poor was allowed to borrow money to buy the allotment and house.</li> <li>- Infrastructures were now completed.</li> <li>- People can use clean water.</li> <li>- People's perception on the impacts of the flood and the benefits of the RP was considerably improved.</li> </ul>

*Source: the survey (2007).*

#### **4.3 Resettlers' evaluation**

To have evaluation of the insiders about the resettlement program, two FGD surveys were done with one for those who were living in the RCs and another one for those who were living in the RPs. Variables included income generating activities, causes making people to move to live in the resettlement cluster, evaluation on advantages and disadvantages of living in the resettlement cluster, evaluation on state of the resettlement cluster, people's satisfaction, and recommendation on the resettlement program. The FGD result showed that before resettling in the RCs, they earned income from different sources such as on-farm and off-farm employment activities, and fish catching activities. In addition, there was no change in income sources and employment since they relocated in the RCs. Because of the long distance between the old place and the new place (i.e., the RCs), some of them did not keep agricultural land. This made their current livelihood more difficult than before. The reason that made them decide to relocate in the RCs was the danger of the flood and landslides. The resettlement program gave them a chance to have a better life. They were supported by making a loan to buy a piece of land inside the RCs. They can borrow a zero-interest loan of 7,000,000 – 10,000,000 VND with the preferential 6-year time.

There were some advantages of living in the resettlement cluster. Firstly, the life condition now was better. They had not to move away when the flood comes in. They felt safer for their children and old people when they had to find a job at another place. Secondly, the quality of life was improved. Water and electricity supplied, healthcare services accessed easily, road network available, going to school convenient were examples of improved quality of life of living in the RCs. All of respondents were very satisfied with the life condition in the resettlement cluster. Besides benefits they got, there were still some disadvantages that made them disappointed. Firstly, distance to getting job was far than before. They had to take more time to go to work outside the RCs. Secondly, for the poor, while their incomes did not increased and even decreased paying extra expenditures of water and electricity bills that they did not have to pay before was actually a burden in their family budget. Besides the positive opinion there were a lot of problems that need to be solved. Firstly, quality of house construction was very poor. In-house toilet system did not work since they lived in the RCs. Although they made many complaints to the commune authority and the program's management board, this situation was not improved at all. Secondly, infrastructure in the RCs was not completely built. Water discharge system did not function well during the flood season. Many areas in the RCs were



inundated when either a heavy rain or the flood came. The poor quality of house construction and infrastructure within the RCs was due to the poor project implementation and the lack of participation of the beneficiary households. In reality, the constructor built the house including an in-house toilet at the cost equal to the price that the resettler paid. The constructor was assigned by the board of management. The resettler had no right to involve in the process. After the house was built, the resettler was informed to receive the house. Consequently, with the low price of 10 VND million, a poor house was sold for the resettler. Thirdly, there was no job opportunity for those who were living in the RCs. Table 7 summarizes findings from the FGD surveys.

Table 7: FGD results of the households living in the resettlement cluster/path

Item	Before living in the resettlement cluster/path	After living in the resettlement cluster/path	Change <sup>a</sup>
Income sources	Tenant in agriculture & non-agriculture activities, and fishing catching.	Tenant in agriculture & non-agriculture activities, and fishing catching.	~
Agricultural land	Some of them had their own agricultural land.	They sold their pieces of land because they cannot go to work at the long distance.	-
Subsistence activities	Besides main income sources they raise vegetable, chicken, and pig.	They were not allowed to raise animal around their houses or inside the RCs.	-
Life condition	<ul style="list-style-type: none"> <li>- Some of them had no houses.</li> <li>- There were no electricity, clean water system, and health services in the old place.</li> <li>- Children had difficulties to go to school during the flood season.</li> </ul>	<ul style="list-style-type: none"> <li>- Basic life conditions were ensured.</li> <li>- Electricity and clean water supplies, and health services were easily accessed.</li> <li>- Children went to school easily.</li> </ul>	+
Living with the flood	<ul style="list-style-type: none"> <li>- Most of them lived in the dangerous areas affected by erosion and the flood.</li> <li>- During the flood season, their livelihoods were badly affected because they had to stay at home to taking care their children and old people.</li> </ul>	<ul style="list-style-type: none"> <li>- They now can go out to find a job whole year without caring about the flood affecting to their children and old people.</li> </ul>	+

<sup>a</sup> + increase/ - decrease/ ~ unchanged. *urce: the survey (2007).*

To evaluate the impacts of the resettlement program on the livelihood of the resettlers, household surveys were implemented. Changes in income sources, facility uses, and job opportunities were compared in the before-and-after analysis frame. Results in Table 8 show that there were four main income sources, namely crops planting, animal raising, on-farm tenant, and off-farm tenant. Tenant jobs were main incomes even when they lived in the RCs. These incomes tended to increase and, especially, it was important income source for those who live in RCs. About 92% of income now came from tenant activities while it was only 70% as they lived outside the RCs. Meanwhile, for those who lived in the RPs, income of tenant activities did not change so much and it was about 60%. Income source from animal raising decreased because that the regulation did not allow people to raise animal inside the RCs. These results were consistent with Xe (2006) 's survey. The survey showed the income per household was not mostly changed after living in the RC although the structure of income sources changed. Off-farm incomes increased significantly while on-farm incomes including employment activities decreased. Per household incomes of agricultural sector, employment activities decreased from 5.5 VND million to 3.7 VND million and 7.4 VND million to 5.6 million, respectively. In the other hands, per household incomes of non-agricultural activities and wage-earner activities increased from 3.0 VND million to 7.1 VND million and 4.7 VND million to 6.2 million, respectively. It can be said that structure change in income generating based mainly on tenant activities was a big challenge to the resettlement program.

Table 8: Changes in income sources of the resettlers

Unit: %

Income source	Resettlement cluster			Resettlement path		
	Before	After	Change <sup>a</sup>	Before	After	Change <sup>a</sup>
Crops planting	14.2	8.3	-	27.8	27.0	-
Animal raising	16.1	0	-	14.6	12.4	-
On-farm tenant	47.6	52.5	+	24.9	23.6	-
Off-farm tenant	22.1	39.2	+	33.7	37.0	+
Total	100.0	100.0		100	100	

<sup>a</sup> + increase/ - decrease

Source: the survey (2007).

For the job creation, most of them said that the job opportunity was not improved. In the RCs, on-farm tenant activities became more difficult. 60% of them thought that the situation was worse than before and 35% of them thought that the situation did not change. Reasons that made difficult to find on-farm job could be because of the distance from the RCs to the place of job finding. Many people lived in the island before moving to the RCs. Living in the new place at the long distance had the difficulties in getting the job information in the old place while job opportunity in the new place was not easy to find. The opportunity of finding off-farm job was a little better. There were 35% of them getting more chance to find a job while 25% of them said

that they had the difficulties to find a job. Those who got more off-farm jobs were the ones previously having income mainly from the on-farm activities. Since the on-farm jobs decreased, they had to get other jobs from off-farm activities. In addition, there were 85% of them having difficulty in seeking a job during the flood season. For those who lived in the RPs, most of them did not see any improvement in seeking a job. Some of them thought that it was better and the other thought that it was worse than before. In the flood season, it was not clear whether the job finding was difficult or not. Table 9 presents the results of evaluation on job opportunity.

Table 9: Resettler's evaluation on job opportunity in the resettlement cluster

Unit: %

Job opportunity	Better	Worse	Unchanged	Total
<b>In resettlement cluster:</b>				
- On-farm job	5	60	35	100
- Off-farm job	35	25	40	100
- Job opportunity in the flood season	0	85	15	100
<b>In resettlement path:</b>				
- On-farm job	10	10	80	100
- Off-farm job	15	30	55	100
- Job opportunity in the flood season	35	35	30	100

Source: the survey (2007).

Benefits that the resettlers had when they lived in the RCs were public services as health care and communication. Uses of electricity and clean water increased. Almost households living now in the RCs used clean water while previously just few of them could do. In addition, all of them had in-house toilet although the quality of the toilet system was not ensured. Table 10 presents the before-after analyses of accessing public services and in-house toilet installation.

Table 10: Percentage of households accessing the facilities in the resettlement cluster

Unit: %

Facility	Resettlement cluster			Resettlement path		
	Before	After	Change <sup>a</sup>	Before	After	Change <sup>a</sup>
Electricity	30	100	+	85	100	+
Clean water	10	100	+	35	95	+
In-house toilet	5	100	+	20	100	+

<sup>a</sup> + increase/ - decrease

Source: the survey (2007).

#### 4.4 Outsider's evaluation

To get opinion of the outsiders about the resettlement program, a third FGD survey was done for those who were living in Tan Hau B2 village of Long An commune. The area is located near the RP of Long Hoa. It is annually affected by the flood. In the interview, questions about status of landowner, on-farm and off-farm income generating activities, causes making people not to move to the RCs, evaluation on advantages and disadvantages of living outside the RCs, and subjective evaluation on the resettlement program were implied in the discussion.

The result showed that most of them had their own agricultural land. Besides income generated from agricultural production, all of them earned incomes from on-farm and off-farm tenant activities. The income earning from these tenant activities exceeded the income earning from agricultural activities such as rice planting and cash crops. This showed that they were mainly the poor. All of them expected to be targeted and selected by the commune authority for joining the resettlement program. Main reason that made them can not join the program was that they were not in the list of the “4 Nos”.

According to the respondents, there were advantages and disadvantages of living outside the RCs. One of advantages was that they got jobs easily. Living near the workplace helped them to earn more income. Another benefit was the stability of life condition. Custom and habit in their life did not change unless they moved into the RPs. In addition, people living in the RCs were not allowed to raise animals that are another savings sources for the poor while they could do. Although there were advantages of living outside the RCs, the outsiders coped with some disadvantages. Firstly, many of them were now living near dangerously eroded areas. So, it was not safe for them and their families during the flood season. This was the most disadvantage for the outsiders. Some of them said that because of safe problem they lost their incomes during the flood season as they had to quit job to take care their families. Secondly, some of outsiders said that their children were not able go to school during flood periods unless they move to live in the RCs. Going to school in the flood season was a dangerous thing for their children. In the study site, traveling during the flood season was very difficult. They expected that the government will establish more new RPs so that they would be able to take part the program. Table 11 summarizes the FGD results.

Table 11: Advantages and disadvantages of living outside the resettlement path

Advantage	Disadvantage
- able to raise animal around the house.	- vulnerable by the flood or landslide.
- near the workplace/easy to find a job.	- bad transportation condition during the flood season.
- no change in life condition and custom.	- unable to go to school during the flood season.
	- no clean water to use.
	- no health care services.

*Source: the survey (2007)*

The FGD results showed that the outsiders were seriously affected by the phenomenon of flooding and landslides. It was extremely dangerous for those who were living in the eroded areas along Kinh Sang river. To evaluate the public awareness about the impacts of the flood, a household survey was implemented in this area. Most of people agreed that the landslides of river bank was because of the annual flood. During the flood season, almost economic activities were interrupted and life condition was changed as well. 100% of them thought that flood was evil. They worried about their lives, assets, and jobs. All of them were willing to move to another place for safe. To live with the flood there were some ways in which building the RPs was recommended by the majority. Table 12 presents some recommendations to cope with the flood.

Table 12: Opinions about the way to live with the flood

Recommendation	Percentage
Establishing the resettlement path	70
Building dyke system	5
Raising the house's stilts	20
Moving to the higher place temporarily	5
Total	100

*Source: the survey (2007)*

## V. CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

People in the VMD recognized that floods have both negative and positive effects. Besides huge damages, floods bring a lot of benefits for the people, especially the poor. They knew how to adapt and response to floods since long time ago. Since 1990s, the government invested more efforts and capital to cope with the disastrous floods. Until the end of last decade, the new perception on flood situation in the VMD so-called “living with the flood” policy was officially accepted. Under this policy, the VMD’s socio-economic development strategy was linked with the adaptation to the flood situation.

The resettlement program was designed for the permanently inundated areas at the VMD since 2001. It was expected to be completed at the end of 2005. Total investment capital for the program was approximately at 200 \$US million. However, the program was not completed yet. There were still 184 RCs not be finished. Vietnamese government decided to accelerate the program so that in the end of 2007 the program would be completed. There were two kinds of the resettlements, namely RCs and RPs. The RC was built at one place while the RP was built along the inter-commune roads. In many RCs public infrastructures such as internal road system, marketplace, clinic, school, and so on were not completed. The RCs even had no completed waste discharge systems. Financial element was also a problem that the program faced. Many resettlers were the poor. Therefore, the capability of refunding loans to the government was still a policy question. Another thing was the employment problem. Review analyses and FGD

survey showed that the insiders' income decreased. Livelihood not improved became a big concern for the insiders. To enable the program to be sustainable, financial supportive policy and job creation would be the priorities on the policy maker's table.

Although there were still complaints for the program's implementation, most of the insiders felt satisfying with the program. Thanks to the program, they had a better life. For those who living in the permanently inundated areas, the program was the best choice for the poor. FGD survey for the outsiders also revealed that they expected to move to live in the RCs. There were still many people who are affected by floods. Enlarging the program was a measure that needs to be in consideration.

However, there was a policy question for the appropriateness of the resettlement program in the context of the LWF policy. Floods affected a large area of the VMD while the RCs were built at areas affected mostly as a requirement of the program. Limited by the financial capacity, this program was not able to solve for whole region. Affected by the global climate change, it was predicted that the VMD would be mostly worsen by the flood situation. To protect whole region of the VMD via this program, the government had to invest billions of \$US while the results of the program was still forward. At the moment, this investment decision was impossible since it was too early to tell about the success of the program. Resettlement program was currently coping with many problems such as a financial constraints, livelihood condition, and the quality of infrastructures.

Another competitive approach vis-à-vis the resettlement program in the context of the LWF policy was to establish temporary residential clusters instead of permanent RCs. During the flood season, people would move to residential clusters for safe and return their home after the flood. This approach realized that flood brought more benefits than evils. People could avoid floods at the time it came and harvested it all times. In the other hand, the government was able to front at the larger area and a higher scale with a reasonable investment. This was very important to the VMD's flood situation that was heavily affected by the global climate change in the future.

## **5.2 Recommendation**

In the long run, to cope with floods effectively, people living in the inundated areas need to adjust habits, social and economic activities in order to adapt to floods. By realizing that flood situation would be more serious due to the impact of the global climate change, instead of coping with floods the LWF policy is probably the best strategy. Exploiting the flood is better than preventing it. This approach allows the VMD maintain the natural characteristic of flood phenomenon that people actually adapted since they come. To direct its residents to realize and react to adapt the flood situation, government plays a very important role. At the national level, planning economic development strategies in the VMD needs to be consistent with the LWF policy. At the local level, authority needs to persuade people to change the realization towards adapting to the flood and choose the way to live with the flood.

Regarding the resettlement program, the most important thing to do right now is to complete the construction of infrastructures for the RCs. Although the local authorities at the program site announced that the RCs are mostly completed, the real situation showed that they are not as expectation. The poor quality of public infrastructures causes the limitation of the program's success. Especially, the water discharge system in the RCs is very bad and it does not

work properly during the flood time. Furthermore, the poor quality of house construction and poor in-house toilet system are the biggest concerns of the insiders. It is recommended that additional measures need to be added so that the program can be completed.

In order to ensure the quality of the RCs, some processes in designing, implementing, and monitoring the resettlement project need to be improved. Designing the RCs should have the participation of the commune authority and the community so that the construction of infrastructures and houses within the RCs satisfies with the real conditions. It should not be that the RCs have the same design for all. Especially, designing the discharge treatment system for the RCs should be re-examined to ensure that it can work during the flood season. In implementing the construction of the RCs, constructors are currently assigned by the management division of district authority. They are not in the control by the commune authority and the board of management of the RCs who could know the situation and real condition better. The problem of poor quality of the RCs could be solved if the participation of the commune authority and the board of management of the RCs is designed in the process of project implementation. In monitoring the construction of infrastructures and houses in the RCs, participation of the beneficial households is an important factor to ensure the quality of constructions. For the construction of in-house toilet system, it is recommended that households will implement instead of the constructors.

The demand of living in the RCs is potentially huge. The enlargement of the program is necessary in the coming time. Examples in the study site showed that the public awareness of adaptation to the permanent inundation situation is going up. Benefits that the insiders have are observed by the outsiders persuaded their own willingness to join the program. Therefore, in the long run the government needs to continue enlarging the program covering all kinds of people affected by the flood situation.

Although the program satisfies most of the poor, the fact that livelihood condition is not improved is a big concern of the insiders. The review analyses revealed that the insiders' income was lower than the outsiders' income (Xe 2006). Moreover, the FGD survey showed that the insiders had more difficulties in getting jobs than before living in the RCs. So, measures to create new jobs which are mainly off-farm activities are needed. It is recommended that social programs such as rural poverty alleviating, traditional "trade village" development, works for rural youth, etc, need to be linked to the resettlement program. This is very important in policy making's point of view. A resettlement program standing for alone is not enough, it also requires synchronous measures to enable the program successful.

Environmental consequences of the program need to be in consideration. There are some aspects of environmental impacts for the resettlement program. A poor water discharge system and a badly in-house toilet system will cause negative impacts for the insiders. One of the things is the problem of health hazard. Especially, it becomes a very serious problem during the flood time. Evaluating the costs of health hazard is necessary to be done in the context of the program. Broadly, a comparative analysis of insider-outsider's health hazard problem should be implemented to measure the impacts on human by a poor living condition in the RCs.

To enable the program to be sustainable, a financial supporting policy needs to be revised. In the context of the program, most of target households are the poor. In the survey, most of them got big worries about capability of repaying the loans. Presently, some of borrowers are in the time schedule of making the payment for the bank. They are now incapable

in repaying the loans. A revised institutional financial policy is necessary to help the poor to be able to pay the loans.

This study is implemented in the areas affected mostly by the floods in the VMD. The fact that floods come more frequently and more seriously is probably because of the impact of climate change. Living with floods via the resettlement program in the VMD would be a lesson for territories and places facing the state of the impact of sea level rise.

Finally, this pilot study simply describes what is happening with the LWF policy implementation and resettlement program in the VMD. Difficulties in designing, implementing, and monitoring the resettlement program need to examine in order that appropriate policy advisories can be withdrawn. Factors affecting to the successfulness and unsuccessfulness of the program should be analyzed comprehensively. It is recommended that more cases studies for future research will be done for other places within the VMD so that the comparison between the RCs in the different places can evaluate results of the resettlement program better. In this proposed research, dimensions of year of resettlement construction, ethnic element, poverty level, etc, are criteria to select RCs for study.

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## **Roles of Local People in Building Resilience for Disaster Risk Management: A Case Study of Flood-prone Village along Mekong River of Cambodia**

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## Abstract

Cambodia is one of the most hazard-prone countries in the region. Flooding of the Mekong River in Cambodia is an annual occurrence to which many aspects of some livelihoods are well adapted but can not for others, especially in extreme years, causes significant property losses and damage. Impacts are experienced in agriculture, infrastructure, human lives and well-being, livestock and socio-economic activities each year. As a consequence, the government of Cambodia prioritizes disaster management as one of the key elements in strategies for poverty alleviation. The study focused the impact on the villagers residing along the Mekong River of Cambodia, to explore the degree of participation of the local people in disaster risk management; and to develop an approach of the community for resilience in disaster risk management.

The study was conducted in Angkor Ang village, Angkor Ang commune, Peam Chour district, Prey Veng province, Cambodia. The primary data was basically obtained from a household survey with sampled households stratified by poor (PHHs) and non-poor households (NPHHs). The primary data collection methods were applied including field observation, key informants interview, focus group discussion, seasonal calendar and social mapping.

The study shows that Angkor of Ang village of Peam Chour district is one of the most affected in Prey Veng province as well as in Cambodia. The flood hits the village every year and has brought the village into the vulnerability and the poverty. Thus, the participation of the villagers is very necessary which enable them to be involved in planning and development-related activities. Yet, the current capacity and resource available cause the villagers passively participated and deeply dependent on external institutions. They could not initiate by themselves and needed the external institutions to facilitate or to lead. This is why the activities may be disappeared when the development project ends. Moreover, the existing development activities are implementing in a short period of time which could not be able to build their capacity and to sustain the activities when the external support completed. Thus, the multi-sectoral involvement is the most appropriate mechanism for the impact mitigation with an initiative to establish the community-based organization (CBO). In this regard, the capacity of the community-based organization (CBO) was required to build up under support from the external developers for the resource mobilization and community development, otherwise, the Self Help Group (SHG).would become a So Hopeless Group (SHG). The existence of the community-based organization (CBO) could allow all the stakeholders to closely work by applying a LOSE Approach including Life, Owning, Socio-economic, and Environment.

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## KEY WORDS

Resilience, Disaster Risk Management, Community Participation, Flood-prone Village and Cambodian Mekong River

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## **I – Introduction**

As one of the world's least developed countries, Cambodia is vulnerably exposed to natural disasters such as floods and droughts as well as occasional typhoons and epidemics (ADPC, 2007). The annual frequency of disasters' occurrence have relatively been contributed to the current poverty of 30.1 % (NIS, 2008) and brought an additional challenge to the human development situation. In Cambodia, flood is the main natural resource disaster resulting from a vast flood plain which is one of the country's most prominent geographical features (CIA World Factbook, 2004-2008). Flood causes from the monsoon season along the Tonle Sap Great Lake and the Mekong River. It hits Cambodia with two distinct types of patterns – the flash floods and the flash flood and large-scale flood. The flash flood causes from heavy downpours upstream on the Mekong River, which usually affect provinces along the Mekong River and the south-eastern areas of the country. While, the large-scale flood in the central area results from a combination of runoff from the Mekong River and heavy rains around the Tonle Sap Lake and it affects the provinces around the lake and the southern provinces (UN, 2001; CARE, 2002; ADPC, 2002; WB, 2005).

The paper mainly aimed to examine the impacts from flood on villagers residing along the Mekong River of Cambodia, to explore the degree of participation of the local people in disaster risk management; and to develop an approach of the community for resilience in disaster risk management. The paper is structured as follows: Section 1-Introduction; Section 2-Study Area and Methods; Section 3-Literature Review; Section 4-Flood Disaster in Cambodia; Section 5-Participation of the Local People in Angkor Ang Village; Section 6-Approach of the Community for Resilience in Disaster Risk Management; and Section 7-Conclusions.

## **II – Study Area and Methods**

Located in the plain region, Prey Veng province has Vietnam on its southern border. It has a total population of 947,372 people (NSI, 2008). The population constitutes 7.07 percent of the total population with a growth rate of 2.40 percent consisting of 453,082 male (47.8%) and 494,290 female (52.2%). Out of the total, 80.54% are farmers, 13.72% are fishermen, 4, 35% are traders and 1.39% are government's officers (2001, Provincial Government Data). Peam Chour is one of the 12 districts of Prey Veng province located 52 km south from the provincial town, lying along the Mekong River and its tributary Tontle Touch. It shares borders with Preah Sdach district in the east, Peam Ro district in the north, Leuk Dek district (Kendal province) in the west and Vietnam in the south. The district has a total population of 67,531 people with 14,367 families, mainly made up of 4 nationalities: Khmer, Vietnamese, Cham and Malay (MAFF, 2003-2007).

In Peam Chour district, the key main occupation of the people were farmers (83%), vender and craftsmen (3%), garment factory workers and construction contractor (4%), civil servant, arm forces and military (4%) and fishermen (6%). The living status is categorized into 3 types: moderate (25%) for those who could earn from USD 0.48 – 0.60 per day; fairly poor for those could earn from USD 0.12-0.37 per day; poor for those who could earn USD 0.12 per day. For the vender and craftsmen could earn from USD 0.72-1.22 per day (Peam Chour DCDM, 2007). The research study was purposively selected Angkor Ang commune. Angkor Ang is one of the 10 communes of Peam Chour district which have a total population of 4,908 people (965

families) including 5 villages. There are totally 2,460 inhabitants (397 families) in Angkor Ang village.

The study area, Angkor Ang village was purposively selected. The households were randomly recruited by stratifying as Poor Households (PHHs) and Non-Poor Households (NPHHs). As the result (397 households of the total population), 140 respondents based on (Yamane, 1967) were contacted for the interview during the field survey. The primary data was basically obtained from a survey by using social tools and participatory approach. The primary data collection methods were applied including a household survey, field observation, key informants, community meeting, seasonal calendar and social mapping. In data analysis process, both qualitative and quantitative analyses were used. The Statistical Package for Social Science (SPSS) software was employed for data processing and analysis including descriptive (frequency, percentages, average, means and cross-tabulation) and statistical analysis (Weighted Average Index based on 3 social scaling technique and T-test application). The qualitative analysis was mainly using statement analysis from the documents, content analysis, problem loop to analyze the interrelationship of several factors related to the study village.

### **III – Literature Review**

#### **3.1 – Disaster, Vulnerability and Poverty**

The term “*disaster*” is an extreme disruption of the functioning of a society that causes widespread human, material, or environmental losses that exceed the ability of the affected society to cope using only its own resources. Even such as tsunami, earthquakes, and flood, by themselves, are not supposed disasters. It is meant to be unless they harmfully and gravely affect human life, health, property and livelihood. In the same time, Helmers (2002) pointed out that the annual flood become a disaster for rice farmers only when they come too early in the crop growing cycle destroying rice seedlings before transplanting or come too high, for too long, destroying established wet season rice crops. Invariably rice farmers define disaster flood as those that destroy the wet season rice crop and other agricultural products and result in extended food shortages. While a link to global climate change has yet to be established, disaster flood has come to occur in Cambodia with greater frequency in the new millennium.

The initiative or the flood disaster risk management is due to the household living condition and status. Poverty might affect capacity of local people to protect themselves and their property, as well as their ability to reside in areas having less exposure to risk. Annually, floods bring huge losses of life and severely impact the large populations. In comparison, the poor are the most severely affected by all natural disasters. The three buzz-words—poverty; vulnerability; and disaster are mutually reinforcing. Several factors including low income, poor housing and public services, lack of social security and insurance coverage force the poor to perform in ways that expose them to greater risk. Since the impacts of natural disasters are likely to disproportionately fall on the poor, therefore specific policies are needed to undertake the link among poverty; vulnerability and disaster. In this sense, the disaster risk reduction and poverty alleviation must be closely linked to mitigate the vulnerability of the people (UN, 1998).

Additionally, the poverty and vulnerability are relatively correlated in both direct and absolute states. The main indicators of poverty are of limited access to resources and income activities and it is only one of the several dimensions of vulnerability. Blankie et al. (1994) explained the

linkage between poverty and vulnerability by pointing out that “vulnerability is a combination of characteristics of a person or group, expressed in relation to hazard exposure which derives from the social and economic condition of the individual, family, or community concerned. High levels of vulnerability imply a grave outcome in hazard events, but are a complex descriptive measure of people’s lack or need. Vulnerability is a relative and specific term, always implying a vulnerability to a particular hazard. In addition to the economic dimension, there are other aspects of social positioning that determine poor people’s vulnerability: class, ethnicity, community structure, community decision-making processes and political issues (e.g. MoP, 2005; WP, 2005; CIA World Factbook, 2004-2008).

A poor community may be economically suffering but at the same time may have social, cultural and political capacities to cope with disasters. Risk reduction strategies for the poor should work towards reducing economic vulnerability and at the same time capitalize on (and perhaps nurture) the inherent social and cultural capacities of poor communities. It is vital that while increasing the economic resilience of vulnerable communities, physical, social and political risks are also known and managed. There is another aspect of vulnerability of the poor, which is frequently ignored: it is often local in nature. In general, the impact assessments capture only the formal and well-defined sectors of the economy. It is becoming clear that the nature of vulnerability of the poor is multifaceted and varied. Therefore, reducing risk to the poor require multi-dimensional approaches and innovative institutional arrangements (Yodmani, 2002)

### **3.2 – Community Development and Roles of Local People**

According to the SIL International (2008), community development is a process of assisting a community in strengthening itself and in developing towards its full potential. It is believed that a community could be developed through 10 principles as healthy process: (1) start where the people are; (2) build relationships; then introduce new ideas, showing how they meet identified needs; (3) keep projects simple; (4) involve as many community people as possible in all activities from the start; (5) train people close to their home communities; (6) train in locally acceptable ways (e.g. methods, facilities); (7) train trainers who can train others; (8) involve local leadership; cooperate with governments; and (10) encourage interdependent relationships vs. dependent or totally independent relationships. In terms of financial resource, the government might not be able to support all worthwhile development initiatives. Requiring an initial resource commitment examined that this is not going to be another government "giveaway" programme. There are many programme interventions would probably function better without the involvement of government at all. Additionally, the act of making a resource commitment will make the contributors more concerned for the success of the development initiative than they otherwise might be. Such a commitment will provide a concrete indication of how interested the community members are in a new initiative. The correlation between such resource commitment and overall project success were observed (Gow, et al, 1981).

Moreover, Ayee, (2000) concluded that the local people must be supported to help themselves however the local people could not be able to mobilize the existing resource for the community development by their own. Without help from external facilitators, the local people would not be in a position to benefit from development assistance programmes specially designed for them. If they are not assisted properly, new programmes will lead to further dependency. The local



capacity needs to be built up first. If people have to be active partners in designing projects and later have to work closely with government agencies in implementation, monitoring and evaluation, they must make a resource commitment which could be in either cash or kind. There are many development programmes have failed because the targets were not solely directed to certain unprivileged groups (Heck, 1979). If the participation is to be a self-sustained process, one that will not wither away once the external facilitators leave, the local people has to be equipped with practical skills. In particular, knowledge and information are crucial to make participation a continuing activity and to give the people an idea of what their rights, roles and responsibilities are. It is a true that the local organizations of the poor are not available in everywhere. Even where they position, they are not in a very good shape. Very little is known about these organizations and their capability for interaction with official implementation agencies in rural areas. There is a tendency to set up new organizations to promote development, and to dismiss the existing traditional organizations and networks as of no particular relevance to development work. Experience indicates that indigenous organizations can prove to be far more dynamic in mobilizing people to join hands with official agencies in the promotion of various development programmes (Mathur, 1996; Cernea, 1983)

The participation of all its members, regardless of sex and age are very necessary for the community development. In general, men had a dominant role within households in the rural community. The man is usually the head of the family, excluding in special conditions. The men administer the family belongings, sort out and direct the agricultural activities (Hoskins, 1980). It is a true that in most societies that men carries out the hard work such as construction even if, most of the time, the women are in charge of transporting the local material. In terms of basic livelihood, men are engaged in clearing, ploughing, preparation of the land for planting, sowing, planting, bedding out, while women take care of the crops and harvesting. In contrast, Cruz (1980) suggests that is this due to the fact that programme authorities accept the traditional allocation of roles according to sex or does it mean that there is no need to mention it because women and men participate equally in all operations?

#### **IV – Flood Disaster in Cambodia**

Cambodia is considered one of the most hazard-prone countries in the region and the flooding in 2000, 2001 and 2002 continually impacted with a very huge damage in terms of human death and economic loss. Flooding of the Mekong River is a regular occurrence bringing human suffering and economic losses. Acutely affect poor families are driven poverty, food insecurity, low production and homelessness. The worst flooding in 2000 within 70 years affected 22 out of the 24 provinces in Cambodia, with a death toll of 347 people, of which 80 percent were children. More than 3.4 million people were affected and physically damaged totaling US\$161 million. The flood in 2001 killed 62 people and the totally estimated losses were US\$ 36 million. Again, in 2002, flood hit the Mekong countries. In Cambodia alone, the flood killed 29 people and the total extent of damage was over US\$12 million. In 2003 and 2004, flood was very mild and led to drought issues (MRC, 2005).

##### **4.1 – Flood Disaster and its Impact in Peam Chour District**

Peam Chour district of Prey Veng province lies along the Cambodian Mekong River, its tributary and other streams. The flood of the Mekong River is a regular occurrence in the district which annually damages and suffers in terms of human death, agriculture, crops, infrastructure, animals

and socio-economic impacts. The district also experienced the flood in 2000 which recoded as the most severe in more than 70 years. Table 4.1 shows that the flood in 2000 killed 12 people and hugely affected to people livelihood (59,283, with 29,763 women) and animal death (246). The flood also damaged so many public and individual physical infrastructures namely house (123), wet season rice (3,624 ha), crops (1,905 ha), canals (4,317 m), dams (3,271 m), water gates (13) and bridges (8). The deaths, losses and damages were due to a very fast water volume increase. In the mean time, the community-resilience on the annual flood occurrence made people less attention paid with unexpectancy of the incident.

**Table 4.1 – Flood Disaster and its Impact in Peam Chour District**

<b>Damages/Suffers</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>
	high	high	medium	low
Affected communes	10 (50 villages)	10 (40 villages)	10 (35 villages)	
Human death	12	08	0	01
Human injury			360	
Affected population	59,283	1,528	4,626	
Animal death	246	139		
Affected house	123		3,245	
Damaged house	123	162	09	32
Damaged wet season rice	3,624 ha	1,785 ha	1,060 ha	
Damaged crop	1,905 ha	2,840 ha	115 ha	
Damaged roads/trails	10,482 m	7,258 m	16,000 m	
Affected school	13	32		
Damaged schools		1		
Damaged dams	3,271 m		11,487 m	
Damage canals	4,317 m			
Damaged water gates	13			
Damaged bridges	8	5	11	

Source: ADPC, Phnom Penh, Cambodia (2007)

Note: xxx = high, xx = medium, x = low; ha = hectares; m = meters



Still, the flood in 2001 was very high which killed 8 people, damaged rice (1,785 ha), damaged crop (2,840 ha). It was a remark that there was no any report of human death in the 2001 flood however the destruction of roads/trails was the highest (16,000 m). The continually-enormous death, loss and damage, in particular, in 2000 and 2001 have brought the villagers with both suffers and awareness on the flood impact. As the result, from 2002, regardless big, medium or small flood's suffers and damages have been reduced due to the awareness of the local people which self-preventive measure were taken into account. Additionally, the attention from governmental agencies, the Red Cross and development partners have paid more attention for capacity building, training, community meeting, in particular, warning system equipped. Also, the socio-economic impacts have been afforded by national and international NGOs to ease the villagers after the impact through construction and rehabilitation.

#### 4.2 – History of Flood Disaster in Angkor Ang Village 1997-2007

Table 4.2 shows the flood disaster and its impact in Angkor Ang village of Peam Chour district from 1997-2007 derived from the social mapping and seasonal calendar during the field work conducted 2008. Within a period of 11 years, it was recorded that the flood in 2000 was the most severe which killed up to 6 people in the village. The reason was that the water volume unexpectedly increased approximately 1.5 m per day and night. Additionally, the flood in 1997 killed at least 3 people and also seriously damaged livestock, agriculture and infrastructure. From the tragedy of the worst catastrophe in 2000, the local people started to be aware on its consequences. The high level of awareness of the local in the village brought them with preventive measures. As the result, the people were able to survive from death during the flood however the livestock, agriculture, crop and infrastructure were still damaged and impacted slightly or hugely depending on the water volume. This signified that the local people were ready to be resilient and to strike the annual flood.

**Table 4.2 – History of Flood Disaster in Angkor Ang Village 1997-2007**

Vulnerability	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Human death	3	1	0	6	0	0	0	0	0	0	0
Residence	xxx	x	x	xxxx	xxx	xx	x	x	x	x	x
Livestock											
Agriculture											
Crop											
Infrastructure											

Source: Field Work (2008)

Note: xxxx = the worst, xxx = severe, xx = medium, x = small

### 4.3 – Flood Disaster and its Impact in Angkor Ang Village

The flood from Mekong River has brought the villagers with pros and cons in terms of income e generation activities and harm. The water and fertilized mud can be used for agriculture and gardening. Still, agriculture (rice) remained the primary source of income but gardening for many types of vegetables are complementary for their subsistence and prosperity. During the flood, death, loss and harm might come at anytime to the local people if they do not have a well-designed preventive measures and actions before the incident. The flash flood of the Mekong River has struck the study area annually and it also brought the community into resilient to the disaster due to the indigenous knowledge and self-adoption.

The death has been reduced since the worst large scale flood in 2000, 2001 and 2002. This is signified that the impact in terms of death is mitigated but loss and damage are still the main issues. The villagers are well aware of the impact of the flood disaster but the mitigation is still limited applied due to knowledge and poverty. The stronger house built is the most important to reduce damage and they do not need to go for secure hill, however, according to the District Committee of Disaster Management of Peam Chour, there were only 25 percent of people were non-poor so 75 percent others were fairly poor (35%) and poor (40%). Those poor and fairly poor households were not able to deal in preparation for preventive actions and measures.

**Table 4.3 – Flood Disaster and its Impact in Angkor Ang Village**

Multiple Answers

Status	PHHs		NPHHs		Total	
	N	%	N	%	N	%
	(N=202)		(N=163)		(N=365)	
Family members killed	0	0.0	0	00.0	0	0.0
Family members feared	58	82.9	62	88.6	120	85.7
Home damaged	26	37.1	07	10.0	33	23.6
Crop/rice destroyed	17	24.3	12	17.1	29	20.7
Property/facilities lost	48	68.6	36	51.4	84	60.0
Diseases infected	51	72.9	46	65.7	97	69.3

Source: Field Work (2008)

PHH = Poor Households; NPHHs = Non-Poor Households

Table 4.3 shows that there was no any death report of 2007 flood in the study area and the main impact from flood on both PHHs and NPHHs (85.7%) were fear, in particular, storms which could damage their home and sink the boats while they transport family members and the

property out for the secured areas. The water-borne disease (69.3 %) and property/facilities lost (60%) were also very concerned by the villagers. The home damage (23.6%) and crop and rice destroyed (20.7%) were also not much because it was not so strong. Yet, the loss and damage during the flood trended to be more seriously for the PHHs rather than the NPHHs of all the cases but only NPHHs were more fear. They were mostly fear of storm and loss of property so they mostly did not want to move from home unless they were alerted to be danger.

## V – Participation of the Local People in Angkor Ang Village

Table 5.1 describes the degree of the participation of the local people for the disaster risk management in Angkor Ang village of Peam Chour district, Prey Veng province, Cambodia. The study focused on the participation of the local people on the measures taken (before, during and after the floods) and community ownership and participation. Victoria (2002) pointed out that the local community is taken as the primary focus of attention (in disaster reduction) since that is the common unit which is affected by disaster and, more importantly, responds to deal with the event. Whether a disaster is major or minor, of national or local proportion, it is the people at the community or village level who suffer its adverse effects. They use coping and survival strategies to face and respond to the situation long before outside help from NGOs or the government arrives. They are interested to protect themselves from the damage and harm. This needs the local participation within the whole process- before, during and after the incident. From the group discussion, the local people were very keen to participate in mitigating the impact however the villagers had no innovation and initiative to deal with large flood. Additionally, the villagers had very poor position in decision making for community development and other disaster-related issues. In Angkor Ang village, the facilitation and financial and technical support from the external institutions were not stably in place within a long-term to build a stronger capacity of the local people. The local participation could not currently start from the villagers themselves and they needed the external institutions to facilitate but not lead so they could be able to sustain the involvement in the future.

**Table 5.1 – Participation of the Local People in Angkor Ang Village**

Status	PHH		NPHH		T-test
	WAI	OA	WAI	OA	
<i>Measures Taken ( before, during and after flooding)</i>					
Preventive measures	.28	L	.47	M	.000**
Rescue and response	.46	M	.45	M	.752
Rehabilitation and construction	.27	L	.69	H	.035*
Impact mitigation	.57	M	.66	H	.100
<i>Community Ownership and Participation</i>					
Awareness of community	.68	H	.69	H	.089
Decision making of community	.46	L	.37	L	.151
Participation of community	.73	H	.68	H	.0004**

Source: Field Survey, 2008

**Notes:** H = High, M= Moderate, L= Low, WAI = Weight Average Index

OA = Overall Assessment

(\*) Significant at 95% level of confidence

Poor	Moderate	Good
0.10-0.33	0.34-0.66	0.67-1.00

The T-test shows a significant different for construction and rehabilitation and perfectly significant different for participation between PHHs and NPHHs. The preventive measures taken by the PHHs were evaluated as poor (.28) and as moderate (.47) for the NPHHs, the rescue and response were assessed as moderate by both PHHs (.46) and NPHHs (WAI=0.45) and the impact mitigation was moderate for PHHs (WAI=.57) and good for NPHHs (WAI=.66). It was a common that the NPHHs could have a better preventive action in terms of food, medicine preparation. Also, the NPHHs could afford to build a stronger house and they did not need to move out for a small or medium-scale flood. Also, it was no doubt that the PHHs had less possibility to renovate the damage. In particular, the PHHs had higher effects than those who were from NPHHs. In terms of community ownership and participation, the T-test shows only a very significant different between PHHs and NPHHs related to participation of the community. The awareness of the local people on the community development and disaster were assessed as good in terms of indigenous knowledge and self-adoption. However, they had no much modern knowledge and technology for the prevention, rescue and response. The current knowledge and facilities available in the communities could only deal with small and medium flood and the villagers would not be completely able to deal with large scale flood.

## VI – Approach of the Community for Resilience in Disaster Risk Management

Figure 6.1 illustrates the Approach of the Community for Resilience in Disaster Risk Management in Mekong River of Cambodia. The approach is suggested as a cycle including “before”; “during”; and “after” the incident. The approach was drawn based on the findings in the previous sections of the study, key informants, group discussions and seasonal calendar. The impact mitigation is the only appropriate mechanism to get a resilient community through (1) developing an effective process for the preparedness; (2) establishing the timely emergent services for rescue and relief with food security insurance; and (3) creating development programme for the rehabilitation and reconstruction of the damaged facilities. The food security is important to maintain for the whole process: before, during and after.

Moreover, the community resilience to flood disaster needs (a) awareness raising and knowledge of the advanced measures on the disaster risk management; (b) interventions during the incident; (b) development activities (i.e. reconstruction and rehabilitation and income generation) and (c) monitoring and evaluation (M&E) system. The monitoring and evaluation (M&E) system is compulsory to set up in the community in order to follow up the trend of the social and economic impacts. The effort is required a comprehensive and multi-sectoral involvements where all the main actors from the government agencies, the civil society, development partners and the local people jointly putting their strong commitments in mitigating the impacts in terms of social, economic and environmental aspects. In particular, the villagers need more help to build their sustainable livelihood through Income Generation Activities (IGAs) and skill development. The interventions and development programme should be applied: before, during and after the flood incident.

Before, the flood strikes, the well-prepared and preventive measures are important for all the people living in the flood-prone area. The preparedness may prevent and mitigate the local people from death, loss and damage. Since, majority of local people have low education and have the advanced knowledge on flood disaster preparedness, in particular so they are at-risk when the large flood eventually occurred. In general, the local people were resilient to flood due to indigenous knowledge (passed by old generation, Social norm and tradition and culture) and self- adoption (home town, common problems and inability to move). However, those two sources of knowledge could not help them if the flood is in large scale like in 2000, 2001 and 2002. The preparedness is made for the prevention and mitigation by alerting the warning of “CARE” (family members, property and health condition) and “FEAR” (death, epidemic, loss and death). In the community, the Self-Help Group (SHG) is importantly established by the villagers themselves for relief, rescue, and update information while the external institutions such as national and international organizations is employed for relief, rescue, food, shelters and medicine during the flood incident.

In the meantime while, the government policy is totally significant for the resource tracking and mobilizing for flood reduction and management. The government policy should be anchored in the three “before, during and after” stages focusing LOSE approach. The LOSE concentration could prevent and reduce the loss of “Life of people and livestock”, “Owning of the local people and public infrastructure damage”; “Socio-economics of the local people” and “Environmental issue”. The response is referred to all the three key actors: the government in terms of policy and planning, the external developers in terms of technical and financial assistance and the local people in terms of physical and mental assistance. Through the observation and key informants with villager heads, there were no public facilities and equipments for rescue and relief during the small and medium flood unless the large one which is specially taken care by many national and international agencies. The 2 existing rescue hills are very small and insecure and the boat sponsored by CARE-International is now very old and not well maintained at the pagoda. The security is also needed to ensure for villagers’ property (Figure 2).

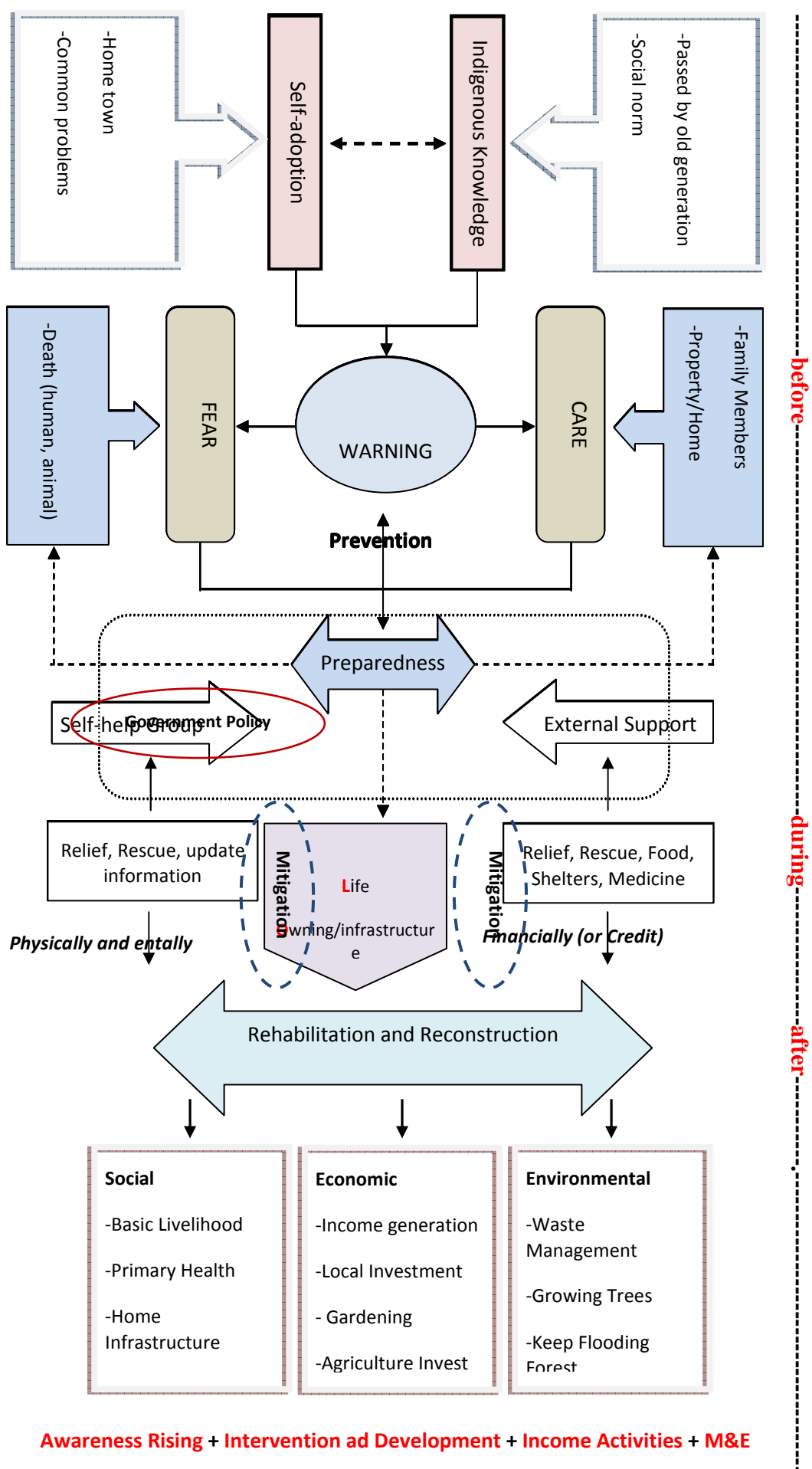
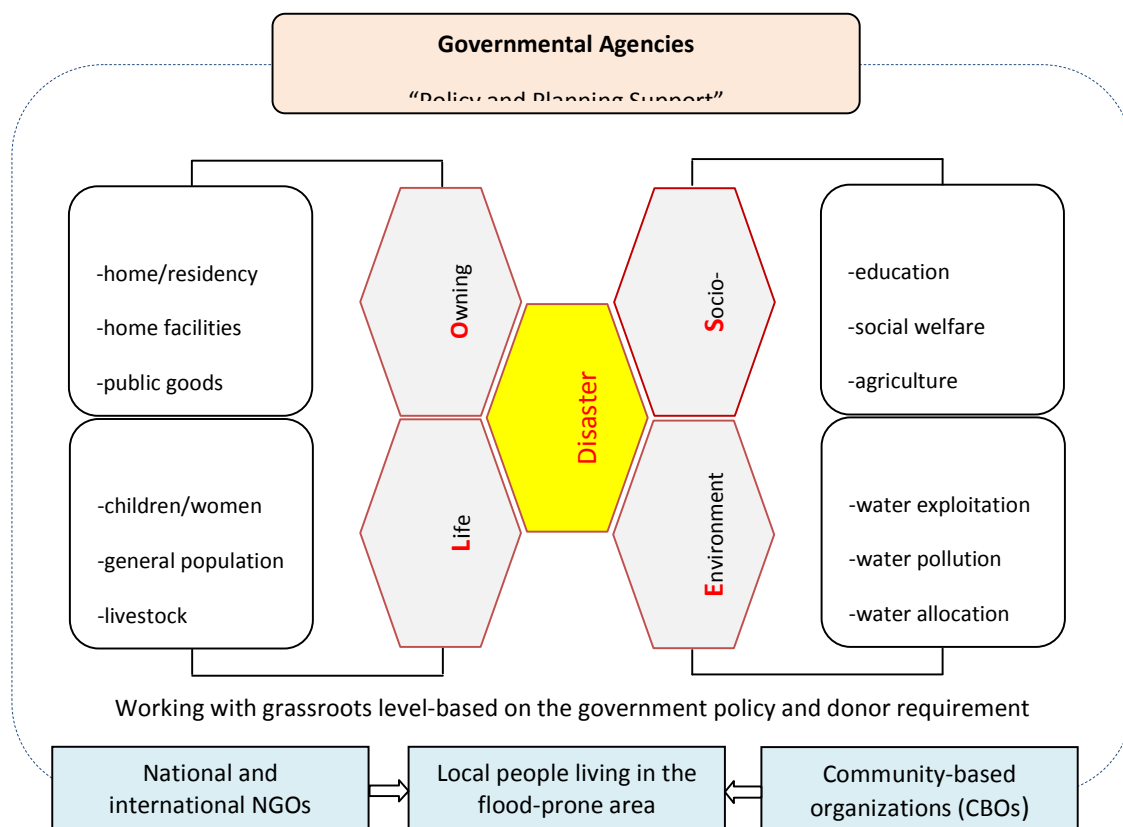


Figure 6.1 – Approach for Community Resilience on Disaster Risk Management in Mekong River of Cambodia

After the flood, the villagers still struggle with many other issues related to the restoration, development, the income generation and health activities. The villagers need to restore their livelihood for households' support from farm and non-farm activities. The mobility for employment in the town or neighboring countries might be emerged. In this regards, the social, economic and environmental aspects are considered as the most important elements in the duration of rehabilitation and reconstruction. The three aspects are required to be equally shared and balanced. The public goods and infrastructures in the community are rebuilt; meanwhile, the basic livelihood and health issues of the villagers are also sustained in which they could start as soon as the flood ends. The resilient to flood disaster could prevent and mitigate the impact from the annual occurrence. When the villagers are very preventive with a well-prepared process; the death, loss and damage are minimized.



**Figure 6.2 – Key Stakeholders of LOSE Approach for Community Resilience**

## **VII – Conclusions and Recommendations**

The study area, Angkor Ang village of Peam Chour district is considered as the most affected flood area in Prey Veng Province, as well as in Cambodia. The village has been hit by flood every year. The annual flash flood has relatively contributed to the poverty of the people residing along the Mekong River of Cambodia and the large flood has brought more unexpectedly death and damage of physical facilities and infrastructures. The annual flood disaster has brought the vulnerability and then driven the villagers into poverty. The main impacts from the annual flood were fear, disease, property loss and home damage. The cropping was slightly affected since villagers only made in the dry season probably in December. In comparison, the villagers from PHHs were the most vulnerable due to incapacity in dealing with preparedness and prevention.

The villagers have applied the preventive preparedness before the flood by using indigenous knowledge and self-adoption. It is due to the fact that the villagers lack of advanced knowledge and facilities for the prevention, rescue and relief. The local people have been able to participate in all the activities organized by the external instructions rather than their own initiative. The villagers could not start by their own as they have low capacity and lack of financial support. The activities are happened unless the external support is available and it always ends when the project withdraw. In the same time, the villagers have a very limited decision rights as they only passively participate in the planning and other development-related activities. With low education, the capacity building is needed a long-term support related to the disaster risk management, sustainable resource mobilization and management, as well as the fund raising. Unfortunately, the available project is small and short and just likes to make women pregnant and run away as soon as she delivered a baby.

There were very few development projects available in the study area and not permanently based. The available projects were mostly only awareness raising but not income generation which is the main need of the villagers. The villagers were very suffering because most of them were not only poor with less than USD 1 per day per person but also they had to spend all of the remaining or even some debts for reconstruction and restoration. Thus, the multi-sectoral involvements are the most appropriate mechanism for the impact mitigation with an initiative to establish the community-based organization (CBO). In this regard, the capacity of the community-based organization (CBO) was required to build up under support from the external developers for the resource mobilization and community development, otherwise, the Self Help Group (SHG). would become a So Hopeless Group (SHG). The existence of the community-based organization (CBO) could allow all the stakeholder to closely work by applying a LOSE Approach including Life, Owning, Socio-economic, and Environment.



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# Environmental Performances of Different Pathways of Rice Husk Utilization in Thailand

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## Abstract

Thailand is one of the largest rice producing nations in the world. To produce rice, a co-product such as rice husk is generated in the milling process. This husk accounts for approximately 23 percent of the total paddy weight. To deal with the problem of rice husk disposal, rice husk has been utilized in different industries. This paper compares the environmental performances of current major and potential uses of rice husk in Thailand.

The rice husk uses chosen to be examined are those uses in electricity generation, in cement manufacture and in cellulosic ethanol production. Life cycle assessment (LCA) with system expansion approach is used to assess the environmental impacts of these rice husk uses. The impact categories analysed are climate change, ozone depletion, acidification, eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, ecotoxicity, ionising radiation, land occupation, land transformation, water depletion, mineral resource depletion and fossil fuel depletion. The results from LCA are reviewed in the context of key policy issues. It is concluded that, in the short term, the electricity option is the most preferable. Nevertheless, with expected oil shortages in the future, rice husk should also be considered for use as a feedstock in cellulosic ethanol production.

**Key Words:** Agricultural residue, Biofuel, Energy Policy, Life cycle assessment, Rice husk, Waste management

## 1 Background

Thailand is one of the largest rice producing nations in the world. In 2007, Thailand produced approximately 32 million tonnes of rice (Office of Agricultural Economics 2007). Moreover, there is a trend for Thai rice exports to increase (International Rice Research Institute 2008). This could imply that if the trend continues, there will be an increased quantity of rice husk in the

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future. Rice husk is a co-product of rice products generated in the rice milling process. This husk accounts for about 23 percent of the total paddy weight (Prasertsan and Sajjakulnukit 2006). To make use of this large quantity of rice husk, the husk has traditionally been used as an energy source in the rice mills themselves. However, there is still some surplus rice husk remaining unused in the mills which causes disposal problems to the rice mill owners (The EC-ASEAN COGEN Programme 1998). In the past, this unused rice husk was disposed of by open-air burning or dumping which caused significant local pollution. To deal with this problem, substantial research has been conducted to find useful applications for rice husk. The unique features of rice husk and its ash have been found to be useful in several industrial applications. More recently, the Thai government has promoted the use of biomass for energy purposes to substitute for fossil fuel consumption and to reduce the environmental impacts caused by using fossil fuels (Prasertsan and Sajjakulnukit 2006). Therefore, rice husk, which is one of the main sources of biomass in Thailand, has the potential to substitute for other fossil fuels.

According to the seventh National Economic and Social Development Plan (1992-1996), the Thai government promoted the privatisation of the energy sector to reduce the investment burden of the government and to raise competition levels in the energy sector. The competition in the sector was expected to increase an efficiency in energy production and to ensure adequate energy at fair prices (Office of the National Economic and Social Development Board 1992). Correspondingly, the Small Power Producer (SPP) Scheme had drawn up by National Energy policy Council (NEPC) with the purpose to encourage the private sector to invest in the energy industry (Energy Policy and Planning Office 1999; Prasertsan and Sajjakulnukit 2006; Amornkosit 2007). The SPP is defined as either the power producer using cogeneration technologies or using renewable energy as a fuel (Energy Policy and Planning Office 1999). More recently, The Very Small Power Producer (VSPP) programme was launched with an aim to distribute electricity generation to the rural areas and increase the public participation in power generation (Kalayanamitr 2004; Amornkosit 2007). The VSPP is defined as a power producer that has a generation capacity lower than 10 MW; and is either a cogenerator or uses renewable energy (Electricity Generating Authority of Thailand (EGAT) 2009). Since rice husk is one of important renewable energy sources of Thailand rice husk has been used as a fuel in a large number of SPPs and VSPPs (Energy Policy and Planning Office 2009). The cement industry is also one of Thailand's large scale rice husk users (Anuwatwong 2006). The Thailand Environment Institute (TEI) (2004) also reports the use of rice husk as a substitute fuel in the Thai cement manufacture.

Apart from using rice husk in the form of solid fuel such as using it in electricity production and cement manufacture, rice husk can potentially be converted to liquid fuel such as cellulosic ethanol according to Saha & Cotta (2008), Saha & Cotta (2007) and Saha et al. (2005). Since the Thai energy policy emphasizes the security of energy supply to help reduce dependency of fossil fuel importation, the option of using rice husk to produce cellulosic ethanol also seems to be beneficent to the nation. This paper compares the environmental performances of the main current and potential uses of rice husk for energy purpose: use in electricity generation, use in cement manufacture and use in cellulosic ethanol production. A comparison of the environmental impacts of these rice husk uses were presented elsewhere (Prasara-A and Grant 2008). However, the use phase of ethanol has not previously been reported.

## **2 Methodology**

### **2.1 Goal and scope**

The goal of this research is to compare the environmental performances of uses of rice husk in electricity generation, in cement manufacture and in cellulosic ethanol production. To achieve this goal, life cycle assessment (LCA), which is one of the useful environmental assessment tools, was used to assess the environmental impacts associated with the selected rice husk use pathways to be investigated. To define the most environmentally friendly use of rice husk, which is the rice husk use option that shows the reduction of environmental impacts to the larger extent, the environmental impacts of the selected rice husk use pathways are compared with that of the conventional production systems (the production systems of the products that the use of rice husk is to replace). In other words, how the uses of rice husk can help to reduce environmental impacts (in the case that they can) can be seen as how much they can save the consumption of the conventional products. Hence, it is important to define the products that rice husk is used as a substitute for, and assess the environmental impacts associated with these production processes. It is necessary to know the scale of these impacts in order to calculate the relative benefits of their substitution with rice husk.

The choices of conventional products to be investigated are based on the view that the use of rice husk can help to reduce emissions caused by the consumption of fossil fuels. This is to conform to the Thai government policies discussed in the previous section, but not to displace any other existing biomass uses that already assist to reduce the consumption of fossil fuels. Therefore, the conventional systems selected for analysis are fossil fuels and not those that use existing biomass products, which already contribute to the reduction of fossil fuels consumption. The conventional product chosen for the electricity option was Thai grid mix production. For the cement option, the conventional product was cement production without using rice husk as a substitute fuel. For the cellulosic ethanol option, the conventional product chosen was a petrol product.

As this LCA study was conducted to help in making a decision between different rice husk use options, the functional unit for each system was defined based on disposing of 1,000 tonnes of rice husk in each rice husk use system, taken into account the use phase of the products to find out whether there are any differences between the use of the products generated from rice husk use systems and the conventional products. In the case of the electricity and cement systems, there is no difference in how the final products are used as compared to the conventional products. Hence, the functional units for these two systems were defined as the amount of electricity generated by processing 1,000 tonnes of rice husk in the production processes.

Nonetheless, there is a distinction between the use of ethanol and use of petrol. Ethanol is used to blend with gasoline to produce gasohol which can be used in existing gasoline-powered engines while petrol can be used directly in the engines. The percentage of ethanol in gasohol can be varied, however, the E10 (mix of 10 percent ethanol and 90 percent of petrol) was used in this study as it can be used in existing vehicles without any engine modification (Goettemoeller and Goettemoeller 2007). Therefore, the functional unit of the cellulosic ethanol system was defined as the use of the amount of ethanol produced from 1,000 tonnes of rice husk (as a feedstock in the ethanol process) in vehicle operation, or how far a vehicle could travel using this amount of

fuel. This study then compares vehicle operation using E10 and using petrol based on the same travel distance just described. The definitive functional units for rice husk use systems examined and for their conventional systems are shown in Fig. 1.

Insert Fig. 1

The functional units defined in Fig. 1 were used to calculate the environmental impacts that were reduced by using rice husk in different rice husk use systems studied. This was done by analysing the environmental impacts caused by the rice husk use systems, including their conventional systems, based on the functional units defined in Fig.1. From this, to obtain the reduced environment impact of using 1,000 tonnes of rice husk in each system, the environmental impacts of the conventional system were simply subtracted from that of the rice husk use system (based on the same functional unit). The results from this calculation indicate whether using rice husk in all systems analysed would result in the reduction of the environmental impacts, and quantify the changes. Negative results would indicate that the use of rice husk has an effect on the reduction of the environmental impacts.

In this study, rice production is excluded from the system boundary. Therefore, the use of rice husk as a fuel in rice mills is also excluded from the boundary as it is considered as part of rice production. This study only considers the uses of rice husk remaining unused within the rice mills. Although the environmental impacts caused by the rice production are considered significant, they do not influence how rice husk are utilized. Hence, the boundary of this study covers only the transportation of rice husk from rice mills to the rice husk use sites and the rice husk utilizing processes.

As a comparative LCA study, system expansion approach is used to take into account the effects of the uses of co-product in some rice husk use system examined. For example, some rice husk use systems provide a co-product which is used in other applications (outside the system boundary) where their conventional systems do not generate co-products. Therefore, the uses of these co-products will affect the LCA results when compared with the environmental impacts of the conventional processes. To deal with this co-product allocation problem, it is suggested that the co-product allocation is avoided by system expansion (Weidema 2001; Ekvall and Weidema 2004). This is undertaken by avoiding the production processes of the products that rice husk and the co-products generated from utilizing rice husk are used to replace in other applications.

It is conceivable that the changes in the amount of rice husk used in one system may affect another system, and consequently affect the environmental profiles of another system examined; however, this is not the aim of the study. This study aims to find out the rice husk use option, in which the substitution of fossil fuels by rice husk would produce the greatest environmental benefit, between three options examined. Hence, the LCA study assesses the environmental impacts of different rice husk use systems based on processing the same amount of rice husk (1,000 tonnes) in three systems investigated. This also applies to the co-products generated in rice husk use systems studied, by assuming that the same amount of co-products are used in different applications. These assumptions were made for a comparison purpose as all options should be judged based on the same basis.

In the electricity generation process, rice husk ash is produced from the rice husk combustion process. In this study, the ash was assumed to be either: sent to the ash consumers, for use as soil conditioner in the paddy rice fields; as a substituting material for clay in clay brick production; and as substituting material for cement in lightweight concrete block production. The option of disposing the ash in landfill was also taken into account. However, for the uses of the ash in industrial applications, the model did not include the whole production processes of these products (soil conditioner, clay brick and lightweight concrete block). Only the effects of using rice husk ash in these production processes were taken into account. In other words, how the use of rice husk ash in different applications may help to reduce their environmental impacts is influenced by the materials that the rice husk ash substitutes in those applications.

## **2.2 Life cycle inventory analysis**

Data were obtained from several sources such as interviews with industry personnel, LCA questionnaires, internet, published journal articles and reports. LCA questionnaires were distributed in August-September 2007 together with interviews with different industry personnel involving with using rice husk in their production. Background data were from LCI databases available in LCA software used in this study (SimaPro version 7.1.6), namely Ecoinvent 2.0 and Australian Life Cycle Inventory Database, and literature. The Thai LCI database is being developed (Malakul, Piumsomboon et al. 2005). However, it had not been made available to the public (from personal communication with the organization developing the Thai LCI database in November 2008). However, LCI data for some production processes are available from published reports (Lohsomboon and Jirajariyavech 2003; Thailand Environment Institute (TEI) 2004). LCI modelling was performed in the LCA software SimaPro version 7.1.6. Data sources for each rice husk use system and how its LCI model was created are described below:

*Electricity generation system* LCI data for the electricity generation option were mainly collected from one specific rice husk power plant. However, some data were taken from other literature sources to close data gaps as not all data needed could be obtained from this site. The LCI data for the Thai grid mix were available from the energy statistics of the Energy Policy and Planning Office (EPPO) (2009). The unit process data of electricity production using different fuel types were taken from European and Australian databases (available in SimaPro version 7.1.6).

*Cement system* LCI data for Thai cement production were based on the report by Thailand Environment Institute (2004). This report shows LCI data for conventional Thai Portland cement production processes in which rice husk are not included. The LCI data for the production process of Portland cement with rice husk replacing 20% of coal were adapted from the existing data in this report. The calculation was done based on an assumption that rice husk are used to substitute for coal by 20% based upon energy content. The  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  contained in rice husk ash were not taken into account because they were in very small amounts, rice husk ash contains more than 90 percent of  $\text{SiO}_2$  (as discussed in section 3.2.2). After substituting rice husk in the cement process, an amount of shale was taken out as rice husk ash contributes  $\text{SiO}_2$  to the clinker (shale is the main raw material providing  $\text{SiO}_2$  into the process). However, shale also provides  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  to the process. Hence,  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  would be lacking as a result of having removed some amount of shale from the process. These chemicals are reintroduced when bauxite and iron ore are added to the process (Thailand Environment Institute (TEI) 2004). Due

to limited data, all emissions were assumed to be the same as the conventional Portland cement production (i.e. without rice husk). However, the fossil CO<sub>2</sub> amount was deducted, based on a calculation of CO<sub>2</sub> emitted by burning the amount of coal replaced by rice husk.

*Cellulosic ethanol system* As the cellulosic ethanol production using rice husk as a feedstock had not yet been introduced to Thailand (at the time of analysis), data from other countries were used in this study. However, there were no LCI data for the production of cellulosic ethanol from rice husk available; the data about the production process of ethanol used for this study were adapted from the production process of cellulosic ethanol production from wood (Jungbluth, Emmenegger et al. 2007). As a consequence, ethanol yield and some available inputs were adjusted to rice husk conditions according to Saha et al. (2005). While inputs from technosphere were proportional to dry matter input, emissions of hydrocarbons were proportional to carbon input and all other emissions were proportional to dry matter input according to Jungbluth et al. (2007). The model of vehicle operation using cellulosic ethanol produced from rice husk was adapted from a model of a passenger car using E10 (ethanol produced from wheat blended with petrol), based on the Australian Urban Driving Cycle (AUDC) (in the Australian Life Cycle Inventory Database in SimaPro version 7.1.6). However, the ethanol production was adapted to the production of the cellulosic ethanol from rice husk.

The biogenic CO<sub>2</sub> was accounted for as neutral for all rice husk use options studied. Based on the IPCC Guidelines for National Greenhouses Gas Inventories (IPCC 2006), CO<sub>2</sub> released by burning rice husk is counted as neutral because it is assumed that the CO<sub>2</sub> will be reabsorbed during the next season of the rice growing phase. Hence, this credit was given to all rice husk use systems to make them comparable. Christensen et al. (2008) suggest that the calculation of the contribution of waste management to global warming can be done both ways: biogenic carbon accounting as neutral and biogenic carbon counting. However, the boundary conditions must be clearly addressed to gain consistent and reliable results. Though the rice growing phase was not included in this study, the biogenic CO<sub>2</sub> was accounted for as neutral in the LCI models for the comparison purpose. As one of the benefits of using rice husk is that it has the carbon neutral feature while the conventional products such as fossil fuels do not. Therefore, the biogenic carbon was accounted as neutral in all rice husk use systems examined.

### **2.3 Life cycle impact assessment**

The impact assessment method used in this study is ReCiPe 2008 version 1.01, using midpoint indicators, hierarchist (H) and world normalization factors. It was used in the manner set up in SimaPro 7.1.6. The ReCiPe 2008 method was developed by Goedkoop et al. (2009), based on two main approaches: the baseline method for impact characterisation in the Handbook on Life Cycle Assessment (Guinee 2002) and the Eco-indicator 99 impact assessment method (Goedkoop and Spriensma 2001). The ReCiPe 2008 method offers results at both midpoint and endpoint levels (Goedkoop, Heijungs et al. 2009). However, this study uses the midpoint results because the results from midpoint level are relatively robust as recommended in the Handbook on Life Cycle Assessment (Guinee 2002). In addition, Goedkoop et al. (2009) note that the uncertainty of the endpoint results analysed by the ReCiPe 2008 method are relatively high compared with that of the midpoint results. This is because the endpoint results are calculated based on their own models. While for the midpoint results, they are based on the internationally accepted models. Hence, the midpoint results analysed by the ReCiPe 2008 method are used in



this study. Hierarchist (H) perspective was chosen to use in this study as its characteristics are considered appropriate for the aim of this study. According to Goedkoop et al. (2000), the Hierarchist version supposes that proper policy can help to manage the problems. The hierarchist (H) version therefore seems to be appropriate for this study since this study aims to generate recommendations about the rice husk disposal strategies for the policy makers.

### **3 Results**

#### **3.1 Rice husk based electricity generation and the co-product uses**

In the electricity system, the use of the co-product (ash) generated in the electricity production process is taken into account. The environmental impacts of selected rice husk ash uses, namely soil conditioner, brick production, light weight concrete block production and landfill, are assessed and compared to identify the most environmentally favourable rice husk ash application option (among the ones investigated). Then, the best rice husk ash use option from this result is incorporated into the electricity system model for comparison with the other rice husk use systems. The normalized impacts of the production of 919 MWh electricity produced from rice husk based electricity generation (which refers to processing 1,000 tonnes of rice husk in the production process) with different ash disposal options are presented in Fig. 2.

Insert Fig. 2

Based on how the LCI models were set up for the purpose of assessing the impacts reduced by using rice husk in the three different rice husk use systems investigated (discussed in section 2.1), the negative results indicate the benefits of using rice husk (or co-product) in that use option. In other words, the negative results imply that the process using rice husk (or co-product) causes less impact than its conventional process.

In Fig. 2, it is clear that the most environmentally friendly option for the disposal of rice husk ash produced from the rice husk power plant is the use of the ash in light weight concrete block production. This option causes less impact on climate change, terrestrial acidification, marine eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, freshwater ecotoxicity, marine ecotoxicity and fossil fuel depletion. All other ash uses have relatively similar benefits.

#### **3.2 Comparison across different rice husk use options**

Table 1 shows the characterized impacts that are reduced by processing 1,000 tonnes of rice husk in the systems examined. The characterized result units differ across impact categories, so it is difficult to compare the results across different impact category analysed. Therefore, the normalized results which are expressed in the same unit for all impact categories analysed (i.e. person×year), will be used for a comparison of the environmental impacts across the different rice husk use options. Fig. 3 shows a comparison of the normalized results of the rice husk use systems investigated. Note that for the electricity generation system, the option of sending rice husk ash from the rice husk power plant to the light weight concrete block production plant is taken into account as it is the most preferable rice husk ash disposal option (results are shown in section 3.1).

Insert Table 1

Insert Fig. 3

Fig. 3 shows that using rice husk in most of the systems examined can help to reduce impacts on fossil fuel depletion, climate change, human toxicity, freshwater and marine ecotoxicity. This is indicated by the significant negative results shown for these impact categories across all categories analysed. Different impact categories can be compared based on the same result unit (normalized unit, i.e. person $\times$ year). However, the results show that using rice husk in some production systems cause higher impacts on terrestrial acidification, marine eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, terrestrial and marine ecotoxicity and metal depletion than their conventional processes.

From the overall results, the cement system has the greatest effect in reducing fossil fuel depletion and climate change when compared with other rice husk use options. However, it causes a little higher impacts on particulate matter formation and metal depletion than the conventional cement system, which rice husk is not used as a substitute fuel.

The cement option shows the largest effect in reducing impacts on climate change. The LCI model of the cement production system was adapted from the conventional cement production process, by removing some amount of coal and shale when using rice husk in the process. This can simply imply that the reduction of greenhouse gases results from using rice husk as a substitute for coal in the cement production process. Therefore, this helps to reduce greenhouse gases from burning coal. Moreover, it helps to considerably reduce impact on fossil fuel depletion, as rice husk is used as a fuel to substitute for coal in cement production. However, it causes a little greater impact on metal depletion when compared with other options. This is because using rice husk in cement production requires extra minerals, as other minerals such as bauxite and iron ore, were added into the process when the husk were used (and some amount of shale was taken out). In addition, the cement option contributes a little higher particulate matter formation than its conventional process.

The cellulosic ethanol option is the worst option among three rice husk use systems investigated. It shows the least effect in reducing impacts on fossil fuel depletion and climate change when comparing with other rice husk use options. This option has the largest effect in reducing impact on freshwater ecotoxicity when comparing with other rice husk use options. However, the magnitude of the impact in this impact category is marginal when comparing across all impact categories analysed. Moreover, the cellulosic ethanol system causes higher impacts on terrestrial acidification, marine eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, terrestrial and marine ecotoxicity than petrol system. Moreover, the impacts on human toxicity of this option are highest of all three rice husk use options.

The electricity production option helps to reduce the impact on human toxicity by the greatest amount, compared with the other options. Moreover, it has minor effect in reducing impacts on freshwater and marine ecotoxicity. In addition, it has a fairly significant effect in reducing impact on climate change and fossil fuel depletion (after cement option) when comparing the results across all impact categories. However, the electricity option causes greater impacts on terrestrial acidification and particulate matter formation than the Thai grid production. Moreover, the

impacts on particulate matter formation of this option are highest of all three rice husk use options.

In general, all of the rice husk use systems analysed show benefits over their conventional systems in terms of fossil fuel depletion, climate change, human toxicity (only for electricity option), freshwater ecotoxicity (except for cement option) and marine ecotoxicity (only for electricity option). Nevertheless, they are not better than the conventional systems in terms of the other impact categories evaluated, such as terrestrial acidification, marine eutrophication, human toxicity, photochemical oxidant formation, particulate matter formation, terrestrial ecotoxicity and marine ecotoxicity and metal depletion.

#### **4 Discussion and conclusions**

The option of using rice husk ash (generated in rice husk based power plant) in light weight concrete block production shows the largest benefits over other ash uses examined. This results from the higher environmental credit given to this ash disposal option (using the ash in light weight concrete block production) by substituting rice husk ash for Portland cement in the concrete block production process. This implies that the environmental impacts associated with processing the amount of Portland cement replaced by rice husk ash, is higher than that of other conventional products which the ash is used to substitute for in other ash uses, such as chemical fertilizer and clay. The reduction of impacts by using rice husk ash in different applications also depends on an efficiency of using the ash to substitute for different conventional products. For example, 1 kg of the ash can be used to replace 1 kg of Portland cement and clay, in light weight concrete block production and clay brick production. While for using the ash as a soil conditioner in paddy rice field, the ash can not totally replace chemical fertilizer as the rice plants need both rice husk ash and chemical fertilizer for higher yields (Songmuang 2000). Therefore, the substitution rate of rice husk ash for the conventional products in different ash use options should also be considered when making decision.

When reviewing LCA results (based on normalized results) in the context of existing Thai energy policy which emphasizes the reduction in fossil fuel consumption. The cement option seems to be the most preferable option. This is because when using rice husk as a fuel in cement kiln, the energy contained in rice husk can be fully recovered as discussed in Lemarchand (2000). The cement option can help to reduce the largest amount of greenhouse gases when comparing with other rice husk use options examined. This is because rice husk is used to substitute for coal in cement manufacture, which CO<sub>2</sub> from burning coal is the highest of that of other fossil fuel types as reported in Chungsangunsit et al. (2004).

However, when considering other impact categories such as human toxicity, freshwater and marine ecotoxicity, the electricity option can help to reduce the largest impacts on these impact categories, while it also has a considerable effect in reducing impacts on fossil fuel depletion and climate change.

The cellulosic ethanol option is the worst option when comparing with the other rice husk use systems. This is because the cellulosic ethanol system has the lowest effect in converting rice husk into energy. Rice husk is used as a feedstock to produce ethanol and ethanol is then used to

blend with petrol to generate E10. E10 will then be used to substitute for petrol. While rice husk can be used directly as a fuel in the electricity production and cement manufacture.

When considering the practicality of all rice husk use systems examined, the electricity option seems to be the most practical option. Although the cement option has the largest effect in reducing impact on fossil fuel depletion and climate change, its capacity in taking rice husk to use in the production is rather limited. The number of Thai cement plants is very small compared with that of the rice husk based power plants (Department of Industrial Works 2009; Energy Policy and Planning Office 2009). Moreover, the cement plants are only located in limited areas nearby limestone sources (Thailand Environment Institute (TEI) 2004), whereas the rice husk based power plants are more scattered around the country (Energy Policy and Planning Office 2009). This can affect the transportation of rice husk from rice mills to the husk users.

Based on the goal and scope, and data available for this research, it is concluded that, in the short term, using rice husk as a fuel in electricity production is the most practical environmentally friendly of the three rice husk use options investigated. This conclusion is made based on the review of the LCA results in the context of the key issues such as the existing Thai energy policy, the capacity of the production systems and the practicality of the rice husk use systems. However, with expected oil shortages in the future, rice husk should also be considered for use in cellulosic ethanol, as this option can help to save some amount of petrol. However, the production process of rice husk based cellulosic ethanol needs improvement to increase yields while using less fuel and materials. This may help to increase the amount of the environmental impacts that are reduced by the cellulosic ethanol system.

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Table 1 Characterized impacts reduced by processing 1,000 tonnes of rice husk in electricity and ethanol systems (analysed by Recipe Midpoint (H) V1.01 / World Recipe H / characterization)

Impact category	Unit	Cement option	Electricity option	Ethanol option
Climate change	kg CO <sub>2</sub> eq	-1.38E+06	-9.53E+05	-2.37E+05
Ozone depletion	kg CFC-11 eq	-1.60E-07	-1.85E-04	-5.50E-02
Terrestrial acidification	kg SO <sub>2</sub> eq	-3.83E+00	1.14E+03	2.18E+03
Freshwater eutrophication	kg P eq	-4.60E-06	-4.28E-03	-5.49E-02
Marine eutrophication	kg N eq	-1.92E+00	8.03E+00	1.30E+02
Human toxicity	kg 1,4DCB eq	2.51E+01	-1.61E+04	2.38E+04
Photochemical oxidant formation	kg NMVOC eq	-1.95E+01	-1.76E+02	8.39E+02
Particulate matter formation	kg PM10 eq	1.29E+02	1.10E+03	5.54E+02
Terrestrial ecotoxicity	kg 1,4-DCB eq	1.35E-01	-3.77E-03	1.23E+01
Freshwater ecotoxicity	kg 1,4-DCB eq	9.94E-02	-1.02E+02	-1.11E+02
Marine ecotoxicity	kg 1,4-DCB eq	-2.45E-01	-1.10E+02	7.36E+01
Ionising radiation	kg U235 eq	-1.47E-02	-3.84E+01	-1.20E+03
Agricultural land occupation	m <sup>2</sup>	-7.25E-05	-3.37E+00	3.42E+01
Urban land occupation	m <sup>2</sup>	3.17E+00	-2.47E+02	-2.13E+00
Natural land transformation	m <sup>2</sup>	2.70E+00	-2.33E+01	1.24E-03
Water depletion	m <sup>3</sup>	1.27E+03	-1.98E+03	-6.09E+03
Metal depletion	kg Fe eq	2.07E+04	-5.13E+02	-4.59E+01
Fossil fuel depletion	kg oil eq	-3.25E+05	-3.05E+05	-8.89E+04

Fig. 1 Definitive functional units for rice husk use systems examined and for their conventional systems

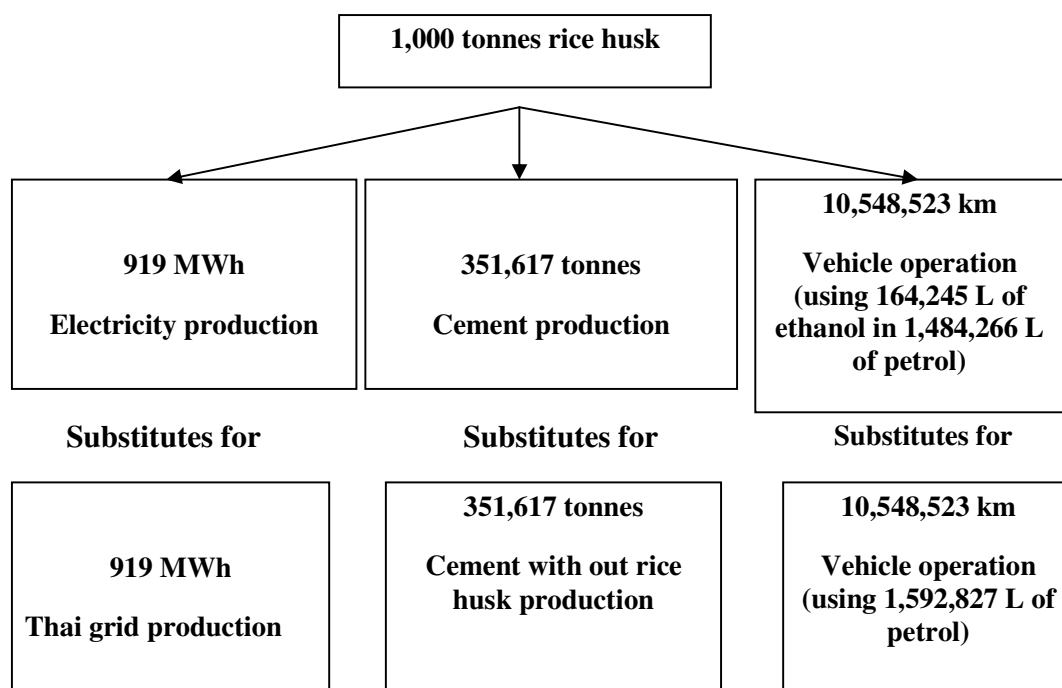




Fig. 2 Normalized impacts of 919 MWh rice husk based electricity production with different ash use options (analysed by Recipe Midpoint (H) V1.01 / World Recipe H / normalization)

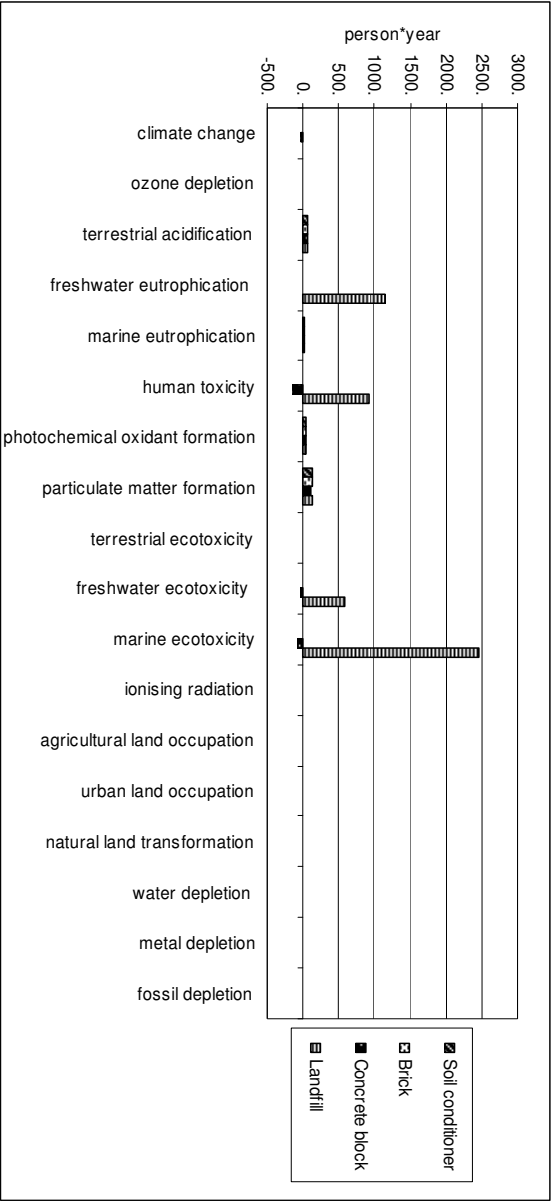
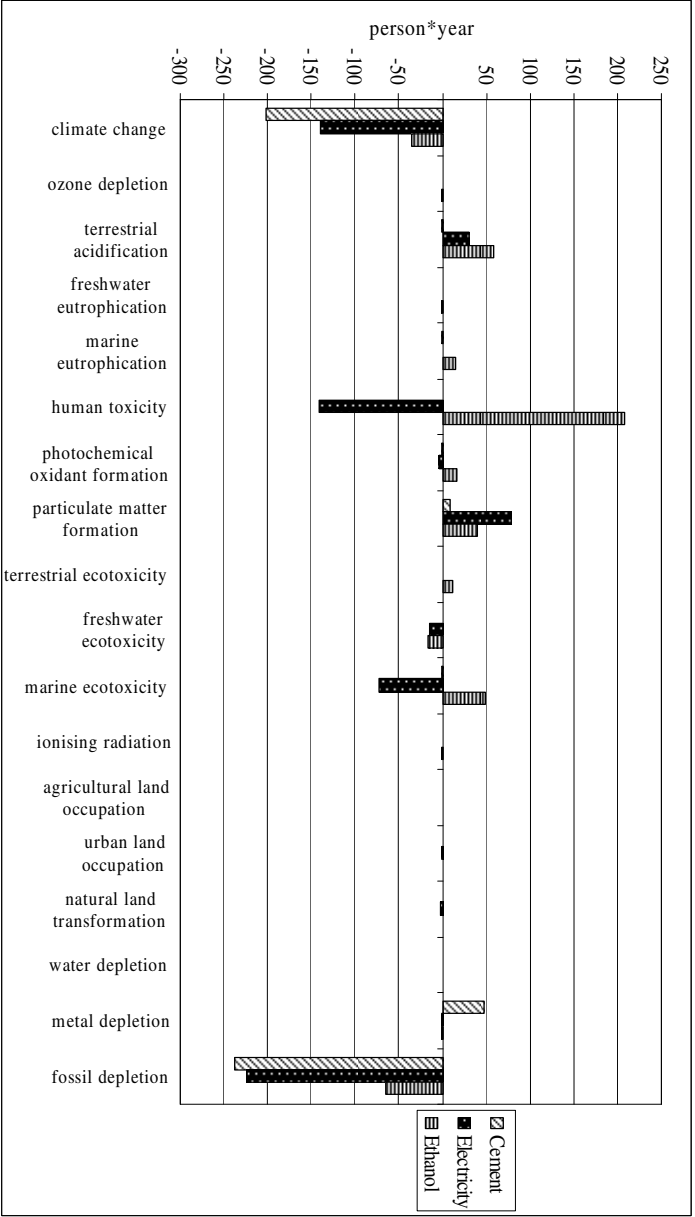


Fig. 3 Normalized impacts reduced by processing 1,000 tonnes of rice husk in different systems (analysed by Recipe Midpoint (H) V1.01 / World Recipe H / normalization)



# THE RELATIONSHIP BETWEEN NATURAL CONDITIONS WITH FORMATION AND DEVELOPMENT OF CLAM GROUNDS (*MERETRIX LYRATA*) IN MEKONG DELTA

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## **ABSTRACT**

Viet Nam's overall mollusk production is estimated at 300,000-350,000 tonnes a year, in which Clam production is estimated about 60,000 tones. In the Mekong Delta, production of this specie concentrated in six coastal provinces - mainly Ben Tre and Tien Giang but also Tra Vinh, Soc Trang, Bac Lieu and Ca Mau ones.

During last October 2009, The Ben Tre clam fishery has just received Marine Stewardship Council (MSC) certification, becoming the first fishery in Southeast Asia to meet the organization's sustainability and management standards. *Meretrix lyrata* - “Ngheu Ben Tre” became the famous commercial brand, an highlight spot on fresh aquaculture not only in Vietnam but also in the world.

Although scientists from government research institutes in Ho Chi Minh and Nha Trang cities have studied detail on natural and socio-economic conditions that effect to development, stabilitzation and also risk of *Meretrix lyrata* in Ben Tre province and also whole coastal waters of Mekong Delta.

This paper focus to present the relationship between natural conditions with creating and developing of clam grounds in Ben Tre as well as Mekong Delta.

Base on survey data in 2007-2009 linking with the history material (aerial photographs, archived satellite imagery, live assesses data and also news' information from 1973 to 2009), the history evolution, formation and development of Clam grounds in this regions have been clearanced.

*Key word: Meretrix lyrata, Ben Tre's clam, remote sensing, rainfall, EOF, SST, Chlorophyll, tidal flat, geomorphology, shore line change.*

## **I) Introduction:**

Viet Nam's overall mollusk production is estimated at 300,000-350,000 tonnes a year, in which Clam production is estimated about 60,000 tones. In the Mekong Delta, production of this specie concentrated in six coastal provinces - mainly Ben Tre and Tien Giang but also Can Gio, Tra Vinh, Soc Trang, Bac Lieu and Ca Mau ones.

During last October 2009, The Ben Tre clam fishery has just received Marine Stewardship Council (MSC) certification, becoming the first fishery in Southeast Asia to meet the organization's sustainability and management standards. *Meretrix lyrata* - "Ngheu Ben Tre" became the famous commercial brand, an highlight spot on fresh aquaculture not only in Vietnam but also on the world.

Until now, there are a lot of scientific projects studied on social economic and natural conditions in Mekong Delta related to live of *Meretrix lyrata*. These publications showed environmental parameters effect to Clam live include: nutrient, suspended matters, primary production and phytoplankton (An et al , 2001 [1], Hung, 2006 [9], water temperature and salinity (An et al , 2001 [1], Hung, 2006 [9] , Tung et al 2007 [16]; rain fall and number of rain days (Hao, 2001 [10], Tung et al 2007 [16], geomorphology, altitude and grain size of sediment in tidal flat (Tuan et al, 1999 [15] , Tung et al, 2007 [16]), effect of NE monsoon result in shore erosion and siltation on tidal flat and constrain to develop (and also mass mortality) of Clam (Tuan et al 1999, [15] An et al , 2001 [1]; Tung et al, 2007 [16]

In own scientific report on *Meretrix lyrata* in tidal flat of Tien Giang province , Tuan et al summarized three main parameters effect to live and development of Clam are: content of organized matter, grain size of sediment and altitude of tidal flat (Tuan et al 1999) [16].

The formation of parent's Clam grounds in Ben Tre strongly related to location of hydrology frontal zones in nearshore water have been showed by An et al , 2001 [1]

According to Nguyen van Hao (Hao, 2001) [10], the main breed season of Clam relate directly to rain season, breed grounds in Ben Tre appear to delay about one to one and half months after started rainfall events. At these periods, the rain fall is enough high and water temperature warmer stimulated parent's Clam to reproduce and creating a great breed grounds on tidal flats in Ben Tre.

The detail study on biological features of Clam such as: food component, satiety index, "condition" index, reproduction characteristics, ... (Tuan et al 1999 [15] , An et al , 2001 [1], Hao, 2001 [10], Tung et al 2007 [16]) had determined preliminary the relationship between environmental, hydro-meteorologic parameters to biological features and Clam's live.

However, almost studies on environment and Clam's live in Mekong delta only base on investigated data and scientific reasons but not attend to complex spatial and temporal variation of environmental to Clam's live. Due to complex dynamic conditions in zone of tidal flat, the distribution of environment parameter is very complex. They related strongly to ebb and flood tide period and result in the pictures of spatial distribution of environment parameters is relative incorrect (due to un-synchronized character of investigated data). The determination of temporal variation is also difficult.

By the way of new approaches base on remote sensing techniques and numerical and statistic modeling, this paper try to explain detail the quantity relationship between natural conditions with formation and development of Clam grounds in Mekong Delta (focus in tidal flats of Tien Giang, ben Tre and Tra vinh provinces).

The main goal of this study to be answer two big questions: when do Clam (include breed and parent grounds) appear ; where do they develop well ?

Some recommendations on broadened the study scale for whole of tidal flats with Clam grounds of Mekong delta and plan to selection suitable sites for Clam mariculture in scenario of 10 – 20 next years in Mekong Delta with affect of climate change (include affect of sea level rise and also global warming).

## II) Material and Methodology:

### 2.1. Studied scale and objects:

The study region focus on tidal flats with Clam grounds in three provinces Tien Giang, Ben Tre and Tra Vinh and in geography limit of  $106^{\circ}05' - 106^{\circ}50' E$  và  $09^{\circ}30' - 10^{\circ}25' N$  (figure 1).

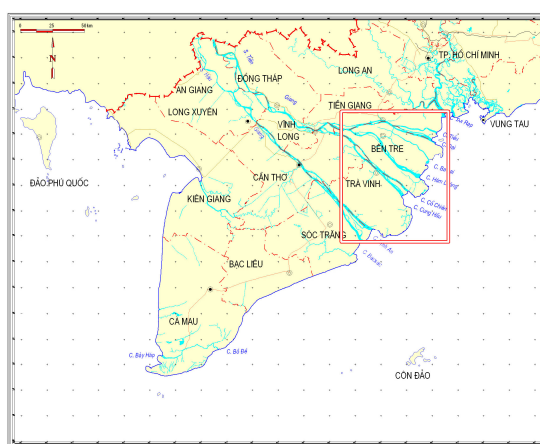


Figure 1. Studied region in base of Mekong Delta

Base on results of previous studies as showed in above mention and applied ability of remote sensing techniques in marine study, we choose environmental parameters for assessment the relationship between natural conditions with formation and development of Clam's ground, as following:

- Accumulate rainfall, sea surface temperature (SST), water salinity (Sal), total solid suspended (TSS), chlorophyll-a (instead of food and nutrient source).
- Hydrology frontal zones, alongshore and tidal current, water level and tide characteristic.
- Geomorpholgy feature (topography and bathymetry) in tidal flats, history evolution (shoreline and morphology changes), grain size of sediment, landuse in land base and sea water (include distribution of mangrove forest, aquaculture, human settlement, paddy field, garden tree, relict dunes,..., formation of underwater relief).

Each parameter group will be using by difference methods and satellite imageries that we will present concretely in below part

### 2.2.- Material:

#### 2.2.1. Investigated data

- Collect the selected results (investigated data and publications) from previous study regarding to Clam live (include investigated data on environmental, bio-resource, geomorphology features related to mollusk live) from country reports of Vo Si Tuan

et al, 1994 [15] , Nguyen Tac An et al , 2001 [1] , Nguyen Thanh Tung et al 2007 [16] and also new investigated data from our project (un public) in 2007 - 2009.

- The monthly meteorology series data (2002 – 2008) on rain fall, wind, salinity, air and water temperature in survey My Tho, An Thuan, Ben Tre stations have been collected with purpose to calibration and validation the processed data derived from satellite imagery.

#### 2.2.2. *Satellite imagery and related data:*

Include a big number of satellite image scenes cover in Mekong Delta from different source as following :

- MODIS image dataset: include 166 daily scenes of MODIS image (level 2B, 1km resolution) which have been download from website <http://oceancolor.gsfc.nasa.gov/> in (2007 – 2008). They have been use to extract the spatial distribution field of SST, TSS and Chlorophyll-a.
- The live assess serve data from Giovanni website of NASA <http://disc2.nascom.nasa.gov/Giovanni/tovas/rain.GPCP.2.shtm> have been use to extract the distribution and variation of rainfall, SST and Chlorophyll-a. They are download in grid 0.25 ° and in ASCII format and include 96 monthly ASCII files (8 \* 12) from 2002 – 2008.
- Datasets of multi spectral with high resolution imagery of USGS include: Landsat MSS – 60 m (1973 – 1977): 5 scenes, Landsat TM – 30m (1988-1990) : 4 scenes, Landsat ETM+ - 30m (1999 – 2003): 9 scenes, Landsat ETM+ - 30 m (2007-2009): 8 scenes. These datasets have been provide directly by US Geology Survey - USGS.
- Datasets of multi spectral with high resolution imagery of Japan Aerospace Exploration Agency include: JERS-MSSR1 – 60 m (1984-1988): 14 scenes, JERS-VNIR – 18 m (1997-1998): 8 scenes and ALOS-AVNIR2 – 10m (2007-2008): 4 scenes. They have been provide directly by JAXA in ALOS - PI contract.

### 2.3. *Methodology:*

#### 2.3.1. *Analysis the spatial and temporal variation of rainfall:*

Ninety six (96) monthly ASCII files on accumulate rainfall from website of Giovanni – NASA are download and then process by serial time analysis by a special statistic technique call be – EOF: Empirical Orthogonal Function. EOF technique allow us to obtain and explain the main features of temporal and also spatial distribution of rainfall. On principle, this method is similar the PCA method with varimax rotation (PCA is multi- variable statistic analysis in modern statistic analysis (Reyment and Jvreskog, 1999) [14].

From collected data on monthly rainfall we organized them to create a numerical matrix [N x M], where N = 86 column according to 86 months , M = 121 row according 121 data pixel of 0.25° grid cover study region. A reverse matrix [M x N] also is used.

Statistica 7.0 software using for processing.

### 2.3.2. Analysis the spatial and temporal variation of SST, TSS, Chlorophyll-a derived from MODIS imagery.

One hundred sixty six (166) daily scenes in ( 2007 – 2008) of MODIS image (level 2B, 1km resolution) cover Mekong Delta have been download from website <http://oceancolor.gsfc.nasa.gov/> and then have been processed step by step as following:

- Georeference by Geographic Lookup Table – GLT algorithm. They have been used for Geometric correction and convert from image co-ordinate into geography co-ordinate in UTM projection, WGS 84 Datum, Zone 48.
- Extract the SST images by algorithm of Dechamp và Phulphin (1980) [5],

$$SST (^{\circ}C) = \alpha + \beta T_i + \gamma (T_i - T_j)$$

where

- SST: Sea surface temperature ( $^{\circ}C$ )
- $T_i, T_j$ : Brighness of Infrared bands ( $31^{st}$  and  $32^{nd}$  in MODIS image (level 2B))
- $\alpha, \beta, \gamma$ : corrected paramenters of Dechamp and Phulphin (1980) [5]
- Extract the images of chlorophyll-a images by algorithm of OC3 (O'Reilly et al (2000) [13])

$$Chlo-a (mg/m^3) = 10^{(0.283 - (2.753 * R) + (1.457 * R^2) + (0.659 * R^3) - (1.403 * R^4))}$$

where

- Chlo-a: content of chlorophyll-a in sea surface layer ( $mg/m^3$ )
- $R = \log_{10}[\max(nLw(443)/nLw(551), nLw(488)/nLw(551))]$
- $nLw(443), nLw(488), nLw(551)$  are normal water-leave radiance correspondent with wavelengths of 443 nm, 488 nm and 551 nm.
- The images of  $nLw(443), nLw(488), nLw(551)$  restore in MODIS image (level 2B)
- Extract the image of Total Solid Suspended Solid (TSS) by algorithm of band ratio of  $nLw443/nLw553$  (Murakami et al, 2004 [11], Asif et al 2007 [2])

$$TSS (mg/l) = 10^{[0.38786 - (2.345*R) + (1.0645*R^2) - (1.03167*R^3)]}$$

where

- TSS: content of suspended solid in sea surface layer ( $mg/l$ )
- $R = \log_{10}[(nLw(443)/nLw(551))]$ .

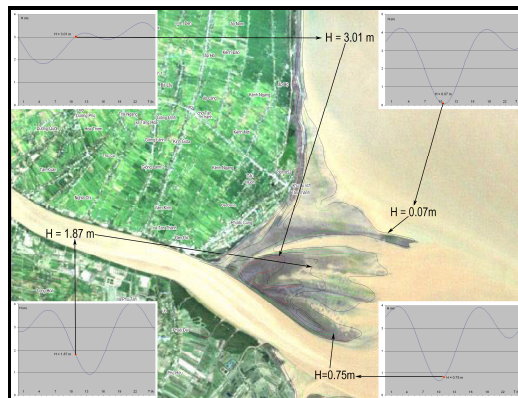
- Create the monthly composite images. Reality, due to cover level of cloud in study region is high and result in obtain daily incorrect image (under affect of cloud, their shadow and also haze). In order to overcome this disadvantage, we used a techniques to create the composite images – monthly average images in which pixels cover cloud and also their shadow are considere as “empty”.

*2.3.3. Application of multi spectral high resolution imagery:* for extracting the geomorphology feature (topography and bathymetry) in tidal flats, history evolution (shoreline and morphology changes), grain size of sediment, landuse in land base and sea water. Some processed procedures for extracting geomorphologic features have been used as following:

- *Detect the topography on tidal flat:*

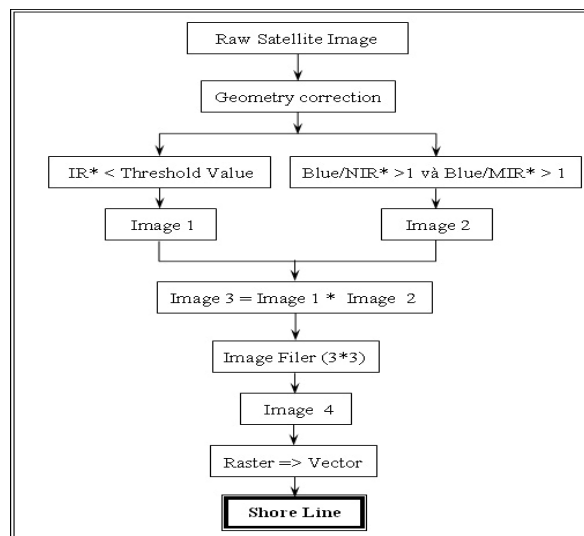
Base on color composite image (Landsat ETM+, MESSR, JERS-VNIR, AVNIR2,...) by visual techniques and screen digitization, we are able to extract waters line in each difference satellite imagery with difference aquisition times.

According to time and day for aquisition image (restore in meta file of raw image) we can get tidal heigh by WXTide32 software. The dataset of water lines in difference will correspondence with difference heigh of tidal flat. Figure 2 is demonstration example



*Figure 2. Topography of Tidal flat in Tien Giang during 2003 extract from 4 Landsat ETM+ images*

- *Extract shore line:*  
Technique for extracting the shore line in difference (decadal) time are used by method of band ratio combine with threshold value of infrared band. (Van, 2008 [17]). This techniques have been used for assessment the shore change in decadal period as well as erosion – deposition process. The procedure for extract shore line have been carried out as figure 3



*Figure 3: Procedure for extracting shore line (after, Van and Binh 2008 [17])*

- *Landuse map in coastal area and tidal flat:*

They have been classified by supervised classification method by Maximum Likelihood algorithm base on ALOS-AVNIR2 images (10m) during 2007 – 2008. The classified objects have been classified include: tidal flat, sediment (sand, silt), mangrove forest, morphology in tidal flat, (sand wave, bar, channel, ...), river and water, shrimp pond, paddy field, garden tree, human settlement, relict dunes,... The training sites for classification are collected along coastal area of three above provinces in surveyed fields of 2008.

- *Hydrology fronts, tidal ebb and flood current, longshore current, algae bloom, eutrophication events*,... have been detected by visual interpretation and screening digitized base on color composite imagery of many kinds of sensor such as: Landsat, MESSR, JERS-VNIR, ALOS-AVNIR2.

2.3.4.- *Multi variable statistic analysis*: using for assessment the universal relationship between environment parameters with yield of Clam. Cluster Analysis – CA is main method are used. Criteria dataset include: rainfall, SST, difference of sea surface temperature  $\Delta T$ ; water salinity, chlorophyll and yield of Clam (monthly data from 2002 to 2008 collect from Clam Rang Dong co-operation). Statistica 7.0 software using for processing.

### **III) Results and discussion:**

#### *3.1.- The meteorology characteristics :*

Study region lie in tropical monsoon zone with air temperature is relative high in whole year and discrimination to 2 clear seasons: rainy and dry . Rainy season occurred from May to November, dry season occurred from December to April of next year. Although surveyed data of meteorological – hydrological office in Southern Branch showed climate characteristics in this region as following

##### *3.1.1.- Number of sunny hours*

All of study region (Tien Giang, Ben Tre, Tra Vinh) get number of sunny hours to be similar and fluctuate in range of 6.80 – 6.86 giờ/day. Number of sunny hour have been change according to season. Almost all of days with high number of sunny hours is concentrate in May to November. During this period, it is clear and blue, cloud level is low and fluctuate from 200 – 300 h/month.

##### *3.1.2.- Air temperature:*

The temporal variety is clear. Minimum value of air temperature happens during January (25.5 °C), they increase fastly and reach first peak during April (29 °C), May (decrease lightly 28.8 °C), June (28.0 °C) and then will decrease and become stabilize with thermal range in 27.4 – 27.6 °C.

##### *3.1.3.- Wind and wave regime:*

All of study region have been effected by monsoon. SW monsoon blow during rainy season with average velocity about 3.6 m/s and strongest during August (4.5 m/s). NE monsoon start from October (or delay a little), average velocity is 2.4 m/s and strongest during February – April with velocity about 5 - 8 m/s. During this period blowing wind is usually dry, hot and



combine with local wind (brize wind) and causing shore erosion, water surf, sea level rise, high salinity and also siltation in some area. They affect badly to live of Clam.

#### 3.1.4. Rain fall:

Analyzed results of EOF from serial data of rainfall dataset from 2002 – 2008 determined the main modes of time and spatial EOFs. Four first EOFs predominate about 50% of explained information of dataset according to 21.5%; 13.4%; 9.5% và 6.1%

Analysis results show that (figure 4)

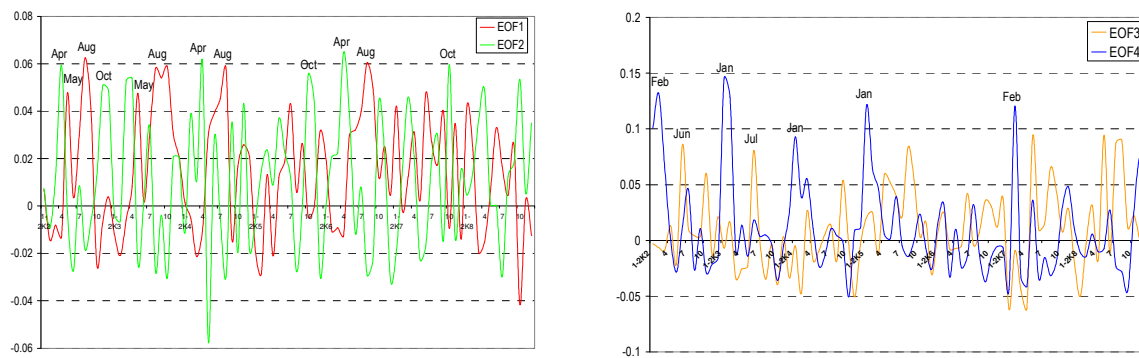


Figure 4. The temporal variation of 4 first EOF mode related to rainfall

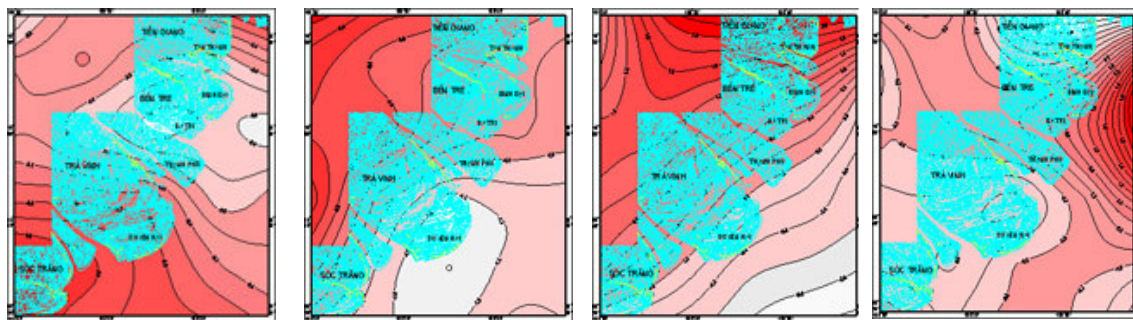
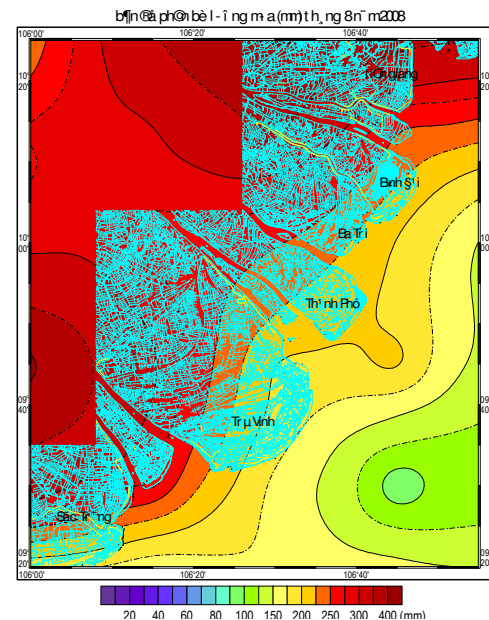


Figure 5. The spatial variation of 4 first EOF space mode related to rainfall

EOF1 explain the information of two rainfall peaks lie in May and August in year. Spatial EOF1 explain, during these periods, high rainfall concentrate mainly in Tien Giang and Tra Vinh (with value reach to 250 – 300mm), in while in coastal area of Ben Tre, they only reach in medium level with value about 150 – 200mm. In upstream of district of BenTre (Chau Thanh, Cho Lach), rainfall is also higher lightly (220 – 250mm). The distribution map of rainfall during May and August of 2008 are typical examples for spatial distribution of rainfall during above periods (figure 6)

*Figure 6. Distributed map of accumulated rainfall during August of 2008 typical for EOF1*



These distributed feature combine with characteristic of longshore current with N-S direction (will present in next parts) prescribed time for reproduction (and also release) of Clam breed in Ben Tre delay (about one and one and half months) compare with Tien Giang and Tra Vinh.

The tidal amplitude get a gradually decrease trend from North (Tieu rive mouth) to South (Dinh An river mouth). This thing will prescribe the dominant direction of tidal current from North East to South West and causing erosion – deposition effects and affect to Clam live.

Tidal amplitude is usually higher during November, December and January. They coincide to period of NE wind action strongly, dry season and can be causing salinity intrusion in inland. Lower tidal amplitude occur from April to September. The condition of calm wind during rainy season combine to weak tidal current (due to low amplitude) and also weaker wave causing comfortable condition for formation of landing ground of Breed Clam during above period.

### 3.2.2.- Sea Surface Temperature (SST):

Investigated results during 2008 – 2009 appear temporal and spacial strong variation of sea temperature, they fluate in range of 29.6 – 31.5 °C. SST dataset in 2007 – 2008 ((figure 11) derived from MODIS imagery show that:

- SST change in range of 26.1 – 30.0 °C (day) and 25.5 – 29.5 (night)
- SST during rainy season are larger compair with value during dry. Clearly, affect of warmer terrestrial water plume from in river create the big difference of SST between two seasons. This warming water plume (especial during immediate season) is important condition that stimulate for reproduce and development of Clam's larvae during July – August in annual.

- Day – night SST difference during rain season get value bigger 2 – 3 times compare to values during dry one.
- SST with gradually decreased trend from North to South, they related strongly to alongshore current features with above direction and increased trend from coastal to offshore in related to terrestrial warmer from in river.
- During rainy season, the warmer plume from inside river created thermal fronts in river mouths. There are the relative coincidence between location of parent's Clam grounds (from investigated data) and location of above frontal.

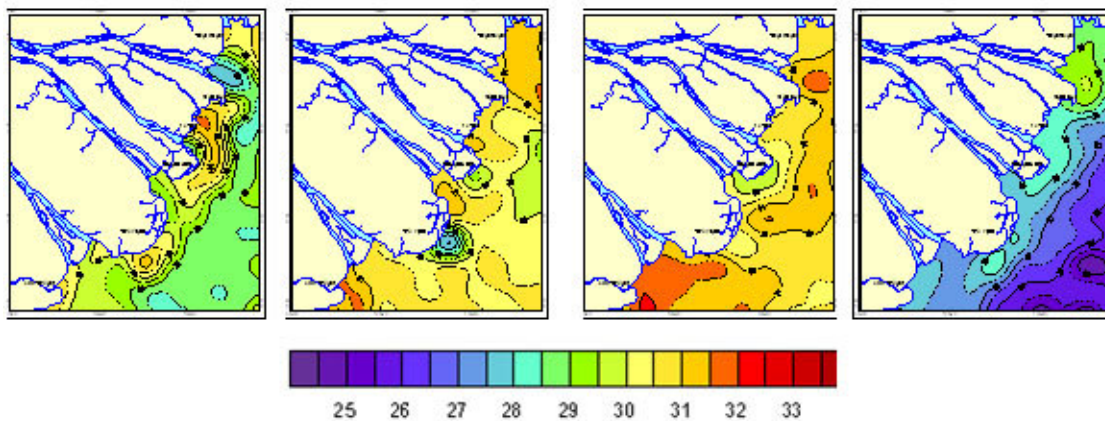


Figure 11. Montly distribution of SST (°C) during Jan, Apr, Jul and Oct of 2008

### 3.2.3.- Total suspended solid (TSS) :

Processed data of Total Suspended Solid (figure 12) derived from MODIS image shows that a general view about coastal current carries a lot of food source for Clam in dominant direction from NE to SW. Beside nutrient source from mangrove forest, algae patches landing into coast by waves and also in river mouths of investigated area. The nutrient and food sources taking from outside include: Food source from Xoai Rap river mouth transport toward Southern side supplies for Clam live during dry season (November to April next year), the second source mainly take from Batsac estuary toward North during rainy season (May to October), rate of sediment transport according to this direction is weaker.

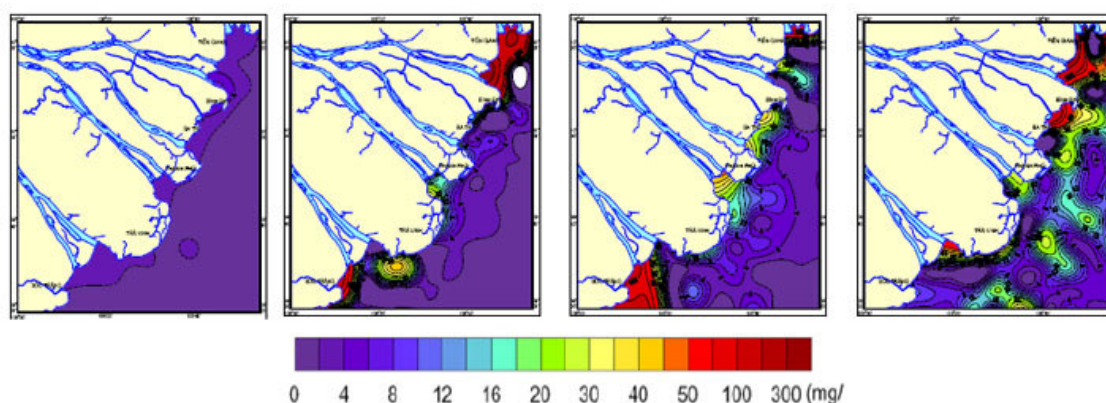


Figure 12. Monthly distribution of TSS (mg/l) during Jan, Apr, Jul and Oct of 2008

#### 3.2.4. *Phytoplankton pigment concentration (Chlorophyll- a)*

Concentration of chlorophyll-a is one of the factors affect primary productivity, phytoplankton, and water quality. Considering concentration of chlorophyll-a is the main factor creates biomass. It is a signature to identify food source for Clam.

Processed data of content of chlorophyll-a (figure 13) derived from MODIS image shows that:

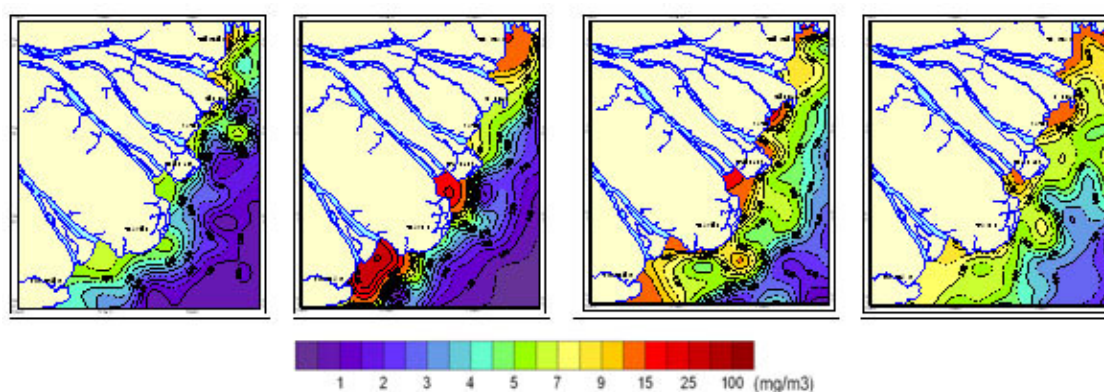


Figure 13. Monthly distribution of Chlo-a ( $\text{mg/m}^3$ ) during Jan, Apr, Jul and Oct of 2008

Chlorophyll-a changed complex in time, but general rule content of chlorophyll-a during dry season higher than their value during rainy season. The its peaks often appear late phase (about one month) in transition period from rainy into dry season (December, January) and opposite (July).

There are two peaks of chlorophyll-a in dry season, December and January. It is coincided with transition period from rainy into dry season (hot, dry and low moisture). In this period, solar radiation causes warmer water, organic substances are broken up quickly. It makes advantged condition for strong development of algae, and then creates algae patches in surface

water. These patches are dead, withered to enter broken organic cycle mentioned above. Additionally, effect of NE wave carried materials into coast, caused muddy deposition of organic substances and food. In general coastal water is high nutrient in this period, but not appropriate for development of Clam.

The third peak in July is lower (compare with two peaks in dry season). It often appears in transition period from dry into rainy season (late phase one month), but it is significant ecology for Clam. Early rains before caused warmer water, stimulated growth and development process, and created advantaged condition for reproduction, growth of Clam in this area.

Statistical analysis resulted in mean concentration of chlorophyll-a decreased gradually from Tien Giang to Ben Tre, and Tra Vinh correlative with 5.2; 3.6 and 3.2 (mg/m<sup>3</sup>). Considering about coastal flow carry with materials in N-S main direction, as well as about food source of supply for Clam from materials in Xoai Rap, Cua Dai, and Cua Tieu river mouth is confirmed again.

#### *3.2.5. The universal relationship between environmental parameters with Clam yield:*

By Cluster Analysis method allow us to find out the complex relationship between environment parameters and yield of Clam. Criteria dataset include: rainfall, SST, difference of sea surface temperature  $\Delta T$ ; water salinity, chlorophyll and yield of Clam (monthly data from 2002 to 2008 collect from Clam's Rang Dong co-operation).

Analysis results show that:

- Clam culture often give highest yield during period of August to November (yield reach 350 T/month) and second period during March – April (220 – 250 T/month). The optimum criteria set for Clam include: SST about 28.5 to 30.0 °C, salinity > 10 ‰, medium concentration of chlorophyll-a (0.5 - 0.8 mg/m<sup>3</sup>) and the medium rainfall (< 10mm/day).

- In some period of September – November, culture yield still reach Medium - High (200 T/month). At that time, high rainfall (> 10mm/day), high temperature (> 30 °C), day-night SST difference is too high (> 4 °C) and high concentration of chlorophyll-a (> 2 mg/m<sup>3</sup>). They limited development of Clam. But the water salinity still enough high (> 10 ‰) is the unique factor for Clam growth.

- The medium – low yield group usually occur during mid of July and October with high rainfall (> 10 mm/day), high temperature (> 30 °C), day-night SST difference is too high (> 4 °C), concentration of chlorophyll-a reach medium high (> 1.7 mg/m<sup>3</sup>), especially low salinity (<8 ‰) caused Clam's mass mortality in several periods.

- The low yield group – rainy season occur during May - June. At that time rainfall also reach medium high level of 7.5 mm/day but temperature is too high (> 30.5 °C) in started rainy season make to restriction the growth of Clam. This time only suitable for reproduction and formation of seed sources.

- The low yield group – dry season occur during November to February. The temperature is too very low (< 26° C) also is best important factor make to prevent growth of Clam. In



addition, at this time, the algae bloom and silty processes occur happen cause to effect to Clam live.

### 3.3. Topography and geomorphologic features in relationship with Clam's live:

#### 3.3.1. Dynamic geomorphologic features in tidal inlet of Mekong Delta :

According to Davis's concept (1964, [6], Bruun, 1978 [4]), Tidal inlet is river mouth and vicinity area have been mixing effected of river and tide regime. Can be divide tidal inlet into 3 groups related to tidal amplitude.

- Micro Tidal Inlets: exist in area where tidal amplitude is lower and less than 2m. The wave action and sand bodies forming by storm are important factors creating these Tidal Inlet. Typical morphology characteristic of this type is linear long, sand bodies and inside long and narrow lagoon. Tu Hien Inlet and Tam Giang lagoon (Hue), Oloan, DaNong Inlets (Phú Yên) in North Central of Vietnam belong to this type.
- Meso Tidal Inlet exist in area where tidal amplitude about 2 – 4 m. Ebb tidal delta, flood tidal delta and also meso size sand wave exist in tidal flat are main relief types creating tidal inlet of this type. This type exist in Southern side of Central of Vietnam such as Phan Ri, Phan Thiet, Ham Thuan Nam (Binh Thuan), Vung Tau,...
- Macro Tidal Inlet exist in area where tidal amplitude > 4m . River mouth get funnel shape and include linear sand bodies (Channel Margin Linear Bar) lie along in direction of ebb tidal current , ... The Tidal Inlets in Mekong delta belong to this type (figure 13)

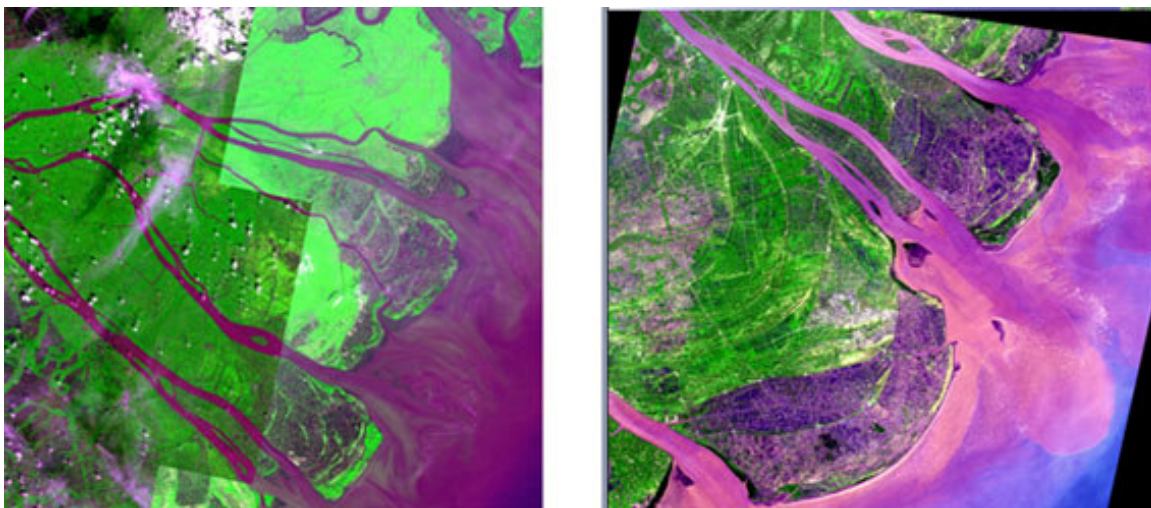


Figure 13. River mouths with funnel shape in Mekong Delta

In tidal flat of Mekong delta exist serial of relief types such as main ebb channel, channel margin linear bar, ripple marks, sand waves, spillover channel, swash bars, terminal lobe as similar as geomorphology model that Boothroyd (1974) [3] described (figure 14)

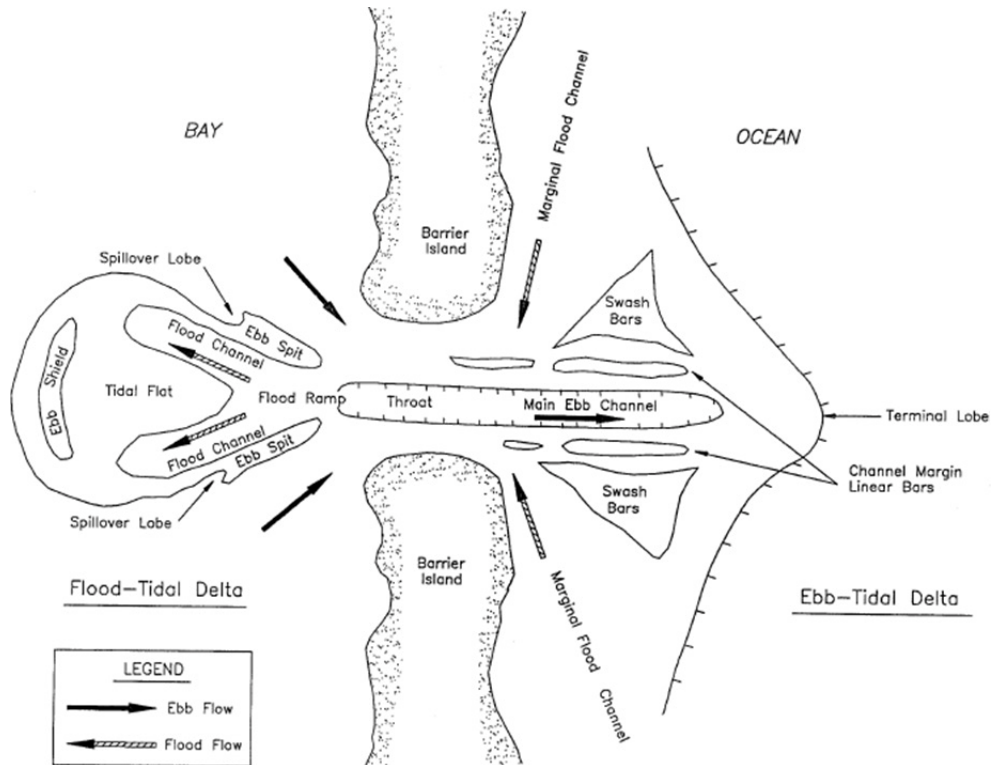


Figure 14. Conceptual dynamic geomorphology model of Tidal Inlet ( after, Boothroyd (1974) [3]

### 3.3.2. Erosion – accumulation , shore line change processes in Mekong Delta

By mean of band ratio method (Van, 2008), shorelines of Mekong Delta during difference periods (1973 from (Landsat MSS – 60 m; 1988 from MESSR – 50 m; 18 m from JERS – VNIR 1998 and 2008 from ALOS–AVNIR2–10 m) have been extrated. The temporal (decadal) shoreline changes in Mekong Delta have been presented in Figure 15.

The processed results show that:

- The erosion – deposition processes occur alternately.
- The erosion process occur in NE tidal flats, meanwhile the deposition process occur in SW ones. The relative position lie in between two river mouths.
- Sand dune moving with main trend from NE to SW according with alongshore direction.
- Flood Tidal Delta lie inside river, they enlarge toward the sea, attach with floating islands and become agriculture plenty lands and also Clam grounds in outside.

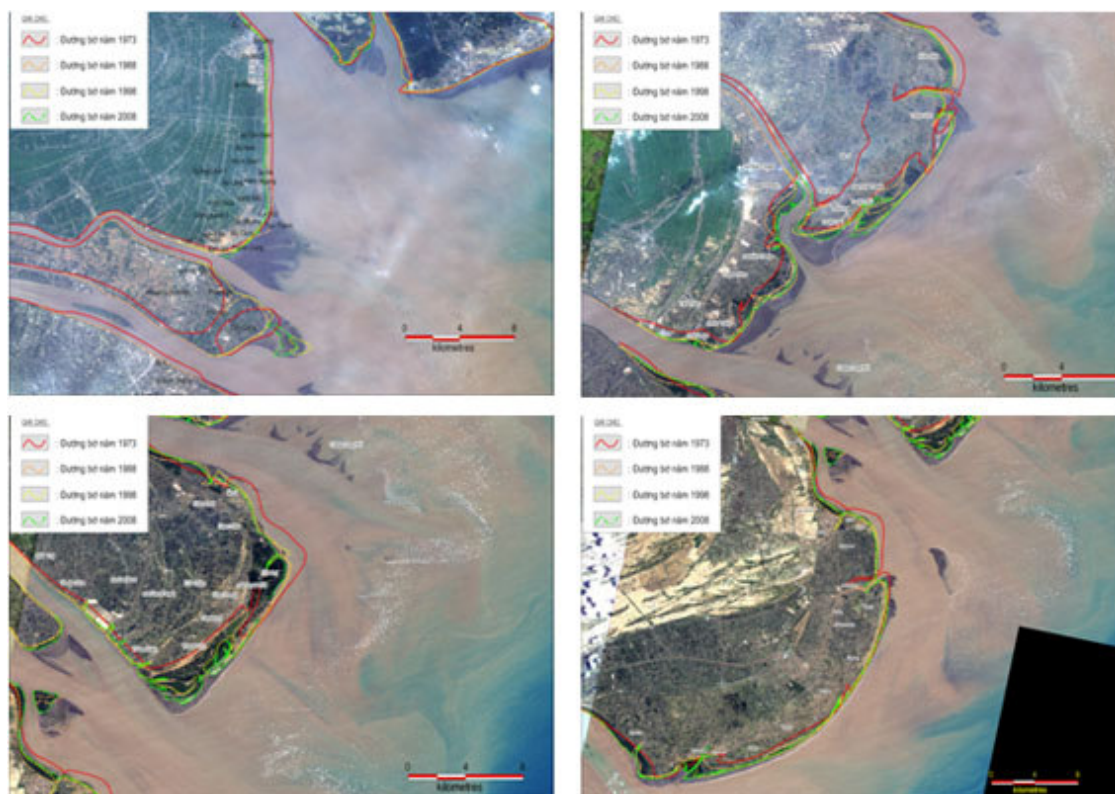


Figure 15. Shore change in Mekong Delta in decadal (1973, 1988, 1998 and 2008)

3.3.3.- *Geomorphologic features in relationship with formation and appearance of Clam grounds*: base on investigated data (on location of Clam grounds, sand wave, tidal current ,...) combine with processed data on landuse status, geomorphology of tidal flat ,... which extract from high resolution image (ALOS-AVNIR2) allow us find out the reason causing formation and appearance of Clam grounds.

- Distribution of Clam grounds on tidal flats of Tien Giang

Coastal section with 12 km long from Ap Cho (Vam Lang) to Cau Muong (Tan Thanh) (figure 16) is area where stand for the affect of both N-S alongshore and tidal current, erosion process is dominant. The tidal flat is slope, narrow and not suitable for formation and growth of Clam grounds.

The tidal flat in Tan Thanh is 6 km long, 5 km wide and cover an area about 1500 ha (estimate from lower low water line). This is one of main Potential Culture Zone (PCZ) for Clam in Tien Giang. In this area usually appears breeding grounds and also parent's grounds lie in an outside underwater bar and is deeper.

Ngang island (Con Ngang) lie between Cua Tieu and Cua Dai river mouths where also exist breeding and parent's grounds of Clam and Shell. It are considered flood tidal delta of tidal inlet in this region.





water of “fluid silty layer” is typical characteristic of breeding ground in this area. The synthetic combination of whole above factors take an ideal condition for information of breed grounds.

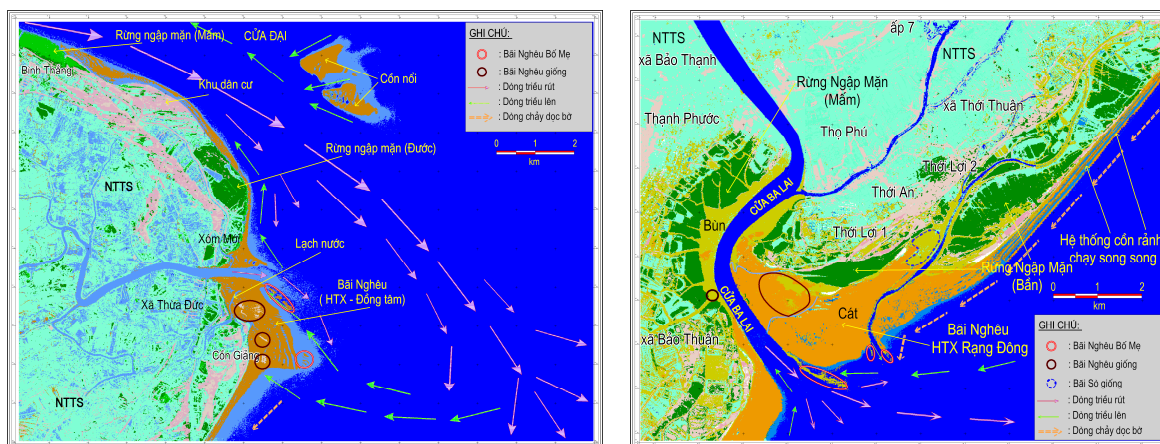


Figure 17. The location of Potential Clam Zones in Binh Dai (Ben Tre) in relationship with geomorphology and dynamic conditions

However, the moving trend in alongshore direction of sand spit in Thoi Thuan is too big (7 km/35 years). Risks of area reducing or disappearance of breeding grounds can occur in near future. Need to study for determining the technical solutions for protection them.

In coastal area of Ba Tri district include PCZ for Clam culture in Bao Thanh, An Thuy and Tan Thuy communes (figure 18). The breeding ground sometimes appear in tidal flat in Tan Thuy but with small size and inconsistency. The processed results from satellite image also found out “long linear bars”, an typical indicator for formation and concentration of parent’s grounds but investigated data show unexpected results. Perhaps, bars is shallower (2.5 – 3m), current and wave action are stronger result in parents Clam is not able to habit in here.

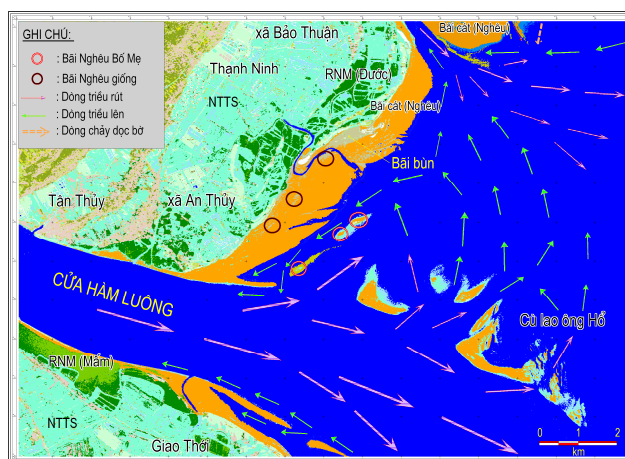


Figure 18. The location of Potential Clam Zones in Ba Tri (Ben Tre) in relationship with geomorphology and dynamic conditions

In coastal area of Thanh Phu district also include PCZ for Clam culture in Thanh Hai (PCZ = 50ha) and Thanh Phong (PCZ = 100 ha) communes. In coastal waters of Thanh Hai also exist a series of “linear bars” in 5 – 6 m deep (figure 19). The parents grounds sometime also appear in here. A raw estimate with supposition of ebb tidal current velocity reach about 80 cm/s, after 6 hours the material carry in water will come to this bar and then will rotate return by flood tidal current (due to characteristic of semi diurnal tide in Mekong delta). Another hand, this is area of

“stand water” and suitable for focusing of parents ground. These Clam grounds will be basis for formation of breeding ground in nearby tidal flats. However, due to condition of slope beach, weaker shelter, the erosion process usually occur , result in breeding ground only exist in short time (some days) and then dissapear.

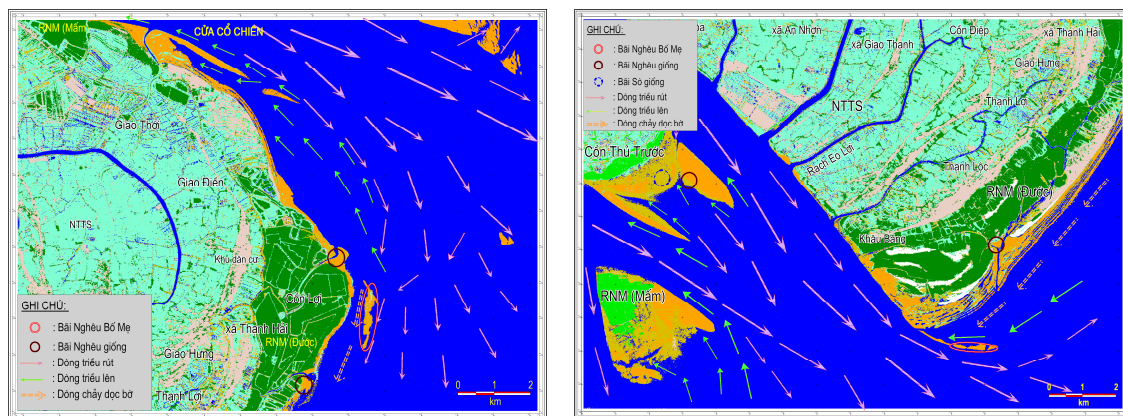


Figure 19. The location of Potential Clam Zones in Thanh Phu (Ben Tre) in relationship with geomorphology and dynamic conditions

### *Distribution of Clam grounds on tidal flats of Tra Vinh.*

- Processed results (figure 20) allow to find out relative similarity between dynamic-geomorphologic conditions with formed locations of Clam parent's and breeding grounds in two regions Thanh Phu (Ben Tre) and Tra Vinh, those are:

+ The forming mechanism of linear bars in outside boundary of tidal current. In Tra Vinh, this bar exist in inshore water close to Nha Mat village (Truong Long Hoa commune), the parent's ground also appear in this area.

+ On tidal flat of Nha Mat, Ba Dong villages where sometimes exist breeding grounds derived from parent's Clam habit on linear bar in deeper water.

+ Exist the Bar – Through system run parallel with shore in middle section of TraVinh coastal where is not able to developing for Clam live.

+ The existed, appearance position and their morphology of sandy, silty grounds in Thu Truoc Island in Cung Hau river is relative similarity with morphology and bio-resources units on Dung Island in Dinh An river

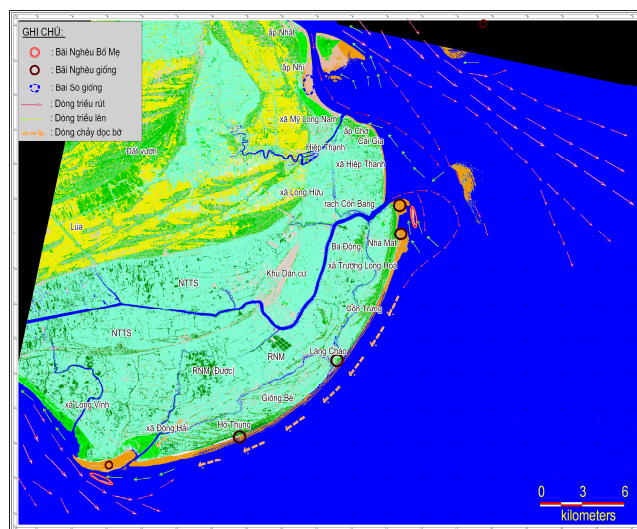


Figure 20. The location of Potential Clam Zones in Thanh Phu (Ben Tre) in relationship with geomorphology and dynamic conditions

#### **IV) Conclusion:**

- Application the remote sensing technique base on multi spectral imagery allow us to determine the quality and quantity relationship between environmental parameters with Clam's live in Mekong Delta.
- Rainfall, Sea water Temperature, Sea water Salinity, Concentration of Chlorophyll-a, Wind- Wave regime, Tide regime, water circulation and also geomorphology features in Mekong Delta are main factors effect to Clam live
- Found out the optimum environmental criteria set for growing of Clam culture
- Determined the suitable locations of parent's and breeding grounds of Clam as well as area of Potential Culture Zone for Clam culture in Tien Giang, Ben Tre and Tra Vinh provinces.

#### **V) Recommendation:**

- Need to enlarge the study region for whole of Mekong Delta (i.e include Can Gio, Soc Trang, Bac Lieu and Ca Mau provinces) and also study objects (include Oyster, Clam and also other bivalve species), so that not only Ben Tre's Clam reach MSC certification but also commercial brand of fresh mariculture of whole Mekong Delta.
- Need to additional and more detail study on bio resource, communities structure, environment, hydro-dynamic regime and geomorphology features in relationship to mollusk's live as well as predict the affect of human interfeeration in future.
- Study (forecast) the selection of suitable sites for Clam culture (and others) of Mekong Delta in effect background of climate change (sea level rise, global warming) in scenario of 10, 20 and 50 next years

#### **Acknowledgement:**

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# FROM RICE TO SHRIMP: ECOLOGICAL CHANGE AND HUMAN ADAPTATION IN THE MEKONG DELTA

Ngo Thi Phuong Lan<sup>\*</sup>

## **Abstract**

*In the last few decades, structural transformation in agriculture has been seen in Vietnam as a key to the success in rural economic development in the country. In the Mekong Delta, the most important rice baskets of Vietnam, farmers have diversified their economic activities, and engaged in production which involves high risks related to global market price fluctuation. This change of livelihood pattern results in a significant change of the delta's ecology.*

*This paper concerns social economic changes as human adaptations to a new living environment in the two rice-to-shrimp farming communities in the Mekong delta, one in the lower part (Ca Mau province) and the other in the upper part of the delta (Long An province). It examines the changes of local ecologies and livelihoods when farmers shift from conventional rice-cultivation to high-value shrimp farming which involves a shift from fresh water to saline water ecology. This paper concludes that human environment is a social process in which human constantly shape their living landscape and they have to adapt to the "created" environment by changing their socioeconomic lives. In the case of rice-to-shrimp shifting, in terms of people's living, when people cannot adapt to new ecological change locally, labor migration is the best solution. However, this phenomenon can be seen as an indicator for the agricultural unsustainability.*

*Theoretically, this comparative study will seek to contribute to the understanding of social changes from an environmental approach.*

Key words: economic structure transformation in agriculture, ecological change, human adaptation, shrimp farming, gender division of labor

## **Introduction**

As a fertile delta which is constantly raised by the silt from the Mekong River, the Mekong delta is the most potential area in agricultural production in Vietnam. In the process of increasing integration into the world market, this delta has undergone significant changes in agricultural production. Along with encouragement policies, trade liberalization, and technological advancement, the delta's various economic activities have shifted to market orientation. Commercially high-value agricultural production has more and more increased in scale and in volume. Consequently, although the delta only makes up 12% of the country's area, annually this delta produces 50% of rice production, 90% of exported rice, 80% aquaculture production, and 60% exported aquaculture of the country (Vietnam Economic News, 2008). Along with the above economic growth, the delta is no longer visualized as peaceful area but a changing delta in various aspects. Especially, the inhabitant's economic living patterns have experienced significant changes. During last decades, the economic structure transformation in agriculture has become a prominent phenomenon in the area.

Analyzing the shift from rice cultivation to shrimp farming in the Mekong delta, this paper asserts that along with the increasing integration into the world market, the delta's ecology has experienced dramatical changes. In this process, human play an important role in shaping their

living environment and this ecological change, in turn, shapes human lives. Human have to use their social material resources to adapt to the new “created” environment.

### **Research methods and case study sites**

This paper presents initial findings of my research based on qualitative methods, including interviews with shrimp farmers and local authorities at different levels, and a participant observation during my fieldwork in the year 2009 and early 2010 at the study sites.

My study examines two shrimp farming communities, one in Long An province and the other in Ca Mau province. These two communities engage in extensive and advanced extensive shrimp culture, two major types of shrimp culture in the Mekong delta. They are both saline affected areas which are characterized of having six months of saline water and six months of fresh water. Their inhabitants previously practiced one-crop rice cultivation. The shift from rice cultivation, which relies on fresh water ecology, to shrimp farming which relies on saline water ecology leads to a change in human pattern of living as a human ecological adaptation. These two cases will present some social aspects of structure transformation in agriculture in the Mekong delta.

### **Shrimp production in the Mekong delta**

According to the Resolution 09/2000/NQ-CP of June 15, 2000 on guidelines and policies for economic structure transformation and agricultural product consumption, economic structure transformation (chuyển dịch cơ cấu kinh tế) is the process of choosing structures, scales and types of products of agricultural production basing on natural resources and market needs in order to have an economically and ecologically high efficiency.

Farmers in the Mekong delta have a long tradition of market-oriented rice production. When the Sai Gon port was opened on February 22<sup>nd</sup>, 1860, rice and pepper were the first two exports of the south of Vietnam. During this period, Vietnam had been a famous exporting rice country in the region and in the world. Markets for rice exporting during period 1860-1945 were such countries as France, Europe, America, Indonesia, Singapore, the Philippines, China, and Japan (Nguyen Phan Quang, 2004)

At present, the Mekong delta has shifted from “a mono-farming to a diversified economy, a high-quality farming, and oriented to industry and service economy” (Huynh Phong Tranh, 2008). Technological advancement which provides high-productivity breeds, new fertilizers, and pesticides has played a crucial role in the course of the transformation in the delta. The structure transformation process in the Mekong delta have taken place intensively with various models such as farmers shifting from agricultural cultivation to aquaculture, to forestry and from rice cultivation to other agricultural products such as fruit farming. Among these prominent models, shifting from rice cultivation to shrimp farming theoretically proves to be an effective one. Thanks to shrimp’s high value, this model had been seen as an appropriate way to overcome poverty for farmers living in poor-productivity saline affected lands where they can normally cultivate one low-productivity rice crop per year.

Trade liberalization along with various policies in favor of aquaculture sector has accelerated the development of shrimp production in the delta. Trade liberalization opens a way for Vietnam shrimp enter the world market. The high demand of the world market is a key element which encourages the delta’s farmers to shift to high-valued shrimp farming. Policies in favour of aquaculture in general and shrimp farming in particular provide legal foundation for the



development of this sector. The key policy that triggered the expansion of aquaculture during period 1994-1999 is the Decision 773-TTg of December 21<sup>st</sup>, 1994 which aimed to build infrastructure for aquaculture such as irrigation system, shrimp nurseries, and large scale farms. Since 1999, many vigorous policies have been adopted to boost the country's shrimp export, namely the Aquaculture Development Programme for 1999-2010 (Decision 224/1999/TTg of 08/12/1999), Government Resolution No 09 in 2000 encouraging crop diversification, allowing a conversion of unproductive rice land into aquaculture, Decision 173/2001/QĐ-TTg of November 6<sup>th</sup>, 2001 promoting further development of aquaculture as the direction for economic development in the Mekong delta (Mai Trong Thong et al 2006:6). In response to these favourable conditions in terms of policy and consumption market, shrimp production is more and more developed in the delta. Ca Mau province in particular, has converted 150,000 ha rice land to shrimp ponds. Shrimp land of this province has reached 257,000 ha in the year 2008 which occupies half the delta shrimp farming area (Nhandan online, 2008).

As for farmers, in order to meet the increasing market demand of shrimp, they take advantage of their natural competitive advantage to participate in commercial shrimp production. Unlike rice production in which a part of produced rice can be used for farmers' own consumptions, shrimps are totally produced for sale. To those who live in mangrove area, according to the allocation system, farmers mix mangrove with shrimp farming (ex. In Nam Can and Dam Doi districts in Ca Mau province, An Minh district in Kien Giang province). Those who previously either cultivated one rice crop per year (ex. in Long An, Soc Trang, Tra Vinh provinces) or produced salt (esp. in Bac Lieu province) in saline affected areas either practice mono-shrimp farming or rice-shrimp rotation farming. Although being encouraged to practice sustainable rice-shrimp rotation system in which rice are cultivated during rainy season while shrimp are raised in dry season and mixed mangrove shrimp model, at the beginning, farmers tended to adopt mono-shrimp farming and clearing mangrove spontaneously due to shrimp's high value with less effort (Mai Trong Thong et al 2006:10). In Cai Nuoc of Ca Mau province in the period 1997-2002, shrimp land increased 8.5 times (Mai Trong Thong et al. 2006:8); Dam Doi district in 1995-1999 was the first place to "destroy saline-prevention-dams", and "to bring saline water illegally to rice fields to raise shrimp" (nhandan online, 2008).

At present, although shrimp productivity tends to decrease due to diseases and declining prices, up to November 2009, shrimp export revenue still occupies the highest ratio in the country's total revenue of aquatic export (Aquatic information center, 2008). This proves that although associated with high risk, shrimp farming is still attractive to the delta's farmers. In the Mekong delta, shrimps are raised in the coastal provinces of the Mekong delta, including Long An, Tien Giang, Ben Tre, Kien Giang, Tra Vinh, Soc Trang, Bac Lieu and Ca Mau provinces.

The 2000-2002 is a prosperous period of shrimp production in Vietnam in general and of the Mekong delta in particular with a remarkable increase in production and farmed area. With this increase, Vietnam enters the top – five leading countries in shrimp export. Only in Ca Mau, the biggest province in shrimp farming of the Mekong delta, shrimp land increases 2.5 times, from 90,551 ha in 1999 up to 239,398 ha in 2003 (Mai Trong Thong, et al 2006:7) and reaching 257,000 ha in 2008 (website of Ca Mau province, 2008).

Major export markets of Vietnam shrimp products are America and Japan who consume 70-80% shrimp export. Next important markets are European countries and other Asian countries such as China, Hong Kong, Taiwan and Korea (Aquatic information center, 2005).

The two main types of shrimp culture in the delta are extensive and advanced extensive. In period 2003-2004, in the Mekong delta, extensive shrimp culture made up 68%, advanced shrimp culture was 27%, intensive and semi-intensive was 5% (Nguyen Thanh Phuong et al. 2004:5). In the year 2008, this structure still remained; intensive and semi-intensive shrimp culture only made up 8% with 46.257ha. Extensive and advanced extensive shrimp cultures are still dominant. In Ca Mau and Bac Lieu provinces, these types of shrimp culture occupy over 90% (Ca Mau people's committee, 2008, General Statistics Office, 2006:450). In my study in 2009 and early 2010, in Hoa My, Cai Nuoc district, Ca Mau province, shrimp farmers mostly practiced extensive shrimp culture (91%) while in Tan Chanh, the biggest commune in shrimp production in Can Duoc district, Long An province, advanced extensive type was prominently applied (98%).

Spontaneousness is a common feature at the commencing period of shrimp production. Gradually, shrimp culture practice has officially been introduced to saline affected areas in the Mekong delta as a useful way to help the locals to improve their living. Government with various encouragement policies plays an important role in the prosperous period of shrimp production (since the year 2000). These policies legalize this new agricultural practice in the traditional rice cultivation areas. The period 2000 - 2002 witnessed a strong development of shrimp production and remarkably ecological and social changes in the Mekong delta.

In Tan Chanh of Can Duoc, Long An, shrimp was officially introduced to farmers as a alternative living pattern in 1994. However, farmers at first reluctantly adopted this new practice. They were doubtful of its success because they have no knowledge of raising shrimp. The remarkable profits from first shrimp crops boosted the increase of shrimp land annually. At present, shrimp farming is the main agricultural activity in the local. They practiced advanced extensive shrimp culture with which they have to feed shrimps. In Hoa My of Cai Nuoc, Ca Mau, shrimp farming did not exist until 2001. Hoa My used to be a fresh - water area thanks to saline prevention dam. With the approval of the government, all rice fields and gardens were converted to shrimp ponds. Being influenced by the striking success of neighboring shrimp areas especially Dam Doi and Nam Can, local farmers were eager to shift to shrimp farming at the same time. They applied extensive shrimp culture with which they do not need to feed shrimps.

### **Ecological change and the locals' socio-economic adaptations**

#### *Ecological change*

In Hoa My of Cai Nuoc and in Tan Chanh of Can Duoc, inhabitants' past living patterns mainly relied on fresh water ecology, by which people grew rice during rainy season. Normally, they grew 5 to 6 month rice because this kind of rice was suitable with the nature of the low terrain and saline affected land.

Living at the intersection of saline and fresh water, local inhabitants have been tried to build dams to prevent saline intrusion in the hope of having a fresh water ecological conditions so that they can cultivate rice for the whole year. Due to the nature of each locality, this effort gains different results.

In Tan Chanh, after the south liberation in 1975, the government had tried its best to built dams to keep fresh water during dry season for rice cultivation. However, this effort failed because, with the existence of dam, earth became more alum and there was a shortage of fresh water for rice cultivation. Due to uneven terrain, when the planting time came, all fields could not be

supplied enough fresh water through small water inlet sluice. Consequently, dams were destroyed intentionally and unintentionally to let the water run as it was.<sup>31</sup>

In Hoa My, dams were built when the first settlers came to reclaim the land. It was said that, annually, when the dry season came, people were mobilized to reinforce dams to prevent the intrusion of saline water. In rainy season, these dams were cut so that fresh water could intrude the inner land for rice cultivation. After 1975, solid dams were built with a durable water inlet sluice. With these saline water -prevention dams, due to having vast land, local inhabitants could cultivate rice, fruit- trees, raise pigs and fish safely (not fearing of saline intrusion to destroy the crops).

In Tan Chanh of Long An, people normally converted rice fields into shrimp ponds. In some cases, they enlarged the ponds by reducing their limited garden and residential land. However, due to limited land, this type of conversion is not common in Tan Chanh. While in Hoa My, due to their large land, people converted both rice fields and gardens into shrimp ponds. They hired excavators to do it.

With the shifting from rice to shrimp, local ecologies have experienced certain changes which force their inhabitant have to adapt. Landscapes of the communities are no longer characterized by green rice fields but treeless shrimp ponds. Farmers in Hoa My described the effect of ecological changes on their ecology as well as their lives as follows:

“letting saline water into fields and ponds had great affect. Gardens were damaged; vegetable and fruits died out... In the past, during dry season when we did not have enough water, we could rely on fresh water ponds. At present, we have no way for getting fresh water for daily use. At present, we use drilled well water and rain water. When shifting to shrimp farming, we had to have drilled well. When letting saline water into the field, rice could not bear grains. At the beginning years, lands were alumized and salinized. Since 2006, it has been getting better... In the past, there was no rạm (small crab). Since the day of transformation, there have been a lot of rạm which dramatically destroyed rice. Previously, we used to bath in cannels. At present, we do not dare. Saline water also makes human “stunted”...”

Man, aged 74, (interviewed in Hoa My 2009)

“Water inlet sluice and dams were destroyed to bring saline water for us to raise shrimp; however, the land is salinized... very affected. At first, all trees died out because of salinity. Previously, we have all kinds of vegetable. They are rare now. Two or three years ago, we raised dikes higher so that we could plant coconuts and bananas. In the past, fresh water fishes were abundant. We could get tens of kilograms of them a day. It does not happen now.”

Man, aged 53, Thi Tuong (interviewed in Hoa My 2009)

This ecological change is a social process in which human play an active role in shaping their environment for the sake of their living. However, this is a two- faced process. Shifting from a

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<sup>31</sup> Interviewed with local authorities in 2009

conventional pattern of living to a new one, human have to adapt to this created environment by changing their ways of life.

*Changes in living patterns as the locals' adaptation to environmental changes*

Tan Chanh inhabitants, due to their limited land associated with low earnings from one rice crop, have long employed other economic activities beside agricultural production for their living. This is possible because of its proximity to Ho Chi Minh city, the busiest city in the south of Vietnam, and its location as a bridge between the southwest and the southeast parts of the south of Vietnam. Common services which they engaged in were boat trading and labor migration to other agricultural areas. In the past, the locals were famous for trading of chinaware, earthen jars, pigs, household products, firewood from the southeast to the southwest part of Vietnam and vice versa.

A customary gender division of labor was one in which men were in charge of heavy labor, especially bread-winning while women were directed to family care. In their leisure after harvest time, men were in charge of trading and labor migrating. In boat trading business, each trip could last months. When it was time to grow and harvest rice, men stayed home to help their families with various agricultural works. Both men and women engaged in rice growing because this kind of work requires much labor. After that, men left for other trips. Their wives could accompany them, leaving the elders and children at home. The locals did not do any agricultural activities during six months of saline water. Other inhabitants, who could not afford for trading boat, migrated to other places to find seasonal jobs. They could work as manual laborers (làm mướn), masons, and carpenters. Labor migration has long been a common phenomenon after harvest time in Khanh Hau, another rice farming community in Long An (Hendry 1964:135-137).

When people shifted to shrimp farming although there was no difference in terms of seasonal rhyme with half year of fresh water and half year of saline water, inhabitants' living pattern experienced a conversion. Previously, they relied on fresh water for their agricultural production, at present, on saline water. Saline water is recognized as a precious resource. At the beginning of the shifting, the model of rice-shrimp rotation was introduced and encouraged as a sustainable system. Therefore, the structure of shrimp ponds included four components: rice field, ditch, and surrounding dike. Rice field occupied about 60% of the pond where farmers were supposed to grow rice during wet season. The ditch occupied about 30% of the pond and around the rice field. Shrimps concentrated on the ditch bottom during daytime to avoid high temperature. Surrounding dike occupied about 20% of the field. Sludge and accretive silt from the ditch were moved to the dike surface every year. However, with striking success of first shrimp crops, people tended to neglect rice farming. They even raised two shrimp crops per year instead of shrimp-rice rotation or they let the field vacant because rice yield was no longer considered as important as shrimp. Moreover, in the context of many farmers did not grow rice, it was very difficult for other farmers to grow rice because of such destroyers as insects, birds and rodents. Gradually, having limited land while wishing to increase shrimp production, farmers have erased the rice field in their ponds to make them deeper so that they can raise many more shrimps. Consequently, long –traditional rice fields are totally converted to deep shrimp ponds. Local living patterns became totally relying on saline water ecology. They raise shrimps in dry season and their leisure time is in rainy season.

In rice cultivation time, both man and women engaged in agricultural work. In shrimp production, man is the key labor because this kind of work requires much labor in water,

complicated technology and muscle works such as dredging the ditch. Man is usually considered as the pillar of the family. Therefore, he is the person who keeps information and knowledge of shrimp production. However, due to the ecological change with a conversion from rice fields to shrimp ponds and repeated failure in shrimp production, and with the boost of various factories in the locality as well as neighboring districts and cities, young men and women have decided to become workers who can get stable monthly salary in stead of unpredictable and unstable income from shrimp production. The rise of shipping build yards in Tan Chanh attracts many local men. They leave shrimp farming to their wives or parents. The year 2009, in a shrimp raising training course in Dinh hamlet, Tan Chanh commune, witnessed a shift in labor division by gender. Because men went out to work, the majority of the course participants were women. Due to this change, women began engaging actively into shrimp production, including selecting shrimp fry, feeding and watching shrimp. Other heavy works, they hired other people to do. However, labor migration of men causes a shortage of labour in agricultural production. This leads to an increase in agricultural cost.

Although remarkable profits of first shrimp crops do help people to have large amount of income which they have ever had when cultivating rice, at present, due to the high risk in terms of prices, changing environment, and diseases, this kind of production is no longer considered as the main source of income for local inhabitants in Tan Chanh. They raise shrimp as one way to try their luck. In the past, due to limited land, rice yield could not meet their consumption for the whole year, therefore, they have to rely to other sources of income such as labor migration and trading, however, farmers could still subsist on certain stable source of rice. Other cash incomes served for other family's expenditures such as parties, health care and education. In shrimp production time, all households' needs have to rely on market supply including rice, the basic food of people.

Contrast to that of Tan Chanh, seasonal cycle in Hoa My changed with the shift from rice to shrimp. Previously, the local only had several main channels. At present, Many interlacing channels were enlarged and dug to let saline water intrude all fields of the area to serve shrimp farming. These channels serve as main transportation way by machine boats for the locals.

Saline water-prevention dam was destroyed to let water run naturally. The local landscape totally changed. Local subsistent economy was replaced. In the rice growing time, the locals practiced a subsistent economy in which they produced rice, vegetable, fruits, pigs, poultry, and fish for their own consumption. Due to their large lands, inhabitants could sell the excess volume of these products for cash. Labor migration was not a common phenomenon during this time because local agricultural work needed much labor.

In Hoa My of Ca Mau, at present, people mainly practice extensive shrimp culture with which they can raise shrimp continuously for the whole year. Contrary to shrimp culture in Tan Chanh, Hoa My farmers do not practice periodic crop, instead they release shrimp fry (post larvae) every month or every two months and harvest shrimp on monthly basis. Like in Tan Chanh, previously both man and women engaged in rice production. At present, man is the key labor in shrimp production. He is also the one who keeps information and knowledge of shrimp raising. Woman mainly involves in selling shrimps. A woman's explanation of her failure in shrimp farming illustrates a common perception of the role of man in shrimp farming

My family has no man. I do not know any knowledge of shrimp raising, no knowledge of shrimp fry, environment, and land. Man normally has more knowledge than us (women).

Female shrimp farmer, aged 45, Thi Tuong (interviewed in 2009)

Due to a high alum and lack of technological information, contrary to Tan Chanh where people were successful in raising shrimp at the beginning, Hoa My although with large shrimp land did not get expected results. At the beginning, the majority of farmers suffered severe loss. While they invested a lot of money on pond building and shrimp fry (at the beginning, price of shrimp fry was much higher than it is now), they gained nothing from shrimp. Moreover, they could not grow rice because of salinity while they have no experiences in dealing with this. In the new living pattern, people cannot have stable source of income as well as food. In the past, rice production provided enough food for the whole year, due to having large land, the majority of households could sell the excess volume of rice to get cash besides other sources of cash such as gardening and fresh water fishing raising. Due to repeated loss in shrimp production since 2001, and the excess of labor in agriculture, young people have chosen to migrate to other places to get jobs. They became workers in various factories in other provinces such as Binh Duong and Dong Nai or went to get manual works in other agricultural production areas. Shrimp farmers are mainly middle-aged and young people who are responsible for taking care of their families.

Shrimp steal become common in the locality. This phenomenon contributes to the suffering of the locals besides shrimp failure. It threatens people lives. Shrimps are much easier to be stolen than fishes and other agricultural products. Local inhabitants have to watch their shrimp fields all night. However, because their fields are too large to be watched, shrimp steals often happen. Thefts often use pesticide to catch shrimps effectively and quickly. Therefore, people do not only loose their shrimps but also suffer an environmental destroy so intensively that it is hard for them to raise next crops. This disaster contributes to the insecurity of people living. A farmer makes an evaluation of the shifting as follows:

“Fresh water ecology is very good. Trees are luxuriant. Aquatic products are abundant. At present, they died out. When letting saline water into fields to raise shrimp, people’s lives are more difficult than they were in the past time. Previously, we had various natural sources of income. Now, we can only rely on shrimp. Raising shrimp despite its insecure earnings is better than rice farming in terms of labor intensity and efforts. If we are lucky, we can earn much more money with less labour and effort than cultivating rice”

In this new pattern of living, besides changes in people living, the locals are facing an internal contradiction in the community. That is a contradiction in using water for shrimp raising among farmers. In Ca Mau, it is a contradiction between extensive and intensive farmers. Although there are regulations for intensive farmers in dredging their ponds, it is hard to check its validity. Therefore, extensive farmers often claim their failure for waste water from intensive ponds. In Long An, because people practice advanced shrimp culture, they have to invest a lot on shrimp food. Although there are regulations on draining water, due to individual benefit, people do not follow them. For example, when someone’s shrimps die out because of catching disease, according to regulations, he has to use chemical to sterilize the pond before draining water out of the pond. However, people often do not do it because of high cost. If neighboring farmers use this effected water, his shrimps are easy to catch diseases.

### **Rice-shrimp farming: an environmentally friendly and sustainable adaptation**

Rice-shrimp farming is considered to have higher efficiency and more sustainable than rice or shrimp monoculture system (Tran Thanh Be, 1994: iv, Vuong, D.Q.T. and Lin, 2001:3).

However, in reality, at first, the Mekong delta farmers did not practice this system due to afore mentioned reasons. Gradually, with accumulative experiences in shrimp farming and rice growing in saline affected areas, as well as great support from local government and live experience of successful rice-shrimp rotation in food security, shrimp farmers, at present, recognize the benefit of rice-shrimp rotation practice. People do recognize that rice improves environment for shrimps and shrimp waste fosters rice. In Long An, when rainy season comes, they prepare their field for growing rice. They use short-time rice variety so that they can harvest before the shrimp raising season. In Ca Mau and Long An, at the beginning of wet season, farmer flush salinity out of their fields using rain and fresh water from channels to grow rice. However, while in Long An, farmers do not raise shrimps in wet season, in Ca Mau, farmers do. They raise fresh-water familiar shrimps (tôm hầm đất) in the rice field. Shrimps live in the ditch while rice grows in the field.

The reality of this rotation practices in the two study communities shows that although the problem of right varieties of rice for saline affected areas are resolved but irrigation system and consistency in rice -shrimp rotation have not. For example, in Hoa My of Ca Mau in the year 2009, rice was cultivated from August to November lunar year, when saline water rose high unexpectedly, low surrounding dikes could not prevent the saline water intrusion. Consequently, many households lost their rice crops totally. In Tan Chanh of Long An, people are no longer or reluctant to grow rice for some reasons: 1) some have converted their rice fields to deep shrimp ponds, therefore, they do not have fields to grow rice; 2) some do not want to grow rice because their limited land. If they grew rice, they would have less gain with great efforts; 3) some still practice rice growing but they have to put much effort on preventing their rice paddies from rodent and birds. The great efforts while less gain disappoints their will to grow rice.

## **Conclusion**

The shift from rice to shrimp leads to an ecological changes which associate with a change in living patterns. This case shows that human environment is a social process in which human constantly shape their living environment and they have to adapt to this “created” environment by changing their socioeconomic lives. In the case of rice-to-shrimp shifting, in terms of people’s living, when people cannot adapt to new ecological change locally, labor migration is the best solution. Although it is the result of labor excess due to the need of less labor in shrimp farming, at the other side, this phenomenon can also be seen as an indicator for the agricultural unsustainability. In reality, rice-shrimp farming has been proved to be a sustainable practice. However, measures to apply this practice needs more attentions, especially at macro levels like the case of study sites has presented.

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**RELATIONSHIP QUALITY IN FISH VALUE CHAINS:  
BUYER - SUPPLIER MANAGEMENT IN THE PANGASIU INDUSTRY,  
VIETNAM**

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## Abstract

This study deals with the importance of investment and trust in designing an export-oriented fish value chain quality management. It analyses relationship quality in the *Pangasius* industry in order to improve product quality through closer supply chain coordination. According to findings from several research streams, we argue that relationship quality must be conceptualized as a construct of trust and investment. Consequently, we derived a conceptual model that commitment and trust *to* relationship quality. The analysis discusses assumptions and concepts of Porter's value chain, transaction cost economics, and theory of institutions.

To verify the applicability of the model, we conducted a survey in the *Pangasius* industry of Vietnam. The data obtained from a sample of 120 fish farmers in the Mekong Delta, Vietnam. Each interview made was taped and properly transcribed. We collected relevant information by interviewing the managers of four processing/export firms. In addition, we consulted secondary data by making use of documentary information, archival records from relevant organizations, library books and Internet facilities. Hence, using different sources of evidence we were able to triangulate our findings on the main issues under study.

Keywords: relationship quality, trust, transaction specific investments, value chain

## 1. INTRODUCTION

In recent years many businesses have recognized the importance of commitment and trust in improving the performance of exchanging parties (Boersma, *et al.* 2003; Nooteboom, 2002; Sako and Helper, 1998; Forsgren *et al.* 1995; Morgan and Hunt, 1994; Easton and Araujo, 1994; Williamson, 1993; Hakansson and Johanson, 1992). As a result, a great deal of attention has been paid by both economic and sociological scholars to develop concepts relevant for studying investment and trust (Williamson, 1985; Hakansson and Snehota, 1995). The economic and sociological approaches differ in their theoretical assumptions and concepts, and several efforts have been made to bridge the gap between these two perspectives, e.g. views of transaction cost economics and networking theory on the discussions of investment and trust, see Johansson and Mattson (1987) and Nooteboom (1993). Their findings show that while transaction cost approach focuses on opportunistic behavior of exchanging parties and the risk associates with it, networking theory focuses on its correlate trust. Networking theory also argues that trust minimizes transaction costs and it is a viable governance structure in a dynamic network environment (Hakansson and Johanson, 1993). Transaction cost theory explains investment in the form of credible commitment or reputation of the firm, and its discussion is limited to relationship specific investments. Networking theory notes that investment is the outcome of mutual adaptation processes and provides a broader way of measuring investments made in a relationship.

In this paper, we want to verify to what extent networking theory can integrate the main concepts of transaction cost theory on investment and trust. Our approach seems in line with Williamson's

view (1992), that transaction cost economics needs to be refined and extended. It is also argued that such an integrated networking theory provides a better explanation to problems of the seafood and other industries (Anderson, *et al.* 1994; Dryer, 1996; Jarillo, 1988; Gulati, 1995; Sven and Gronhaug, 1995; Mitullah, 1999; McCormick, 1999)[1]. Based on this integrated networking theory, a comprehensive conceptual framework is developed.

In order to verify the applicability of the model derived, we made a study on the Vietnam fish industry by specifically analysing the importance of investment and trust between fish suppliers and export firms, which want to meet the demand of EU fish importers.

## **2. THEORETICAL APPROACH**

This section discusses concepts of transaction cost theory in the light of networking theory. The basic concept of transaction cost theory concerns efficiency. We observed several deficiencies of this theory in the problem under study. However, the concept of efficiency can be integrated in the networking theory. Networking theory makes a distinction between ‘transfer activities’, which are related to efficiency, and ‘transformation activities’, which are related to effectiveness (Hakansson and Johanson, 1992). However, the networking perspective indicates that instead of considering minimizing the cost of one transaction alone, the efficiency criterion should be based on a set of transactions between two parties or should be aimed at maximizing the joint transaction value of a given transaction among several value system actors (Zajac and Olsen, 1993). In this case, the unit of analysis concerns the relationship rather than a discrete transaction, which provides a strong basis for understanding the coordination of industrial activities in a broader context. Also, the network approach considers the transaction costs as only one aspect of the total network relationships. To achieve an overall assessment of the network relationship, these costs must be compared with the total advantages of the cooperation.

Transaction cost theory claims that the choice of governance structure is determined by attributes of transaction and assumptions on human behaviour (Williamson, 1985). The discussions on transaction cost theory also show that a high level of asset specificity leads to high sunk costs. It further implies that firms are likely to stick to a particular operating structure and therefore will not be able to respond to strategic changes in market expectations or competitive conditions. Due to the sunk costs, asset specificity can also be viewed as a variable that may have a negative influence on the development of long-term business relations. From the networking perspective, the concept of asset specificity is very closely related to the discussion of heterogeneity, mutual adaptation, power and market assets (Hagg and Johanson, 1982; Johanson and Mattsson, 1987). According to the networking approach, investment is realized as a result of a mutual adaptation process and is positively related to the development of closer relationships. Firms in the network are engaged in exchange processes, and every transaction made is considered to be an investment. This investment concept is integrated in our conceptual model as one of the key features of relationships.

Frequent exchanges between partners may be the result of a gradual development of trust that helps partners to lower transaction costs by safeguarding against opportunism. The implications

of the effect of trust on governance structures are generally ignored in transaction cost theory. This limitation of social embeddedness of economic actions and trust is best dealt with in networking theory (Granovetter, 1985, Uzzi 1997, Grabher 1993). From a networking perspective, opportunism is not considered as a basic characteristic of the actor. Instead trust is an important concept in the networking approach. We share the view that informal networks reduce transaction costs because of the high level of trust in the relationships. A high level of trust enables firms to reduce negotiation costs, it helps to reduce transactional uncertainty and it creates opportunities for the exchange of goods and services. Hence, our conceptual framework relies heavily on instruments that build trust. The detailed discussion on this issue is presented in later sections.

### 3. THE CONCEPTUAL FRAMEWORK

Based on the theoretical discussions, we derived two strongly inter-related elements, *investment* and *trust*, crucial for analysing network processes.

#### **Investment**

If industry actors are to realize their objectives – such as getting access to resources or markets – each actor is expected to invest in relationships. The concept of investment in marketing and networking theories deserves special attention. Empirical studies, see e.g. Easton and Araujo (1994), show that Williamson's concept was a very narrow one, essentially concerning the bare minimum investment that a partner needs to make to sustain the relationship at all. They proposed a hierarchy of investments within buyer-seller relationships. Also, in Hagg and Johanson (1982) and Forsgren *et al.* (1995) three types of market investments are analysed: general, market-specific, and relationship-specific investments. General market investment concerns overall investments made in a business. Market-specific investments refer to investments made for a specific market, product or geographical region. Finally, relationship-specific investments are investments of which the value becomes zero if the relationship comes to an end.

In our conceptual model, we considered two types of investments, namely market-specific investments and relationship-specific investments, and we adopted same arguments from Hagg and Johanson (1982) in analysing market investments. To develop business relations, firms should make market-specific investments, which are flexible by nature and do not necessarily create sunk costs. For instance, flexibility is found to be one of the most important characteristics of successful firms in the seafood industry [2]. This is because the industry mainly relies on access to marine resources, predominantly fish, and the monthly catch fluctuates. At the same time, the demand for fish also changes from time to time. In such a situation, firms are expected to be flexible enough to re-adjust to such changes by adapting their organizations in terms of size, form of production, or technology. This implies that firms do not necessarily have to invest in assets that create sunk costs. It is also possible for industry actors to invest in relationship-specific investments. This specially holds true when exporters prefer to get a regular supply of fish; to make this possible they develop business ties with individual fish suppliers by providing credit or other services.

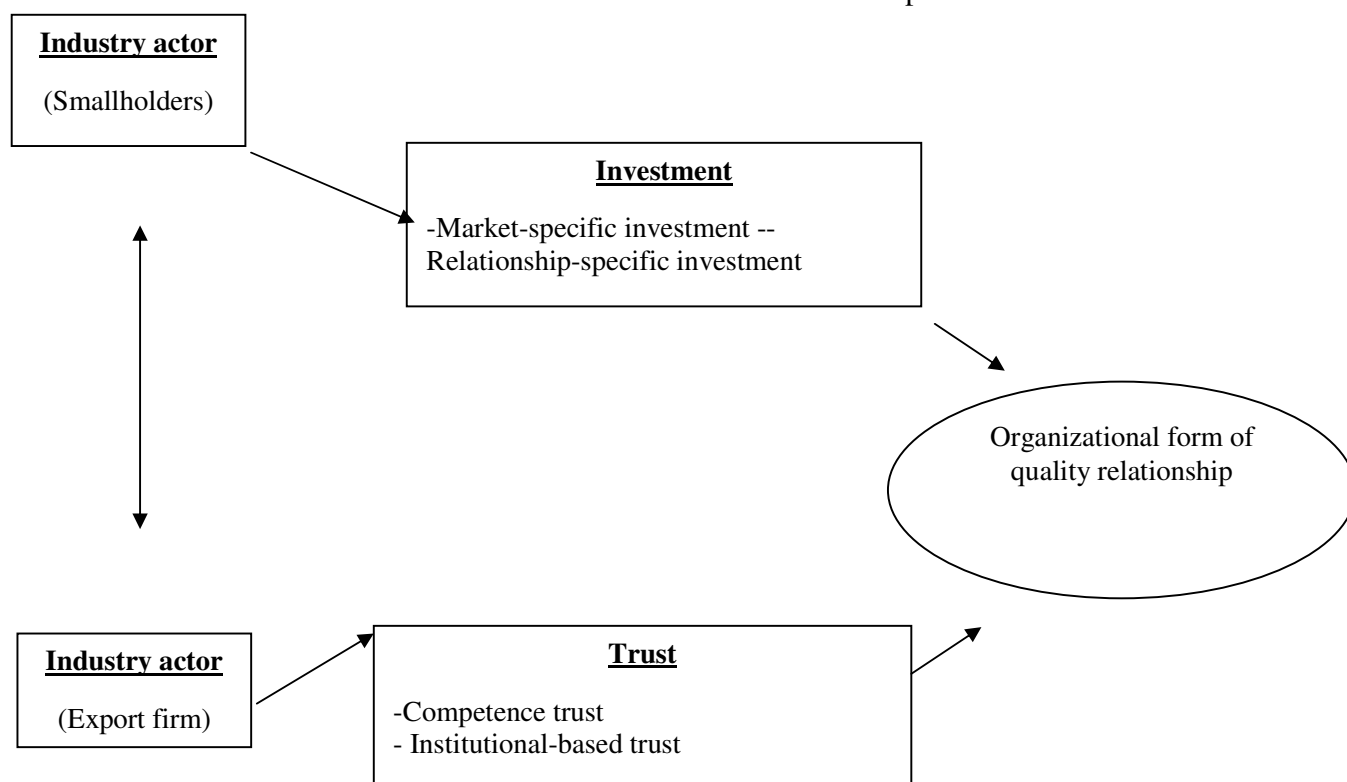
## Trust

The literature clearly shows that trust creates stability and guarantees continuity in the relationships between industry actors and it is the glue that holds the relationship together. Several studies consider trust as a central feature of business relationships and propose different ways of measuring trust. For instance, Sako (1992) identified three types of trust, namely, contractual, competence and goodwill trust. Similarly, Shapiro *et al.* (1992) discussed deterrence-based, knowledge-based, and identification-based trust. Mishra (1996) focuses on competence, reliability and openness in defining trust. According to Doney and Cannon (1997), the development of trust involves five processes: a calculative, capability, predictive, intentionality and transference processes[3]. Zucker (1986) defined trust as a set of expectations shared by all those involved in an exchange and identified three dimensions of trust, namely process-based, characteristics-based and institutional-based trust. Such classification integrates most of the instruments of measuring trust as explained by other researchers and allows us to examine the concept of trust in a broader perspective. Hence, in our study, we adopted Zucker's (1986) definition and classifications of trust, with the exception that we redefined process-based trust as competence trust.

*Competence trust* is based on concrete experience concerning certain behavioural patterns. It results from the dynamics of past and future exchange processes and it is influenced by the reputation of industry actors. Each party gathers information on past transactions with which they can evaluate the other partner's trustworthiness. As a means of evaluation, they consider both technical and managerial competences in living up to their promises. Competence trust combines the explanations provided by Sako (1992) on the same issue, and the discussions of Shapiro *et al.* (1992) on knowledge-based trust. It is also consistent with the discussions of Mishra (1996), and Doney and Cannon (1997). *Characteristic-based trust* refers to the influence of social norms, religion, personal bonds or friendship in the relationships between industry actors. This is similar to the discussions of Sako (1992) and Shapiro *et al.* (1992) on goodwill trust and identification-based trust, respectively. According to Williamson (2000), characteristic-based trust represents a level 1 form of institutional arrangement, which is characterized by informal institutions, customs and norms.

*Institutional-based trust* concerns formal social structures, which are usually backed by sanctions based on the law. These include property rights, business contracts, formation of fish cooperative and fishery legislations. This type of trust incorporates the discussion by Sako (1992) on contractual trust, and the implications of deterrence-based trust as stated by Shapiro *et al.* (1992). Similarly, according to Williamson (2000), institutional-based trust represents level 2 and level 3 forms of institutional arrangements, which include the rules of the game and actual play of the game itself.

Figure 1: Conceptual framework of the importance of investment and trust in developing business relations between fish farmers and export firms



#### 4. RESEARCH DESIGN

A research design links the data to be collected to the research question and it provides useful guidelines for analyzing data (Yin 1994, Miles and Huberman 1992). There is no single research design and which method (s) to follow depends on the research problem and its purpose (Ghauri *et al.* 1995). Our research design is aimed at selecting a research method that is relevant to finding an answer to our research question: *What is the role of investment and trust in organizing an export-oriented fish supply chain in the Vietnam fish industry?* We make use of case studies. A case study design depends on the unit of analysis. The unit of analysis may be an individual, a firm, a decision or a program (Yin 1994). In choosing the case, the most important criterion is that we learn as much as possible from the case (Eisenhardt 1995, Stake 1995). In our research, the unit of analysis refers to the business relationship that a firm has with other organizations. Accordingly, we developed a case study protocol that is in line with the model and each variable was properly classified and made operational. Each actor is asked questions specifically related to investment and trust. In order to verify the applicability of the model derived, we studied business relations between fish suppliers and export firms in Vietnam.

There are different ways of collecting data. The case study and survey methods are the two most frequently used research methods. In a survey method, samples are usually large, and the focus is

not on an individual in a sample but rather on the general profiles or statistics derived from individual cases. Questionnaires, personal interviews and telephone surveys are some of the methods used in the survey method. According to Yin (1994), a case study is defined as “an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident”. In a case study, a single subject or phenomenon which is bounded by time and activity (event, process) is explored. The case study’s strength is its ability to deal with a full variety of evidence like documents, interviews and observations.

In order to understand the view of fish suppliers, we carried out both case study interviews and survey research. A case study and survey methods may complement each other. In our research with fish suppliers, we found that it is useful to start with a case study approach and then based use a survey method. By using both a case study and survey research we managed to gather all relevant information, which allows us to present a compete case study on fish suppliers. In total, there are 11 villages in An Giang and after consultation with key fishery experts we selected 3 fish villages for a case study. Accordingly, we carried out a case study interview with twenty-six farmers. The respondents were asked about their view on the importance of investment and trust in developing business relations between themselves and export firms. Each interview made was taped and properly transcribed. To complement the case study results, we also administered a survey, through semi-structured questionnaires, with 63 fishermen selected from 26 fishing villages. In the survey, the variables were classified and the respondents were asked to rate the importance of each variable, through a five-point Likert scale: (1) not important at all, (2) not important, (3) neutral, (4) important, and (5) very important. We presented the frequency, mean and standard deviation of each response using an SPSS statistical package. The results of both case study interviews and surveys were linked to each variable under investigation and were compared with the views of partner firms. In order to verify the views of both respondents, we also referred to financial records and reports prepared by respondents and other organizations. Hence, using different sources of evidence we were able to triangulate our findings on the main issues under study.

## **5. ANALYSIS**

An analysis is made on the importance of making investment in the relationship between fishermen and export firms and the role of trust in maintaining the relationship. The importance of flexible supply contract as an organisational form of relationship is discussed as well.

### **Investment Made in Relationships**

In order to gain access to credit and attractive fish prices from the export firm, fishermen have to show their willingness to make market-specific and relationship-specific investments. Regarding market-specific investment, we asked the respondents to rate two variables: the “willingness to invest in advanced quality assurance” and the “willingness to use new technology”. According to the survey, 92% of the respondents said that a “willingness to invest in advanced quality assurance” was (very) important. 62% of the respondents rated the “willingness to use new technology” as (very) important. In particular, they said they were prepared to invest in an icebox and fish preservation methods (Table 1). About 24 per cent of the respondents answered that they did not need to invest in modern quality assurance for they already had these facilities.

Table 1: The importance of **investment** in the future relationship between fish farmers (N=120) and processing/export firms

Importance of investment Factors	Very important	Important	Neutral	Not important	Not important at all	Mean	Standard deviation
<b><i>Market-specific investments</i></b>							
Willingness to invest in advanced quality assurance	73.0	19.0	4.8	3.2	0.0	4.62	0.73
Willingness to use new technology	25.4	36.5	14.3	20.6	3.2	3.60	1.17
<b><i>Relationship-specific investments</i></b>							
Willingness to deliver fish after every crop to the same processing firms	46.00	39.7	11.1	3.2	0.0	4.29	0.79
Commitment to deliver quality fish	12.7	34.9	25.4	22.2	4.8	3.29	1.09
Readiness to deliver fish in large volume	44.4	39.7	7.9	1.6	6.3	4.14	1.07
Adaptation to production schedules	15.9	30.2	27.0	19.0	7.9	3.27	1.18

Source: Survey data, 2008.

Fish farmers are also expected to make commitments to the export firm in the field of relationship-specific investments. The respondents were shown four variables and they were asked to rate each variable in terms of its importance. These variables were “willingness to deliver fish after every crop to the same processing firms”, “commitment to deliver quality fish”, “readiness to deliver fish in large volumes”, and “adaptation to production schedules”. According to the survey results, the respondents rated “willingness to deliver fish after every crop to the same processing firms” and “commitment to deliver fish in large volumes” as (very) important made up 86 per cent and 84 per cent, respectively. The respondents who rated



“commitment to deliver quality fish” and “adaptation to production schedules” as (very) important made up 48 per cent and 46 per cent, respectively (Table 1). This finding shows that fish farmers know the importance of a regular supply of large volumes of fish in order to develop relationships with export firms. However, the respondents find it less important for the relationship to deliver quality fish. According to the respondents, it requires more of an effort and more costs to culture quality fish – and above all, fish farmers cannot predict what price of fish they sell, for this is mainly a matter of luck. This prevents fish farmers from delivering quality fish within a specific time schedule.

### The Role of Trust in Maintaining the Relationship

The amount of investments to be made by both fish farmers and processing/export firms may change in time and will be influenced by the level of trust developed between the parties. According to our conceptual framework, two forms of trust explain the relationship between fish farmers and processing/export firms, namely competence trust, and institutional-based trust.

#### *Competence trust*

Competence trust concerns the managerial and technical ability of a fish farmer or an export firm in dealing with its promises and agreements. From four variables the respondents were asked to select the ones that best represent the competence of export firms in the future. The variables include attractive prices, the promise of being a regular buyer, the provision of credit, and the provision of market information. The survey results reveal that those who rated ‘credit provision’ and ‘attractive prices’ as (very) important make up 84 per cent and 76 per cent, respectively. On the other hand, 52 per cent and 19 per cent rated the variables ‘regular buyer’ and ‘provision of market information’ as (very) important, respectively (Table 2). This confirms that in order to win the confidence of fish farmers and to develop trust, processing/export firms should be able to provide credit and set an attractive fish price. This may increase the number of fish farmers who regularly supply fish to the export firms.

Table 2: The importance of **trust** in the future relationship between fish farmers (N=120) and processing/export firms

Importance of trust	Very importa nt	Importan t	Neutral	Not important	Not important at all	Mean	Standard deviation
Factors							
<b><i>Competence-based trust</i></b>							
Attractive price	46.00	30.2	11.1	12.7	0.0	4.10	1.04
Promising to be a regular buyer	20.6	31.7	42.9	4.8	0.0	3.68	0.86

Getting access credit	44.4	39.7	12.7	1.6	1.6	4.24	0.86
Providing market information	4.8	14.3	34.9	46.0	0.0	2.78	0.87
<i><b>Institutional-based trust</b></i>							
Written contracts	71.4	11.1	7.9	7.9	1.6	4.43	1.04
Unwritten contracts	11.1	19.0	27.0	25.4	17.5	2.81	1.25

Source: Survey data, 2008.

Export firms stressed that the competence of a fish farmer is best evaluated by his reputation as a regular supplier and by his punctuality in meeting deadlines. However, they complained that fish farmers failed to offer the desired competence because they could not regularly supply, and also they did not adhere to quality requirements.

#### *Institutional-based trust*

Institutional-based trust is associated with property rights, laws and mechanisms of enforcing laws that influence the relationship of fish farmer with processing/export firms. So far, contractual agreements between fish farmers and export firms were almost non-existent, and the few agreements that did exist consisted of oral promises. The respondents were asked to evaluate the importance of written and non-written contracts in the future. 83 per cent rated “written contracts” and 30 per cent “non-written contracts” as (very) important (Table 2). The managers of export firms think that written contracts are better than unwritten ones because they can be used as a reference document in case one of the parties refuses to act according to the agreement.

Fish farmers were shown five variables of importance in the design of a flexible supply contract and they were asked to rate each variable in terms of its importance. The variables included realizing a reasonable profit margin, fixing the duration of the contract, quality specifications, quantity specifications, and just-in-time delivery. The results are shown in Table 3. They confirm that fish farmers are more interested in profitable contractual agreement, which allow them to supply fish in large volumes to the export firms.

Table 3: Flexible supply contract

Importance flexible of contract	Very important	Important	Neutral	Not important	Not important at all	Mean	Standard deviation

Factors							
Gaining reasonable profit margin	77.8	17.5	4.8	0.0	0.0	4.73	0.54
Fix a specific contract in advance	17.5	44.4	19.0	11.1	7.9	3.52	1.15
Fish quality specification	9.5	25.4	36.5	25.4	3.2	3.13	1.01
Quantity specification	36.5	39.7	9.5	7.9	6.3	3.92	1.17
Just-in-time delivery	14.3	44.4	27.0	7.9	6.3	3.52	1.04

Source: Survey data, 2008.

The export firms pointed out that apart from gaining a reasonable profit margin, the contract should also stress just-in-time delivery as well as quality specification. This also shows the preference for the delivery of quality fish over quantity, because the export firms prefer to buy specific species that have high demand on the world market. The managers considered demand conditions, cost of fishing supplies, fixing lifetime of the contract, and exchange of market information as relatively less important. To conclude, the main finding is that both fish suppliers and exporters are willing to enter into a flexible supply contract that is profitable for them.

## 6. DISCUSSION

The case study and survey results indicate a number of findings. The findings also show the importance of making investments to develop business relations between fish farmers and processing/export firms. The responding fish farmers pointed out their willingness to invest in advanced quality assurance, to use new technology, and to deliver in large volumes to the one and the same export firm.

The size of the investment made by fish farmers and export firms through time is also influenced by the level of trust developed between the parties. The case study and survey results confirm that providing credit and setting attractive fish prices are not only the reasons for fish farmers to develop a relationship with an exporter, they are also major criteria to evaluate the competence of an exporter. According to the export firms, the competence of a fish farmer is best evaluated

by his reputation as a regular supplier and his accuracy in meeting deadlines. It is also found that both fish farmers and exporters are willing to use a written flexible supply contract that is profitable to both of them. Such a contract can be realized by linking the main activities performed by fish farmers and export firms and by developing commercial ties related to pricing decisions, credit ties that are concerned with sanctioning loans, technical ties related to the adaptation of production processes.

## 7. CONCLUSIONS

This paper attempts to bridge differences between the transaction cost theory and networking theory by integrating the assumptions and limitations of transaction cost theory into the discussion of networking theory. The theoretical discussions and the field research confirm the usefulness of networking theory in dealing with supply chain problems. In order to verify the applicability of the framework derived, we considered the features of investment and trust in developing business relations between fish farmers and processing/export firms in a new business environment: the Vietnam fish industry. We wanted to contribute to the existing discussions on networking theory by exploring to which extent such concepts could be applied in totally different setting just as the Vietnam fish industry. The framework considers market-specific investment, relationship-specific investment, competence trust, and institutional-based trust. The case study and survey results demonstrated that the variables included in the framework were instrumental in analyzing supply chain problems in the Vietnam fish industry. Industry actors acknowledged the importance of market-specific and relationship-specific investments in order to realize each other's objectives. Through time the relationship between both actors is influenced by the level of trust and extent of resource control exercised by exchanging parties. Managerial and technical competences of partners, compliance with formal and informal mechanisms of enforcing laws, and the existence of balanced bargaining power are also important factors for maintaining the relationship. The same concepts can also be applied in dealing with problems of the fish industry of other developing economies.

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## **Community-based fish culture – a viable coping strategy for farmers in the Mekong Delta?**

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### **Abstract**

Floodplains are characterized by a period of several months when the land is not available for agriculture and large and open areas are used for fisheries. Enclosures in the flooded areas can be utilized for fish production to produce a crop of stocked fish, in addition to naturally occurring self-recruited species. The WorldFish Center and Research Institute for Aquaculture n° 2 (RIA 2) tested options for community-based fish culture in floodplain enclosures in the Mekong Delta. The trials yielded fish production in the range of 61 to 179 kg/ha. Results indicate that the models tested are sensitive and dependant on flood patterns and limitations imposed by the rice culture calendar. Other technical challenges included short grow-out period and fingerling size. These initial trials have shown that community-based fish culture is an innovative approach for the Mekong Delta that has the potential to provide an alternative livelihood option in the face of environmental change and development. To increase uptake, the technical design of the approach could be further optimised, and mechanisms for community participation could be enhanced to increase economic incentives for adoption of the technology by farmers.

**Key words:** Mekong Delta, floodplain aquaculture, environmental change

### *The Delta Environment*

In the Vietnamese Mekong Delta, an area of 1.2 to 1.9 million hectares is annually flooded, with 1 million hectares inundated by floods of more than 1 meter. Yet this flooded environment has been exposed to developments that have transformed the floodplains, bringing them under increased control. The intensification of rice culture, including the spread of High Yielding Rice Varieties (HYV), and the development of Flood Control Drainage and Irrigation systems in flood plains and deltas has led to the replacement of deep water rice with two or even three HYV irrigated rice crops in the dry season, followed by a fallow period during the flood (Kakonen 2008). In recent years, the floodplain has provided an important resource for the development of fresh water aquaculture, particularly intensive production of pangasids. In between 2000 and 2006, the aquaculture area in the Mekong Delta increased by 39%, and in 2007 aquaculture in

the Mekong Delta represents 72% for the national production. However, intensive aquaculture in cage or pond is not necessarily an option accessible for poor farmers in the floodplain, and the environmental cost of these production systems is significant (GTZ 2005).

The Mekong Delta is characterised by constant change, and very high land and water productivity (Pech and Sunada 2008). Climate change is likely to bring more change to this dynamic environment, as recent studies on climate change indicate that the runoff throughout the Mekong basin is expected to increase by 21% (Eastham et al. 2008) and annual flood volumes are likely to increase with greater peak flows and longer duration of flooding compared to historic conditions. It is estimated that the average area of flooding in the Mekong Delta is likely to increase by an annual average of 3,800 km<sup>2</sup>. At the same time, projection scenarios on agricultural productivity and population growth relate a high probability of food scarcity (Eastham et al. 2008). Floodplain aquaculture and more generally agrarian system will have to evolve in order to cope with these environmental changes, to sustain not only economic growth but also livelihoods of farmers in the Delta.

#### *Community-based aquaculture – design and approach*

Flooded areas are considered to be relatively ‘unproductive’, as valuable agricultural land is submerged for part of the year, creating open access waterbodies. Yet these seasonal water bodies provide an opportunity to increase water and land productivity by integrating fish culture in seasonally inundated rice fields. Enhanced water productivity is the basis for the community-based fish culture concept, which has been tested by the WorldFish Center and national research partners in five countries<sup>34</sup> since 2005.

Community Based Fish Culture aims to provide an option for households in seasonally flooding areas to benefit from fish culture, where the costs of individual aquaculture systems are prohibitive. Governed by the same technical design principles as individual aquaculture, such as size and stocking density of cultured fish, community-based aquaculture also introduces institutions for managing fish culture on a collective basis. Pilot testing of the approach therefore involved both a technical and an institutional component, with the outcome of fish culture equally dependent on successful community management as it was on the profitable production of fish.

In Bangladesh, decades of experience in community-based fisheries has supported the development of fish culture systems, implemented on a community basis, that are now generating important benefits for both landowners and landless fishers. The success of the approach suggested that other floodplain communities in Asia and Africa may also benefit from increased productivity during the flood season. This led to the dissemination and testing of community-based fish culture in Cambodia, Vietnam, China and Mali.

In the Mekong Delta, fingerlings were stocked in flooded rice fields after the rice harvest in August, during the early stage of the flood. Flood control infrastructure in the form of dikes surrounding rice fields, provided a boundary for the fish culture site. Participation in the fish culture trials was based on ownership of land within the boundary of the selected project site,

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<sup>34</sup> Bangladesh, Cambodia, Vietnam, China, Mali.

with members organized in a group to oversee the fish culture activities and basic administration and record keeping. Fish are harvested and sold when the rice fields are drained, at the end of the flood in December. Between 2006 and 2009, nine sites in Can Tho, Dong Thap, An Giang and Vinh Long provinces were selected to test the fish culture model<sup>35</sup>. Fish culture groups were provided with funds in the first year of fish culture trials to purchase fingerlings and materials for maintaining the site boundary. If fish culture was successful, it was expected that some of the income would be returned to a central fund to support the purchase of fingerlings the following year, encouraging self-sufficiency of the farmer group.

Assistance and technical support is provided by the local Department of Fisheries (DoF) and Research Institute of Aquaculture n<sup>o</sup>2 (RIA 2). At some sites, additional financial support for dike maintenance and improvement was provided by the commune.

#### *Site selection*

We present the results and analysis of some of the project sites in Can Tho, Vinh long and Dong Thap provinces.

The technical design, such as area or fish species stocked and benefit sharing agreements, are presented in Table 1 and Table 2. Fish culture was implemented in areas where two rice crop per year or three rice crop per year were produced. In the latter case, the water level and flood period are shorter, with 2 sites with a flood depth of less than 100 cm and rice fields flooded later in the year - in September rather than August.

Regulations governing access to the waterbody during the fish culture period, duties of each member of the group and benefit sharing arrangements were discussed during a general meeting facilitated by RIA n<sup>o</sup>2 at the start of the trial. In all sites, fishing in the fish culture area during fish grow-out was prohibited, for members and non-members.

The model is based on extensive fish culture of species suited for floodplain aquaculture, such as common carp (*Cyprinus carpio*), bighead carps (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). In a few cases grass carp (*Ctenopharyngodon idella*) was also stocked. Only in one site, in Can Tho, province high value species such as snakehead (*Channa striata*) and red tilapia (*Oreochromis sp*) were nursed and stocked. Production was based on the availability of natural food in the water body.

In addition, a series of surveys was implemented in the some of the project sites to understand the constraining and enabling factors for collective aquaculture in floodplains. The survey was based on semi-structured interviews with project beneficiaries and non beneficiaries to understand the process of project implementation, technical and economic aspects but also

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<sup>35</sup> In 2006 in four sites in Dong thap (one site- Phu Cuong - Tam Nong), An Giang (one site- Vinh Hanh – Chau Thanh) and Can Tho (two sites- D1 Thanh Thang - Vinh Thanh and Thoi Dong – Co Do). In 2007 in four site ( three in Can Tho D1, C2 Thanh Thang – Vinh Thanh, Truong Phu B Co Do ) and one in Vinh Long ( Tan Hung, Binh Tan ) In 2008 in one site in Dong thap ( Truong Xuan Thap Muoi). In 2009 two sites in Dong Thap province (Truong Xuan, Hung Thanh – Thap Muoi) and one site in Can Tho ( D1 Thanh Thang- Vinh Thanh)

incentives and constraints faced by project members. In each site more than 50% of the beneficiaries and at least 10 households not involved in the project were interviewed. In total, 130 households were interviewed in (67 households involved in the project and 63 households not involved)

## **Results and Discussion**

### *Benefit from community-based fish culture*

Fish culture on a community-basis in the Mekong Delta produced varying results in terms of production, income and subsequent adoption of the technology by farmers.

Comparatively with non fish culture area, the fish production of flooded rice fields can be increased. Additional benefits on rice field ecology and impact on rice culture could be observed. The culture of fish in rice field could reduce the cost of soil preparation, the cost of inputs, with less pesticide, insecticide, fertilizers and rice seeds.

A straightforward comparison of production across sites is complicated by the variations in size and characteristics of project sites, and the constraints that affected production at each location. Fish production from fish stocking, ranged from 61 to 179 kg/ha, with associated net benefit of 50 USD/ha (Table 2).

However, while these figures are comparable to outputs in some locations in Bangladesh, the perception of success differed amongst project participants in the two countries, with farmers in the Mekong Delta showing a preference for alternative livelihood options available to them during the flood season, that were able to yield a higher income.

### *Supporting and constraining factors*

As both the technical and institutional design components of the project have been introduced to each of the project countries for the first time, mechanisms were needed to permit flexibility in the research approach to adapt the technology to local conditions. The project concept was based on the principles of adaptive management, an iterative process that encourages the review and adaptation of activities after each harvest cycle. However, at a number of sites, participants chose to discontinue fish culture after one culture cycle.

Several technical, economic and social factors explain these results, including technical design of the fish culture system, flood characteristics, the dike system, integration of the fish culture within the rice based production system, as well as marketing aspects and social characteristics of the fish culture group.

### *Technical factors*

#### *Intensive v. extensive culture*

On this scale, it was found that extensive culture, based on naturally available feed, was more appropriate than semi-intensive culture, using commercial, pelleted feed.. However, the provision of feed increased the operational cost of production to 74 USD/ha compared with extensive culture of lower value species where the operational cost was 21USD/ha. Moreover, production results were not high enough to cover the cost of nursing, with a low survival rate of 10% and 1% for red tilapia and snakehead respectively. Survival rate was recorded between 13 and 33% on average in the different sites for other species, with average fingerling size of around 6g per fish.

#### *Stocking size*

Fish stocking is particularly important in these extensive, relatively open systems, where self-recruiting wild fish are also present. Selecting the correct size of fish for stocking is dependent upon a critical balance between cost and survival. Small size fingerlings may be reduce costs, but predation by wildfish increases mortality. Larger size fingerlings may shower greater survival, but at higher overall costs. The research showed that fingerlings larger than 6g should be selected for stocking.

### *Environmental Factors*

Flood duration, height and flood delay were important factors in determining production. With a production system based only on natural water productivity, water levels need to be sufficiently high to create suitable conditions for fish culture. In Can Tho and Vinh Long provinces, the water level reached only 60 and 63 cm in 2007, limiting fish grow. Floods arrived later than expected, delaying fish stocking and thus reducing the grow-out period. This last fact highlights the dependency of the model on environmental conditions and its integration in the broader production system in space and in time.

Areas supporting double rice culture are more suitable for the development of community-based fish culture when compared to triple rice crop areas. The size of the fingerlings should also be adapted to this short grow-out period to reach marketable size in less than 12 weeks of growth. Fish culture in seasonally inundated rice fields depends on the rice culture calendar. Fish culture can begin in nurseries, while rice is still cultivated, but in most cases fish were stocked after rice harvest as water levels began to rise. Fish harvest is timed according to flood recession, which indicates the start of rice field drainage and of rice culture. Project members and non members having land inside the fish culture areas prioritized their activities toward rice culture and were willing to harvest the fish as early as possible in order to start rice culture. Rice culture after the flood period was never delayed in the different sites to allow for a longer fish grow-out period indicating the preference, and value, of rice culture over fish culture. The coordination of the rice cropping calendar necessitates drainage of the entire cultivated area surrounded by dikes. As a result, fish culture cannot be extended and fish must be harvested. In the cases where not all the landowners are involved in the fish culture group, water management for rice culture can generate conflicts. Rice culture in triple cropping areas is of high economic importance for

farmers and for national interest, particularly in the light of the recent food crisis and high price of rice. Rice production is therefore a priority in these areas, and fish culture is considered a secondary activity. On average, the net return from dry season irrigated rice (December to April) can generate 860 to 1,612 USD/ha (n=28), according to soil type, rice variety and market price.

### *Socio-Economic factors*

An optimum market environment is required to maximise the benefits from fish culture production. The potential benefits available from fish production in the flooded area were undermined by the effects of market supply and demand, and fluctuations in fish market price. When asked, marketing of the harvested fish was ranked as one the main challenges of the model by 26%, 33%, and 18% of the respondents participating in the project in three hamlets in Can Tho province. The period of harvesting, in November and early December, coincided with the bulk of wild fish harvest, when fish supply is most abundant, thus lowering fish prices on the regional market, with a variation from 0.34 USD/kg in November to 1.14 USD/kg in April for common carp (*Cyprinus carpio*). Harvesting fish when supply is lower could significantly improve the value of fish production, however, this would require that the fish are held until the optimum time for harvest, and with land at a premium, the conversion of valuable agricultural land to a holding pond was not a feasible option. Introducing a wider range of stakeholders into the group, including landholders or commercial fish producers with holding facilities for large volumes of fish, may be one option if issues of power and elite capture could be controlled.

Participants considered that fish culture demanded too much of their time in the form of guarding duties, meetings and harvesting. Comparatively, the different off farm and non farm labor can provide higher incomes during the flood period, with farmers engaging in a range of activities according to opportunities in fishing and rice post-harvest processing or construction work (Table 3). For villagers, the project was perceived as a new technique, without guarantee of results and potential benefits will be earned only at the end of the flood season while other activities can provide daily income for household needs. This is a common issue in aquaculture and agriculture systems. Households rely upon a range of activities that meet different household needs. Activities that provide a daily source of income are critical to most households who lack savings, however, aquaculture in particular can provide a form of saving and additional income source. These activities provide the greatest contribution to the households when they complement one another within the household portfolio.

The operational costs of fish culture also varied according to the rules established by each fish culture group. At two sites in Can Tho province, labor to guard and harvest were paid, with costs accounting for 10 to 20% of the total cost of production, while in other groups these activities were undertaken by group members at no cost.

Indirect benefit of fish culture on rice culture operational cost need found in this project needs to be investigated further. Other studies have found either no negative effects of fish on rice production when cultured concurrently (Vromant et al., 2002; Sinh, 1995), with generally positive impact on farm income (Berg, 2002; Duong et al., 1998; Gupta et al., 1998; Mai et al., 1992). Such benefits can be considered to be a valuable contribution of this model to the long term environmental protection strategy.

## Conclusions

### *Is Community Based Aquaculture a viable option for coping with change in the Mekong Delta?*

Community-based fish culture is a new and innovative technology for the Mekong Delta. Unlike Bangladesh, where community-based fisheries management has a long history, the community-based fish culture project in Vietnam represents the first attempt to encourage farmers to pool their resources and work collectively for fish production in flooded areas. As such, the results of the trials should be considered within this context, as an approach with potential for optimisation under the appropriate environmental, social and economic conditions.

As the Mekong Delta undergoes rapid change, farmers will be required to adapt to changing circumstances that are both man-made and natural in origin. A policy of expanding commercial aquaculture and encouraging farmers and fishers to adopt alternative livelihoods, including employment on aquaculture farms, could make community-based aquaculture a more attractive option for farmers if it means they are able to retain access to land and livelihood. Following improvements in the technical design, this low-cost, community based fish culture model, and the associated benefits to rural farmers in terms of food security and increased income, may gain the support of national and local authorities seeking to improve the well-being of the rural poor, as well as increasing solidarity in communities. Further more, the environmental costs of extensive fish culture are lower than intensive, export oriented aquaculture.

Considering the potential environmental changes in the region, with longer flood period, higher water level and decreased fisheries (Eastham et al. 2008), fish culture in seasonally inundated rice field is an interesting option for development. Increased height and duration of flooding in areas that currently produce three rice crops per year may reduce production to two crops per year. Under these circumstances, community based fish culture could provide a suitable, alternative use of inundated lands and a coping strategy for farmers as they adjust to a new environment. Unlike individual aquaculture systems, where decision making powers regarding technical design of an aquaculture system, and preferences for participation rest with one individual or household, community-based fish culture requires that both the technical design and the institutional approach for managing the fish culture system and sharing benefits have to be equally successful. Collective action requires a substantial investment of time and sufficient social capital amongst the participants, requiring that the benefits of working together must outweigh those of the next best alternative occupation. Testing both components simultaneously requires that sufficient motivation exists in the community group to overcome constraints to production, and that participants are able to accept a degree of risk and the possibility of failure in the early stages of testing.

The reluctance of groups to continue the trials for more than one year, suggests that:

- 1) sufficient livelihood alternatives were available to the participants which generated greater benefits than fish culture
- 2) alternative options delivered livelihood benefits that fish culture could not provide
- 3) that demands on labour were sufficiently high to suggest that participants must choose between fish culture or other options

### *Recommendations and Lessons Learned*

The results show that in the Mekong Delta, with well developed flood protection infrastructure to delimit fish culture area, extensive fish culture on a large area is possible. However, the model is still dependent on flood patterns, with low water level or delayed flood limiting the fish growth.

Double rice crop areas are preferable for fish culture development, allowing a longer fish culture period as they tend to be characterised by floods of more than one meter, and are therefore more suitable to support fish culture. Fish culture between two rice crops requires the involvement and the agreement of all the rice farmers of the area to coordinate water management and extend the fish growth period as long as possible. The growth period, which cannot be extended due to rice culture, will influence the choice of fingerling size. The fingerlings size should be determined in order to reduce operational cost by using small size fingerling, but the size needs to be sufficient to allow a high survival rate and to reach marketable size at harvest time.

Marketing channels and low fish prices during harvest were found to be one of the main challenges limiting financial benefit of the model. Improvement of marketing channels can be achieved with sequential harvest and the delay of the harvest when fish prices are higher in January or even February.

Smaller production units involving fewer farmers could be more effective, when compared to the large production units where farmers have to market large amounts of fish in a short period. We can make the hypothesis that small units of less than 10 hectares managed by smaller groups and delimited by fences (within a larger unit delimited by dikes and embankments) can be easier to harvest in several stages, with selective marketing of market sized fishes. Delayed marketing can be envisaged, if farmers own homestead ponds, with the stocking of non-marketable sized fish into a pond until further grow and higher market prices.

In addition, smaller units of production will reduce group size, and reduce the likelihood of conflict. With smaller groups, governance mechanisms to promote transparency, equity and sharing of labor might be easier to implement. For example, trials in one community in Can Tho province in 2009 support this hypothesis. The group comprised 11 members. Fish production of 179kg/ha was recorded and, according to members, a smaller group composed of relatives is easier to manage, with less potential conflict over divergent ideas on management strategies and technical options.

These initial trials have shown that community-based fish culture is an innovative approach for the Mekong Delta that has the potential to provide an alternative livelihood option in the face of environmental change and development. To increase uptake, the technical design of the approach could be further optimised, and mechanisms for community participation could be enhanced to increase economic incentives, which are an important factor for adoption of the technology by farmers.

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Table 2 : Characteristics of the project sites in Vietnam

	<i>D1</i>	<i>C2</i>	<i>Trung Phu B</i>	<i>Hung Binh</i>	<i>Truong Xuan</i>
<i>Province</i>	Can Tho c	Can Tho	Can Tho city	Vinh Long	Dong Thap
<i>District</i>	Vinh Thanh	Vinh Thanh	Co Do	Binh minh	Thap Mouy
<i>Rice cropping</i>	Double	Double	Triple	Triple	Double
<i>Flood period</i>	Aug. to Nov.	Aug. to Nov.	Sep to Nov.	Sept. to Nov.	Aug. to Nov.
<i>Max Water level in 2007 or 2008</i>	102 cm, 1 <sup>st</sup> week of November	106 cm, 1 <sup>st</sup> week of November	60 cm, 1 <sup>st</sup> week of November	63 cm, 1 <sup>st</sup> week of November	> 100 cm in November (2008)
<i>Project site area (ha)</i>	65 (2005-2007) 19 (2009)	48	39	26	90 (2008) 120 (2009)
<i>Sharing Benefit</i>	Area owned (2006, 2007) Membership (2009)	Area owned	Area owned	Membership	Membership
<i>Households involved in the project</i>	34(2005,2006) 30 (2007) 11 (2009)	28	28	5	13 (2008) 7 (2009)

Table 3: Production (kg), yield (kg/ha) and economic results of the community based fish culture. (1USD = 17,429 vnd in 2008; 1 USD = 16,000 vnd in 2005, 2006 and 2007)

	<i>Year of culture</i>	<i>Cultured Fish production (kg)</i>	<i>Cultured fish yield (kg/ha)</i>	<i>Wild fish yield (kg/ha)</i>	<i>Operational cost (USD/ha)</i>	<i>Net return (USD/ha)</i>
<i>Vietnam</i>						
D1	2006	11,271	173	m.d	74	-4
D1	2007	8,052	124	38	39	41
D1	2009	3,403	179	31	21	-9
C2	2007	5,511	114	10	65	13
Trung Phu B	2007	4,935	126	10	21	16
Hung Binh	2007	2,191	84	8	50	-23
Truong Xuan	2008	5,900	61	6 + 31 <sup>a</sup>	31	-6
Truong Xuan	2009	10,822	90	9+12 <sup>b</sup>	41	-8

m.d: missing data

a): 6 kg/ha harvested by the group and 31 kg/ha estimated harvest by landowners when the water level was lower than rice field's dike.

b) 9 kg/ha harvested by the group and 12 kg/ha estimated harvest by landowners when the water level was lower than rice field's dike.

Table 4: Salaries and incomes from different non farm and off farm activities during the fish culture period (1USD = 17,429 Vietnamese Dong). Results presented are based on semi-structured interview of 130 in Vietnam (project and non project households).

<i>Activities</i>	<i>Salary or Net return (USD)</i>	<i>Average days hired/fishing</i>	<i>Seasonal Income (USD)</i>
Hired labor in rice field	2.3 to 4.6 USD/day	17.5	40 to 80
Hired labor in forest sector	2 USD/day	15 to 60	30 -120
Digging	4 USD/day	10 to 30	40 to 120
Rice post harvest	2.3 to 2.8 USD/day	12.5 to 17.5	36 to 50
Construction work	3.4 USD/day	variable	not estimated
Fishing	0.3 to 5.7 USD/day	variable	not estimated
Renting out land for duck raising	5.7 to 28 USD/month	30	5.7 to 28
Duck raising (100 heads)	86 to 143 USD	-	86 to 143
Lotus culture	0-1,147 USD	-	0 - 1,147

# **The Politics and Culture of “Climate Change”: US Actors and Global Implications**

Charles Waugh<sup>\*</sup>

## **Abstract**

Since the election of Barack Obama, much has been made of the new green economy, with the president himself calling for an investment in renewable energy and climate mitigation strategies that he believes will have the twofold effect of resuscitating the American economy and preparing the nation for a hotter world. But despite his emphasis on the creation of new jobs and of whole new sectors of the economy, many people in the US—both ordinary citizens and elected leaders alike—remain skeptical of the need for a new green economy, and in fact remain skeptical of the idea that humans are contributing to global warming at all. Thus, environmental justice arguments based on American carbon production and the disproportionate impact of rising temperatures and rising sea levels on tropical developing nations such as Vietnam frequently fall on deaf ears. This paper explores the political and cultural construction of this deafness, seeking a better understanding of how and why so many Americans refuse to act to address global warming. The two main sources of this deafness that this paper will address are 1) the politics of carbon-intensive energy producers such as the coal and oil industries, demonstrating the ways in which those industries have distorted the debate over global warming, have found eager allies in political candidates willing to accept large campaign contributions, and—with the help of other industries such as automobile manufacturing and home construction—have encouraged the second main source of denial: 2) a culture of aggrandized individualism that places greater value on personal identity construction than on the national and global common good. Once these sources are established, the paper recommends strategies for overcoming cultural and political resistance to climate change mitigation that may be effective not only in the US, but in Vietnam as well.

## **Keywords**

Climate change, culture, individualism, narrative

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## Text

Since the election of Barack Obama in the United States, much has been made by the American news media of the new green economy, with the president himself calling for an investment in renewable energy and climate change mitigation strategies that he believes will have the twofold effect of resuscitating the American economy and preparing the nation for a hotter world. But so far, the overall impact of many of these strategies has fallen short of their goals. For example, one plan, the Consumer Assistance to Recycle and Save Act of 2009 (better known by its nickname “Cash for Clunkers”), sought to reduce carbon emissions and to revitalize automobile sales by encouraging owners of inefficient and highly polluting vehicles to trade them in for newer, more efficient and less polluting models. The government subsidized the program by supplying the money to buy the old vehicles in order to ensure they would be taken off the road and destroyed. Americans traded in nearly 680,000 cars and trucks for more efficient replacements, saving an annual average of \$32,947,886 in fuel, and preventing an estimated 379,000 metric tons of CO<sub>2</sub> from being released annually (US Dept of Transportation 2009). While any reduction of CO<sub>2</sub> emissions should be received enthusiastically, at just 0.15% of the United States’ annual carbon emissions, such results fail to be inspiring, and in fact, raise the question of why more people didn’t take advantage of the program; after all, 680,000 may initially seem like a lot of cars, but it represents just 0.27% of the total number of registered vehicles in the US, or the participation of just 0.22% of the US population.

Setting aside the economic reasons for not participating, from figures like the US’s total annual carbon emissions as reported by the United Nations’ Millennium Development Goals Indicators, we know that the US is the second largest CO<sub>2</sub> emitter in the world, and for a long time was the number one emitter. As individuals, Americans live a more carbon intensive lifestyle than all but a few nationalities (UN Statistics 2010). Why didn’t more of them take advantage of a program that would not only benefit themselves, but also help reduce this enormous carbon footprint?

The full response to that question has many complicated parts, and this paper will address several of them, but the short answer is that many people in the US--both ordinary citizens and elected leaders alike--remain skeptical of core climate change assumptions. Some look at their local weather and refuse to believe the Earth is warming in any significantly different way than in other decades-long trends, and some, when they finally do confront the overwhelming data that the Earth is indeed growing warmer, quickly attribute that warming to the Earth’s natural long term cycles of warming and cooling, and in effect deny that human activity has anything to do it. In both scenarios, these skeptics implicitly claim that nothing humans can do will make any difference.

It might be easier to understanding how US climate change deniers arrive at this skepticism if seen through an example. In the state where I live, Utah, the conservative state legislature recently responded to the US Environmental Protection Agency’s “carbon reduction policies” by passing House Joint Resolution 12, which “urges the United States Environmental Protection Agency to immediately halt its carbon dioxide reduction policies and programs and withdraw its ‘Endangerment Finding’ and related regulations until a full and independent investigation of the climate data conspiracy and global warming science can be substantiated” (Utah 2010). It follows with a litany of unsubstantiated reasons why climate change science is flawed or otherwise cannot be trusted, how climate change action will cost governments and tax

payers billions of dollars that will simply line the pockets of climate change researchers, prevent the use of millions of acres of agricultural land, starve the people now eating food produced on that land, and “ultimately lock billions of human beings into long-term poverty” (Utah 2010). The paranoid hyperbole the bill expresses arises in part as a response to recent revelations that climate scientists altered findings to create a sense of urgency in the public, but is also representative of the way many Utahns (though not all, obviously!) and many Americans feel about climate change. Letters to the editor published in my local newspaper often debate climate change (though “debate” may not exactly be the best word to describe what happens in these exchanges); a typical entry goes like this: “[Climate change science] is purely unadulterated ‘horse pucky.’ These clowns are in it for the money at yours and my tax money expense [sic]....With the recent revealing reports of false documents of global warming, Al Gore and his pals should be ‘cut off’ from our taxpayers’ funding....Climate change is a scam at our expense. Believe it. You far-out loons are crazy” (Larsen 2010).

Neither the writer of this letter nor the writer of House Joint Resolution 12 is a scientist, nor are they apparently consumers of information from leading scholarly or even popular science journals or even mainstream media. So where do they get such strong feelings about climate change, and why would they believe climate change mitigation strategies are just some far fetched and elaborate conspiracy to steal their money?

As early as 1998, the biggest energy producers in the United States, corporations such as Exxon, Shell, and BP, along with organizations that they support such as the American Petroleum Institute and the Cato Institute, began a systematic campaign designed entirely to create this skepticism. Taking the offensive on what they believed would be a downturn in demand for their products, or a tax on the carbon their products released, they began to funnel huge sums of money to organizations and scientists who would provide research to support the contentions that global warming did not exist and that human activity could not be definitively linked to climate change. Exxon alone ultimately paid more than 16 million USD between 1998 and 2004 to forty different groups, who in turn paid researchers to produce reports to support their claims. Perhaps the most cynical part is that the oil corporations never had any intention of ever proving the validity of their paid scientists’ work. In a memo leaked to and then published by the New York Times, the American Petroleum Institute declared that their campaign would be successful just by creating the *appearance* of doubt about climate change science. They knew as long as the media presented the issue of climate change as a *debate*, at least some of the public would believe the science was inconclusive and there would be no real motivation to limit fossil fuel exploitation or use. Since then, Exxon has claimed to “soften its stance” on global warming, and yet they have continued to support climate denial institutes with millions of dollars every year since making that claim. (Union of Concerned Scientists 2007).<sup>i</sup>

The energy corporations also made large donations to political campaigns, giving candidates who were sympathetic to energy exploration and development vast sums to spend during elections, thus helping them to get elected. Candidates claim campaign donations don’t necessarily mean they do whatever the donors tell them to. But in practice, it seems this is often the case. For example, in January of 2010, the Alton Coal Development company made a \$10,000 contribution to the re-election campaign of the energy sector-friendly governor of Utah, Gary Herbert. That same day, at the governor’s request, Alton’s application to open a mine in an environmentally sensitive area was fast-tracked for approval. When pressed, the governor

claimed the two incidents were unrelated, and as long as no record exists of his asking for the money or the coal company asking for his help with the approval process, corruption like this goes unpunished (Foy 2010). The same kind of political campaign contributing occurs at the federal level of government as well.<sup>ii</sup>

Given this corruption, as an ordinary American citizen, it would be easy for me simply to blame the politicians and the corporations for the denial of climate science and the perpetuation of a carbon intensive way of life. But the situation is more complicated than that; in fact, it goes to the very core of American identity. What those corrupt corporations and politicians are really defending is the uninhibited freedom for individuals to emit as much carbon as they can personally afford, to buy as many things and to use as much energy as they can pay for. (It is no coincidence that several of the climate change denial groups funded by Exxon have names like the Frontiers of Freedom Institute and the Free Enterprise Institute). And as selfish as that sounds, it is a privilege that resonates with vast numbers of Americans. Of course, the corporations are still intimately involved, since they're selling what the American people are buying, but a deep complicity runs between the average American citizen and the corporations that sell them the things they want.

A good way to see this comes from the automobile industry, which by nature involves both a carbon intensive production process as well as product. Since the establishment of fuel efficiency standards in the US in 1975, the American automobile industry has argued consistently for the more lenient standards that have allowed them to cater to base consumer demands: more passenger and cargo space, more powerful engines, more luxurious interiors. At the same time, these more lenient standards have allowed them to focus less on efficiency, and more on the idea that a car is not just a car, but an extension of the owner's personality. A recent BMW commercial aired in the US demonstrates this idea quite clearly. The commercial depicts beautiful cars being driven by people with big smiles on their faces, and the narrator says, "We realized a long time ago, that what you make people feel is just as important as what you make, and at BMW, we make joy" (BMW 2010). In the US, big trucks are sold on the idea they make the owner tougher, more rugged. Minivans are sold by suggesting that parents are better parents if they buy the van that keeps their children safer, or now, better entertained. The car's efficiency is usually treated as an afterthought, even in ads for the most efficient cars. For example, commercials for the popular brand of hybrid electric and gas car, the Toyota Prius, mainly pitch a certain kind of way of being in the world, a personality that makes the world a happier place to live in.

In their "Harmony" TV commercial, Prius promises the buyer "more power and more space," two of the things many Americans want in their car, and that "the world gets fewer smog forming emissions." But the pitch for the environment is understated in comparison to the ad's music and visual effects. The song in the background is Loretta Lynn's, "Let Your Love Flow," and as we watch the Prius drive along a highway, the landscape is transformed from a bland white to a vibrant green and blue made up of smiling children in blossoming plant costumes. Presumably because in the US so many people are still in denial about global warming, the ad doesn't even mention the reduction in carbon emissions, suggesting instead the reduction in smog (Toyota 2010). Apparently, the important thing to take away from the ad is, as BMW put it, how it makes you feel. But this sort of identity construction at least is relatively benign in comparison to what happens in Ford's "Built Ford Tough" commercials. In hundreds of



different ads, various aspects of their trucks' designs are touted as being tougher than their competition, with the implication always being, as one ad asks the viewer directly at the end, "Are *you* tough enough?" (Ford 2007). In other words, the overdesign of the truck, adding weight and losing efficiency, is justified by a consumer who also wants to be seen as stronger and more capable of physical work than anyone else.

One way to explain this emphasis on toughness comes from America's frontier history, whose mythology has been perpetuated by popular culture since the late eighteenth century. In brief, these stories feature individuals who go out into the wilderness with just the right tools and supplies and turn that wilderness into civilization. These are the stories of early explorers like Daniel Boone and Davy Crockett, but also western cowboys like Wyatt Earp and Wild Bill Hickok who are portrayed as individuals who struggled heroically to bring law and order to the frontier. Of course the legends around these historical figures have exaggerated their accomplishments, and like all myths, some things are emphasized over others. It doesn't matter that Earp had brothers and friends, or that Crockett had a wife and children and neighbors helping him, the myth reinforces that these men as self-reliant individuals played an enormous role in making the US what it is today.

American studies scholars have rigorously debated the origins and mythic quality of this rugged American individualism, and not all of that scholarship can be revisited here, but one common explanation suggests that, despite the truly interdependent nature of early American life, "throughout the Revolutionary period and beyond, most Americans made their livings in agriculturally-based hamlets, or in free-standing farmer's homesteads of one or a few families. These material circumstances seem likely to have encouraged a clear sense of *economic self-reliance* or *independence* in much of the population, which, in turn, may have eventually promoted a generally more individualistic outlook among many settlers" (Grabb et. al, 1999, p. 527). This emphasis on economic self-reliance runs through a great deal of American thought, even through the writing of the US's greatest champions of the environment such as Ralph Waldo Emerson, Henry David Thoreau, and Wendell Berry, though they also accompanied their celebration of independence with the warning not to become "the tools of their tools" (Thoreau, 1854, p.132). A second common explanation for American individualism comes from what political scientist Barry Shain calls a conflation of "local communal hostility toward the provincial or the imperial (later national) center...with a common 20<sup>th</sup> century hostility toward all authority" (Shain, 1999, p. 86). Such feelings are not exclusively American; many cultures and peoples feel similarly, even in Việt Nam, where the saying goes, "Phép vua thua lệ làng." But unlike in Việt Nam, where there is also a saying, "Biết thì thừa thớt, không biết thì dựa cột mà nghe," America's infatuation with individualism has led many to believe that all opinions are equally important. Combining these two explanations gives us a competent portrait of the consumer that Ford truck commercials are trying to reach: someone who earns his living by himself, with his hands, and who doesn't like being told what to do by anyone, and if not that person, someone who fantasizes about being him.

The values this myth and these advertisements perpetuate are precisely the ones expressed by the writer of the letter to my local paper quoted above. The value of rugged economic self-reliance and distrust of outside authority combine to express the fear that government agencies, scientists, and representatives are using climate change as a way to tell them what to do and to take their money. The nexus of corporations, politicians and

conservative media make the situation worse by presenting irrational opinions about individual rights as rational counterarguments to the scientific certainty of global warming. Because the only information some Americans get is what they hear on politically motivated radio and television programs, these citizens never fully confront the legitimacy of climate change science. At the same time, they are inundated with corporate messages to indulge their sense of individual importance, to enjoy what they think they've earned, and ignore requests made for the common, global good.

And even if these Americans were presented with clearly articulated, sound scientific proof of climate change, their feelings of skepticism and distrust, and ultimately the fear of losing their privileged access to an overabundance of material goods would most likely prevent them from being convinced. Climate scholar Mike Hulme has applied planning theorist Horst Rittel's term "wicked problem" to these entrenched rejections of climate change science because they so intractably defy reasonable problem-solving strategies. But Hulme refuses to give up on the idea that it will take everyone in the world, especially climate change skeptics, to change our world for the better. Coincidentally, his answer to this "wicked problem" employs the exact same methods of myth-making, identity construction, and even a distrust of authoritative solutions that helped make the problem so intractable to begin with.

Hulme's book, *Why We Disagree About Climate Change* (2009), explores the many ways that people around the world perceive climate change, explaining how different values, beliefs and forms of government combine to make "solving" climate change as a problem impossible. Because "solving" climate change involves "uncertainty; inconsistent and ill-defined needs, preferences and values; unclear understanding of the means, consequences or cumulative impacts of collective actions; and fluid participation in which multiple, partisan participants vary in the amount of resources they invest" (Carley and Christie 2001, p. 156), no authoritative, top-down solution will ever satisfy everyone, even if one could be devised. Instead, Hulme argues that "we need to approach climate change as an imaginative idea, an idea that we develop and employ to fulfill a variety of tasks for us" (p. 329).

Treating climate change as a source of inspiration frees us to go more directly to the forms of identity construction that will allow us to find common ground and take action that will help us all. As the Alliance of Religions and Conservation has suggested, "Without...[narrative, myth, and metaphor], policies will have very few real roots.... Without narrative, few people are ever moved to change or adapt" (Alliance 2007), and Hulme agrees: "In a world where the globalizing powers of capital, trade and consumption separate us from the local stories that give meaning not just to climate, but also frequently to our lives, this [strategy] also offers a way of reconnecting ourselves with climate through the telling of stories" (p. 356). In other words, to mobilize the world to act on climate change, we have to "inspire," not to "convince." We have to construct stories about ourselves and climate that allow us to better examine who we are, who we want to be, and what we want from life.

Such a strategy seems especially well-suited to American climate change skepticism. It allows us to build from our mythic past when we struggled to make a better life out of an unpredictable wilderness. It allows us to turn that distrust of authoritative, top-down decision-making into individualistic, every-day solutions that still allow for a high quality of life. And it allows us to construct narratives that connect the values of the past with the choices we must make in the present. As Hulme suggests, "We can use the idea of global climate change to tell

ourselves new stories about ... the consequences of our collective behaviours. We can use the idea of climate change to move beyond the separated categories of the physical and the cultural, beyond the framing of climate change that uses the language of problem and solution” (p. 357). Thus, we must express the idea of climate change in stories that can inspire the world, one individual at a time, to create a new way of understanding the choices we make and how they affect people who live far away from us.

As an example, I’d like to tell a story of my own about climate change. After all, I am not a scientist. I am an observer of culture, a translator and storyteller. My professional work so far has mainly attempted to help Americans understand Vietnam and Vietnamese understand America so that we can heal the wounds of the past. Maybe now this story and others like it will help create an even deeper understanding between our two peoples that can help us face our future together.

In the spring of 2009, my wife, Jen, and 6 year old son, Owen, and I set up temporary residence in the old town of Hội An in Quảng Nam Province, Việt Nam. We had visited there twice before, in 2004 and 2005, and had made friends with several families--some western and some Vietnamese--and so we were excited about the prospect of getting to know them and the place even better by living there for several months while we conducted research on the Agent Orange remediation in Đà Nẵng and finished a few writing projects we had already begun. Adding to my excitement, my parents had agreed to come visit us for two weeks after first seeing Ha Nội and Ha Long Bay in the north and before touring the Mekong in the south. I’ve lived in Việt Nam several times, and have been researching and writing about it for fifteen years, but my parents had never seen Việt Nam with their own eyes. What they knew about Việt Nam came only from the pictures of violence on their TV sets during the years of the American war, from what my uncle had told them after having been stationed in Saigon during the war, and incongruently, from what work of mine they’d read. With this visit I would finally be able to show my parents firsthand many of the things I so dearly love about my home away from home.

We chose to come during the spring, when Quảng Nam typically is driest. But for the whole first week after my parents arrived, dark clouds rolled in every day from over Cham Island bringing pouring rain. More than once we ended up stranded in a downpour, unable to find a taxi to take us the five kilometers outside town to our guesthouse. During the night of the full moon, thousands of tourists and locals alike packed the old town to take part in the festival, in which the Hội Anese traditionally float lit candles upriver with the tide and watch for the moment when the tide shifts and the candles rush down to the sea. When a huge storm broke, we found ourselves stuck on a dark corner for an hour, waiting for a taxi. Normally, when we’re in Việt Nam, my family and I travel by motorbike. We carry rain ponchos and get around pretty much like most Vietnamese do. In the past, my father used to ride a motorcycle too, but he was diagnosed with multiple sclerosis five years ago, and now his right leg doesn’t move very well, throwing off his balance and making motorbike travel unwise. While we waited, I grew more and more agitated. My son kept bouncing between a utility pole and a brick wall, smearing red clay and grime all over his clothes. My father teetered in circles on the uneven sidewalk. I could see the exhaustion on my mother’s face. Feelings of responsibility for their health, safety, and comfort welled up inside me. I wanted them to enjoy their time in Việt Nam every bit as much as I do, and I couldn’t imagine five people standing in the rain under three umbrellas was anyone’s idea of fun. At last, after an hour of waiting, we made it home, but my feeling of

helplessness toward all that rain remained with me long afterward. During the second week of my parents' visit, we had better luck: the skies cleared and we were able to enjoy showing them the beaches, the old town architecture, and the ancient temples at Mỹ Sơn.

Coincidentally, around the same time, an editor in the US contacted me about contributing an essay on work and environmental justice to a book she wanted to put together. With that night on the corner in the rain on my mind, I suggested contributing an essay on work and climate justice--the notion that developing nations will suffer greater consequences of global warming than many developed nations--that would also contain a thread about my stay in Vietnam. She agreed, but I didn't worry much about the essay while we visited with my parents in Hội An; after all, the essay wouldn't be due for another nine months. Instead, we focused on enjoying each other's company in a beautiful, magical place.

This past winter, when the time finally came to write the essay, my family had all returned home to the US months before. Outside the window by my desk, snow blanketed the ground, covering the mountains ringing my valley town in white. Even so, we received less than average snow this year, just 60% or so of the 100 centimeters we typically have on the ground. Where my parents live, 2500 kilometers to the east in a state called Ohio, they had been hit with unusual and extremely cold weather, with the same much greater than average snowfalls that have attracted attention to rest of the northeastern US this winter. Some places in that region received more than a meter of snow in a single storm.

I felt some trepidation writing the essay, knowing that it would involve my father, who because of his profession I suspected might be a climate change skeptic. He owns and runs a quality assurance business that certifies the proper and timely manufacture of big equipment orders for clients mainly drawn from the oil industry. All through the winter he drives to manufacturing sites within a 400 kilometer radius from his home, inspecting control valve assemblies, jet-engine propelled oil pumps, and dozens of other parts to these enormous, complicated machines. The car he drives is not terribly efficient. It is a sport-utility vehicle (SUV), larger and heavier than a regular car, with a taller profile that makes it easier for him to get in and out of and four wheel drive and big tires that make him feel safer on the region's snowy roads.

At the very least, I knew from his clientele, the amount he drives, and his SUV that climate change doesn't typically have a very big impact on the decisions he makes. He's been becoming more conservative over the past decades, something I have attributed to his daily interactions with people in the oil industry, and to the conservative radio programs that are long on hyperbole and short on facts that he often listens to while driving to and from work sites. But, I didn't really know his thoughts on climate change since we'd never really talked about it. So I called him.

Unsurprisingly I caught him at work, in Indianapolis, inspecting an assembly for a client in Taiwan. The next day, he returned my call while making the three hundred kilometer drive home. As we spoke, I could hear the staticky hiss of his tires on Interstate Highway 70, and could imagine the vast white fields stretching out to the north and south, the endless rows of crumpled cornstalks poking sporadically through the snow.

A kind of awe crept into his voice as he reacted to my news about the forecasted sea level rise and the impact it will have on two places he thinks fondly of when he recalls his trip to Vietnam: Hôì An and the Mekong Delta. Much to my surprise, he didn't disparage or even dispute the IPCC predictions; rather, he told me that he recognizes the warming of the world, that he has seen proof of it for himself in the fact that the Ohio River has not frozen over since the winters of his youth, and that he views the warming as part of the larger cycles of temperature fluctuation the Earth has always had. But then he also conceded the greenhouse effect, and even that humans have helped speed up the rate of warming through the release of the carbon from all the coal and oil burned since western industrialization began. But, he said, he didn't want to trade the lifestyle he has now for one from the pre-industrial past, and he felt at a loss to imagine a way to solve the problem.

"What about an economy of scale," I asked, "where individual actions don't matter so much by themselves, but if we all do things just a little bit smarter, when they're multiplied by billions of people across the planet, they *can* have a big impact?"

"Sure," he said, "but only when you can actually get enough people to act, and most people have a hard time seeing the need to do anything. Convince people here, now," he said, referring to the dozens of storms and subzero days Ohio's had this winter, "that the world is getting warmer."

"But if you do know," I said hesitantly, imagining the bulk of the vehicle around him, the V8 under the hood, the large tires I could hear over the phone, "shouldn't you do something, out of a sense of responsibility, or even if only to save yourself the gas money?"

"Yeah," he said with an embarrassed laugh, "I let my heart make the decision to buy my car, not my head. If they make a hybrid with the clearance and weight and four wheel drive to get me through the winters, I probably should've bought it."

I was so impressed, shocked even by how much agreement we found in this conversation, that I decided not to reproach him further by saying he should've bought one of the few hybrid SUVs available in 2008, like the Ford Escape. Instead, I settled for the hope that now that he *is* thinking about climate change that he will make a better choice in the future.

In every way, my father lives the American dream. He came from a working class home, has worked long hours his whole life, has had his share of failures and triumphs along the way, and now has finally established a successful business for himself. Undoubtedly he feels he has earned the right to indulge himself now that he's approaching retirement. Undoubtedly he feels he has paid for everything he's got.

The trouble is, so many of the costs of carbon emissions are hidden to us that they rarely ever get factored into day-to-day or even bigger, once-in-a-few-years decisions. No labels on a new car's window tells a buyer explicitly how much carbon it will release in a year's worth of driving. No label suggests that millions of people will be displaced, that lives will be ruined, or cultures threatened because of business as usual in America. And certainly no label makes the argument that the lifestyles we live today are the result of global inequities of the past, perpetuated into the present. The only stories he had in his head when he bought that SUV was

the one of his own success, and the one the car company told him about how much he would enjoy it.

But now that we've talked, he also has the story of what will happen to a place he loves when sea levels rise by a meter or more. And now, whether he can see it in his own weather in Ohio or not, he carries Việt Nam's fate in a warmer world in his heart and in his imagination. He knows that what seemed before to be innocuous actions do have larger consequences, and he can summon to mind the actual faces of people who will be affected. In short, because he now knows a story with characters and places he recognizes and outcomes he can readily imagine and dislike, his compassion has been aroused.

The conversation with my father about climate change allowed the two of us to share stories and to think imaginatively about what a changing climate means both for the people of Việt Nam as well as the people of the United States. It allowed us to consider how we do our jobs, how we make the countless decisions every day holds, and who is impacted by them. It helped us consider how our fates are intertwined with the world's. The essay I wrote will not change the world. But I know that my writing it helped my father and me think about climate change in ways we never had before, and the possibility remains that others will also be moved by reading it. And that, I think, is what the climate researcher Mike Hulme meant when he suggested that we need to use narrative "to reveal the creative psychological, ethical and spiritual work that climate change is doing for us...opening up possibilities for re-situating culture and the human spirit at the heart of our understanding of our changing climate" (p. 326). This is work we all can do.

Neither Hulme nor I mean to suggest that narrative alone can help us address global climate change. Only through science can we begin to know the full range of physical effects a warmer world will create. But as this interdisciplinary conference demonstrates, it will take approaching climate change from every conceivable intellectual direction to know what climate change will *mean*, and it will take stories that reflect each of our own cultures' values and aspirations to inspire the world, one individual at a time, to *act*.

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<sup>i</sup> The climate change denial actions of ExxonMobil and the institutes it supports is well documented. For example, see Cushman, J. (1998 April 26) Industrial Group Plans To Battle Climate Treaty. *New York Times*, p. 1; Harkinson, J. (2009 Jul 1) Despite Pledge, ExxonMobil Still Funding Climate Change Deniers. *Mother Jones*. Retrieved from <http://motherjones.com/blue-marble/2009/07/despite-pledge-exxonmobil-still-funding-climate-change-deniers>.

<sup>ii</sup> As just one example, James Inhofe, Republican Senator from Oklahoma and the most vocal skeptic of global warming in the Senate, has received \$432,950 between 2005 and 2010 in campaign contributions from the oil and gas industry, \$206,654 from electric utility political action committees, and \$176,983 from lobbyists. It's hard not to imagine that he is not saying what the energy industries want him to say.

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## **Adjusting to Climatic Variation: Historical Perspectives from North American Agricultural Development**

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**Abstract:** The IPCC projects that temperatures on the North American continent will rise by 2-5 degrees C by 2100. Such abrupt changes will create major challenges for agriculture, significantly altering the area suitable from key staple crops such as wheat. The historical record offers considerable insight into the capability of agriculture to adapt to climatic challenges. During the 19<sup>th</sup> and 20<sup>th</sup> centuries, new biological technologies allowed North American grain farmers to push wheat production into environments considered too arid, too variable, and too harsh to cultivate. The climatic challenges that previous generations of farmers overcame rivaled the magnitude of those predicted for the next hundred years in North America.

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The Intergovernmental Panel on Climate Change (IPCC) projects that by the end of the 21<sup>st</sup> century temperatures on the North American continent will 2-3 degrees C higher at its coasts and 5 degrees C higher at the more northern latitudes. Sea levels may rise between 0.18 and 0.58 meters (1-3). A recent MIT study suggests far greater changes will occur (4). Climate changes will have important impacts on agriculture (5, 6). Researchers at the International Maize and Wheat Improvement Center (CIMMYT) anticipate North America wheat farmers will push the margin of wheat production roughly 1,000 km north into northern Canada and Alaska, while heat and drought will make cultivation untenable in many areas of the southern Great Plains (7). Numerous researchers have speculated how farmers might change plant varieties, cropping patterns, and cultural methods to mitigate some of the costs of abrupt climatic changes (8). Climate scholars of all stripes rely on the past—ice cores, ocean cores, tree rings, fossil fuel consumption, recent temperature trends, and the like—to interpret the extent and possible impacts of climate change, but one important historical record pertaining to adjustments to climatic challenges has been underappreciated.

The agricultural settlement of North America required that farmers repeatedly adapt to unfamiliar and hostile climatic conditions. We build a long-run local-level production record to quantify and decipher how wheat growers in the United States and Canada learned to produce in new environments (9- 11, S1). During the entire span of wheat cultivation in North America the secular changes in climatic conditions at fixed locations were not extreme enough to offer much guidance. However, the cross-sectional variations in climatic conditions that settlers encountered rivaled the magnitude of the predicted changes over the next century.

### *Quantifying Cross Sectional Changes in Production and Climate*

Between 1839 and 2009, North American wheat output increased about 37 times; 26 times in the United States and over 270 times in Canada (S2). In 1839, the geographic center (mean) of North American wheat production was located in far eastern Ohio about 16 km south of Wheeling, (now West) Virginia. Cultivation was concentrated in Ohio and upstate New York; relatively little was grown as far west as Illinois. Today (2007) the center of production had moved 1,800 km, into west central South Dakota (10, 11, 13). Almost all of this movement occurred before 1929, during an era when modern plant sciences were in their infancy.

The change in the location entailed large shifts in the range of growing conditions.

The nine panels of Fig. 1 display the main features of the changing geographic distribution of the North American wheat crop across latitudes; longitudes; annual, January, and July mean temperatures and mean precipitation; and elevation. The series cover the period from 1839 to 2007, utilizing county-level information from U.S. and Canada. The number of units varies over time, but taking 1929 as an example, we record data on 3,070 counties in the U.S. and 216 units in Canada. The wheat production data come every ten years from 1839 to 1978 and every five years thereafter. The geo-climatic variables reflect average 1941-70 conditions in each county or agricultural district recorded by U.S. National Oceanic and Atmospheric Administration or the Canadian Atmospheric Environment Service (13, 14). These climate norms largely predate the

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more recent climate changes associated with the global warming, and they do not capture temporary weather events such as the great blizzard of 1839. The distributions weight the fixed county-level geo-climatic characteristics by changing wheat output in each locality.

Panel A summarizes the changing longitude of wheat production in North America for roughly 170 years. The median production shifted 21 degrees between 1839 and 1929, with almost no movement thereafter. By 1879, the median was beyond the western boundary of production in 1839. The increases in the most westward quantile (the 95 percent line) in the 1850s, 1860s, and 1870s capture the rapid expansion of grain cultivation in California where farmers adopted novel techniques and varieties to cope with the significantly hotter and more arid environment.

The median latitude of production (Panel B) was relatively constant until the 1890s when the northern plains and the Canadian prairies began to come on line. In 1929 the median production was at latitude near the northern fringe of production in 1839 (the 95 percent line). The most northern 25 percent of production (reflected in the 75 percent line) moved roughly 8 degrees of latitude (over 800 km) between 1839 and 1929. The most northern 10 percent of production moved even more. The movement of the most northern 25 percent was on par with the shift in the wheat frontier that CIMMYT researchers project over the next half century (7).

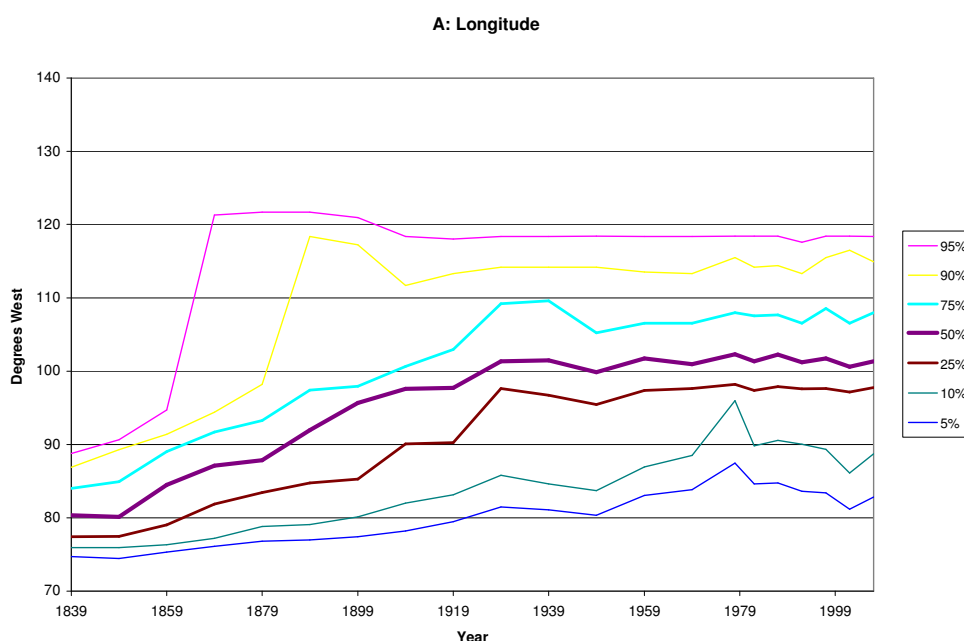
Dramatic changes occurred in the distribution of production across climatic conditions. In 1839 the median production took place in an environment with a (1941-70) norm of nearly 100 cm of precipitation (Panel C). By 1929, median production took place on land with less than 50 cm of precipitation; this was a drier environment than virtually any place growing wheat in the U.S. or Canada in 1839. In 1929 the marginal fringe (the 10 percent line) with 35 cm or less of precipitation produced about one-fifth more wheat than was grown in North America in 1839. The range of annual moisture conditions widened substantially; the difference between the 10 and 90 percent lines increased from 36 cm in 1839 to over 58 cm in 1929. The distribution of production by annual precipitation has changed little since 1929. The fall in precipitation was apparent across the year. January precipitation (Panel D) for median wheat production fell from 7 cm to less to 2 cm between 1839 and 1929—this meant that there was much less snow cover to protect winter wheat. Summer rainfall also fell dramatically (Panel E). The driest 10 percent of production moved from areas with 7.8 cm of rain in July in 1839 to areas that averaged 0.9 cm in 1889. The driest 5 percent of production in 1889 received less than 0.1 cm of rain in July. This was due to the movement of production into California where it seldom rained in the summer.

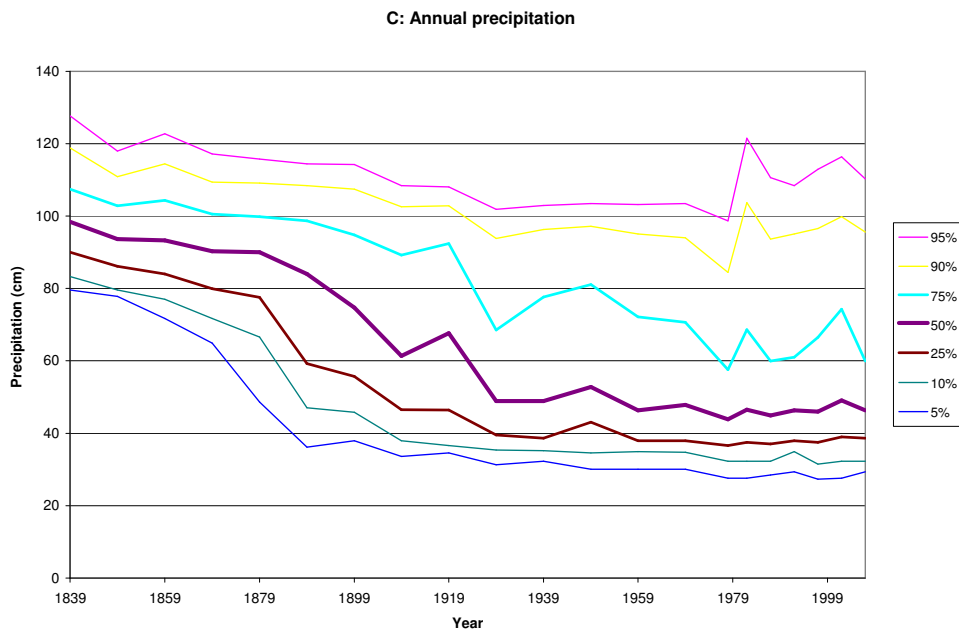
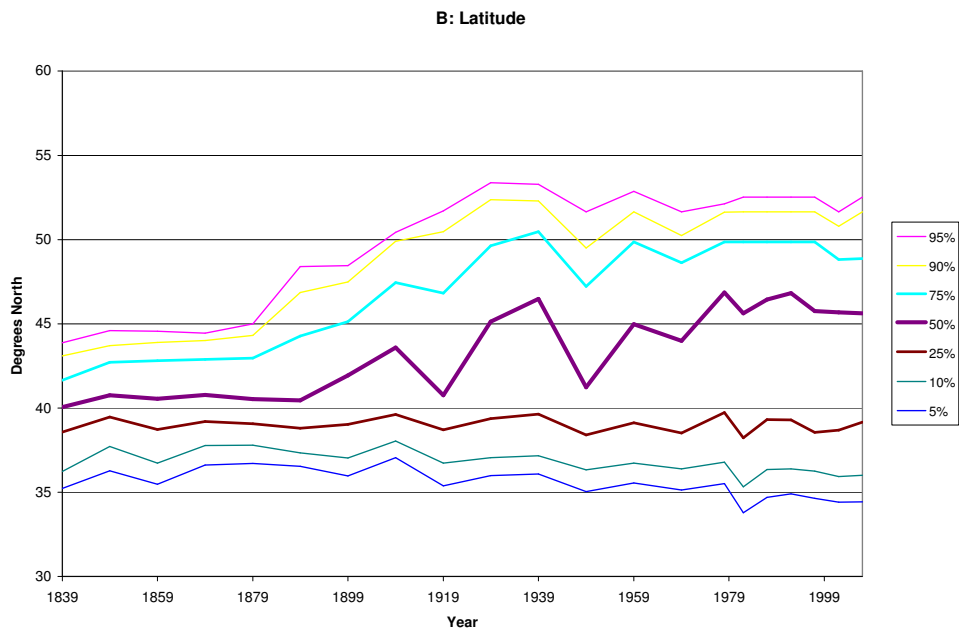
The median annual and January temperature norms fell by 3.7 degrees C and 5.9 degrees C respectively between 1839 and 2007 (Panel F). The range of temperature conditions greatly widened, with a pronounced movement into colder domains. The 90-10 differential doubled from 6.3 to 13.1 degrees C over past 170 years. Again, most of the change occurred before the dawn of modern plant sciences. Focusing on average annual temperature, the coldest 10 percent of production occurred at 8.4 degrees C in 1839 but at 1.6 degrees in 1929. The fall in winter temperature was more extreme (Panel G). The coldest 10 percent of production measured by January temperature occurred at -5.1 degrees in 1839 but at -17.7 degrees in 1929, a fall of 12.6 degrees. In 1929 much more wheat was grown in places where the January temperature averaged less than -17 degrees C than was grown in North America in 1839—a date when little wheat was produced in areas with a January temperature norm as low as -7 degrees.

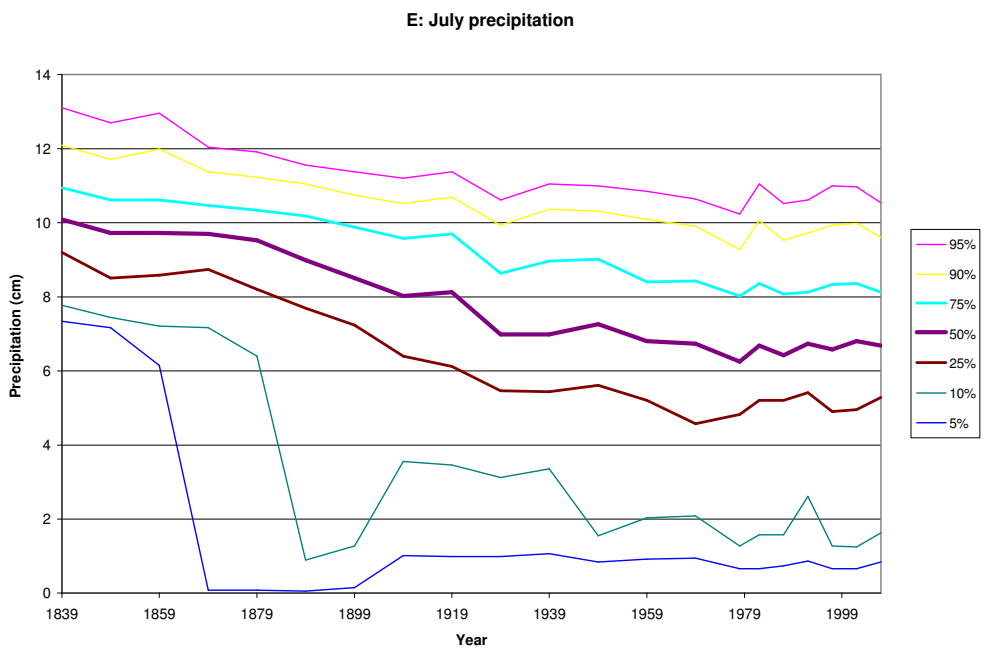
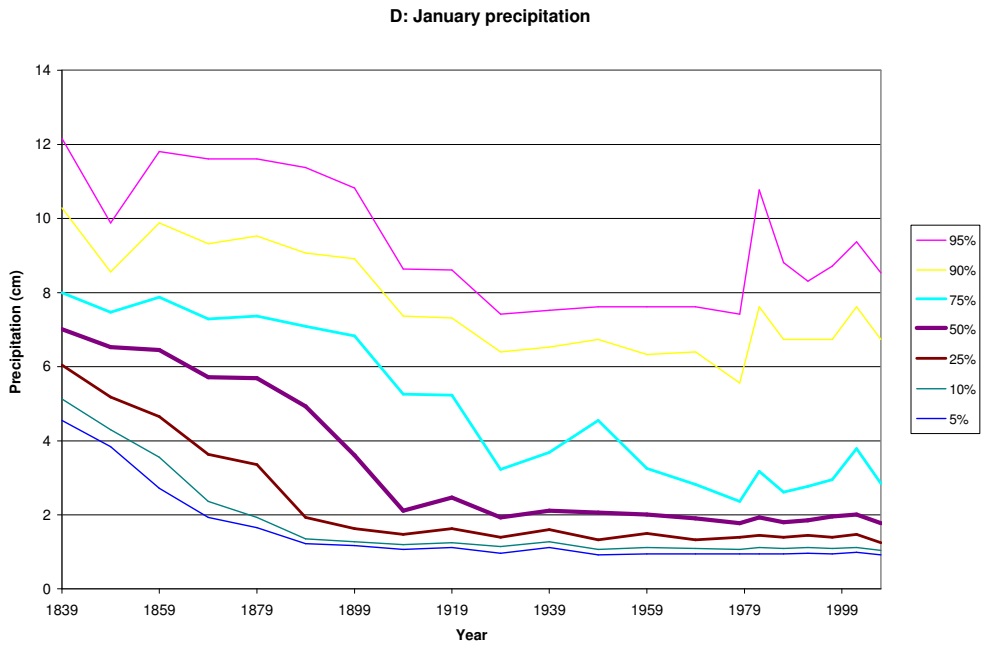
The changes have not been limited to moving into places with colder climates, but the expansion in hot areas has been swamped in our figures by the much greater shift into cold areas given our presentation of percentiles (Panel H). Focusing on warmer fringe of production, in 1839 5.1 million bushels of wheat were produced with a July temperature norm of 26 degrees C or hotter. By 1929 over 192 million bushels were produced under such conditions.

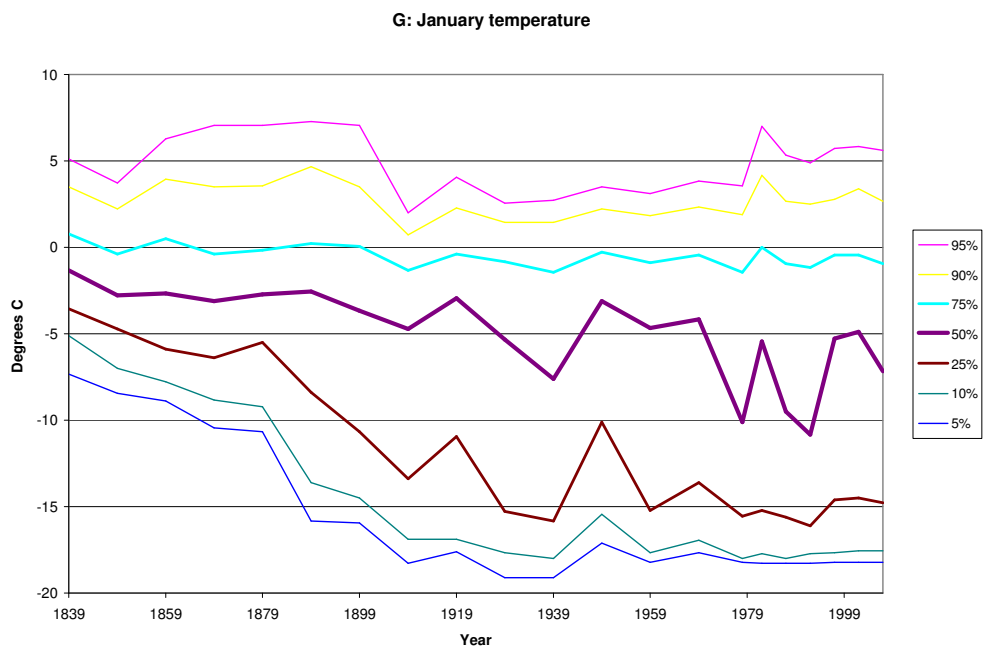
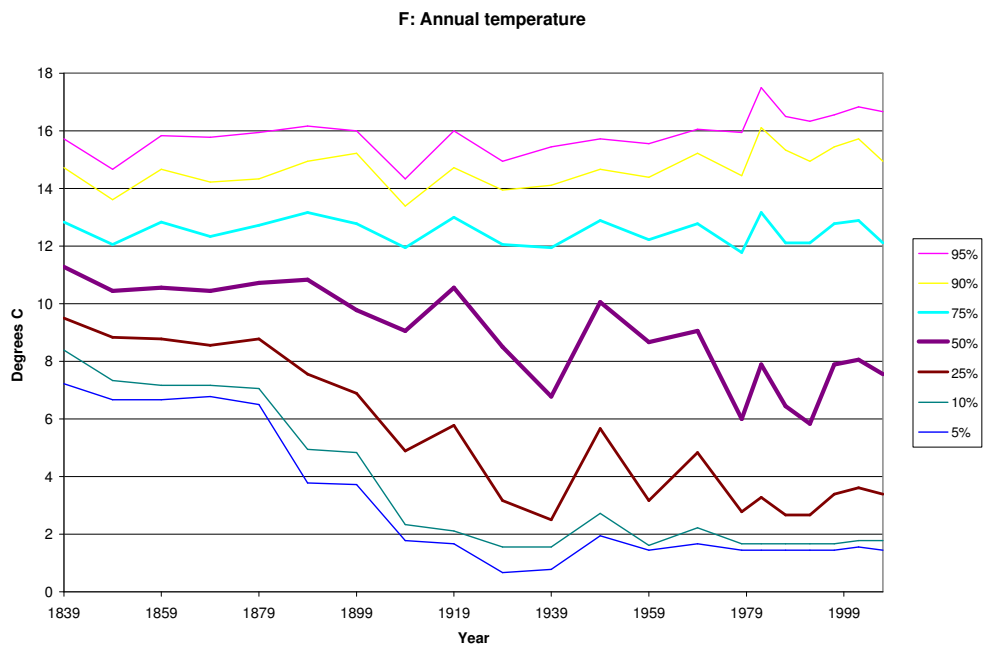
Between 1839 and 1929 the median elevation of production increased by 367 meters and highest 10 percent (the 90 percent line) rose by almost 750 meters (Panel I). The areas currently threatened by rising sea levels never produced more than one percent of North American wheat.

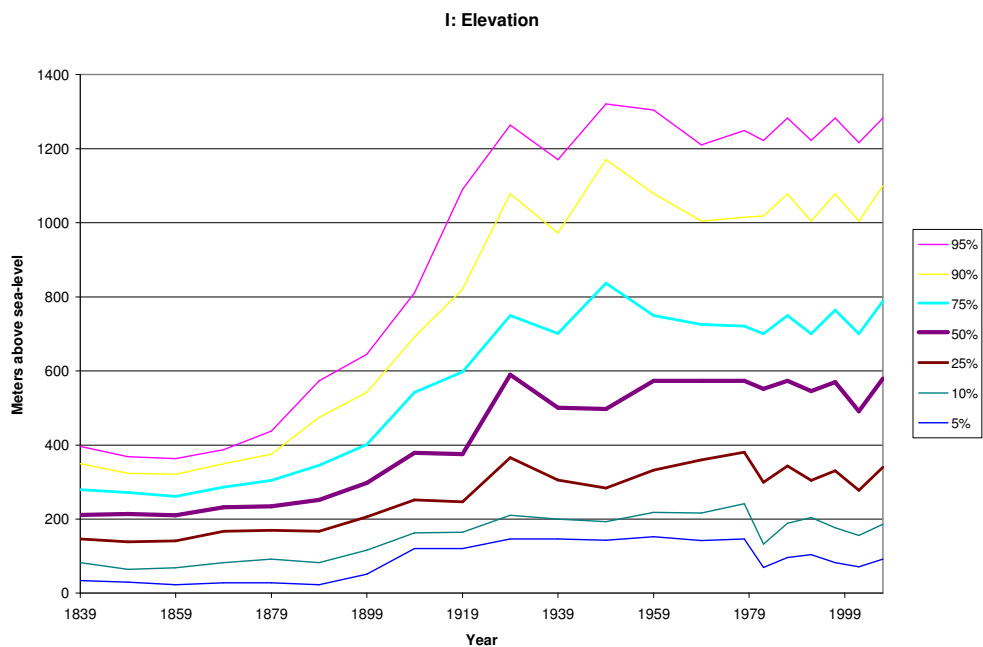
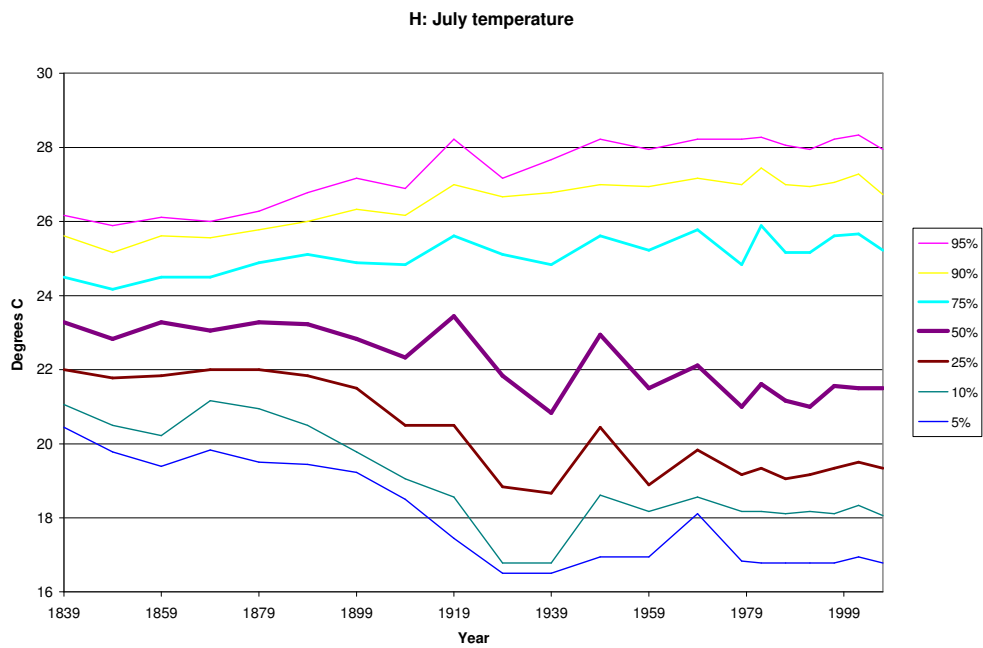
Fig. 1: Changing distribution of North American wheat production, 1839-2007











Source: Compiled from (9-11, 13, 14).

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*Biological Innovation to Adapt to Environmental Change*

The recent testimonials to the late Norman Borlaug remind us of the revolutionary accomplishments that he and other plant breeders made during the past 50 years. But the search for and breeding of improved crop varieties did not begin when Borlaug started his work for the Rockefeller Foundation in Mexico (1944). Over the previous 3 centuries, farmers and breeders discovered the varieties that made wheat culture possible in much of North America. Wheat was introduced into the territory that would become Canada and the United States in 1602, roughly 108 years after the crop was first introduced to the Western Hemisphere. Cultivators in eastern Canada and New England continuously experimented with new landraces in search of cold tolerant and pest resistant wheats, but without much success (15). Farmers further south fared better. However, when pioneers moved wheat culture westward onto the northern prairies, Great Plains, and Pacific coast, they confronted climatic conditions far different from those prevailing in the East or in Western Europe. Attempts to grow traditional wheat varieties often ended in disaster.

The experiences of the early members in Selkirk colony who settled on the Red and Assiniboine Rivers near Lake Winnipeg offer an example. The winter wheat, first tried in 1811-12, failed. Successive crops of spring wheat also succumbed to drought, freezing, and insects leaving the colonist without seed for the 1820 crop. During the winter and early spring of 1820, a band of the settlers trekked over 2000 km (round trip) to Prairie du Chien on the upper Mississippi River to secure a replacement seed. After about a decade of hungry times, the colony began to sustain itself, if not flourish (16). The prolonged troubles of the Selkirk colonists represented a clear case of settlers leapfrogging beyond the limits of climatic knowledge. But even when settlers inched west in a more orderly fashion the challenge of adapting to new climates was daunting. In the 1840s the continual attempts to grow winter wheat on the Wisconsin prairie ended in failure and wheat culture only succeeded after farmers switched to a new variety of spring wheat (17, 18). Similar stories of disappointment were common as farmers learned to cope with different climatic conditions.

The Great Plains was often depicted as the “Great American Desert” and considered incapable of supporting agriculture. The first waves of settlers from the humid East and Midwest moved into the High Plains during the relatively wet years of the 1880s. These farmers, railroad, and federal and state officials all significantly miscalculated the climatic obstacles that had to be overcome (19). Success required decades of experimentation and often depended on knowledge and varieties introduced by immigrants from frigid and arid locales of Eurasia. Just as there is uncertainty about future secular changes in weather patterns, 19<sup>th</sup> century settlers lacked reliable information about long-run conditions across both time and space.

The successful spread of wheat cultivation across the vast tracts extending from the Texas Panhandle into the Canadian prairies required the extension of railroads and harvest mechanization. But it also was dependent on the introduction and breeding of hard red winter and hard red spring wheats that were entirely new to North America. Over the late 19<sup>th</sup> century, the premier hard spring wheat cultivated in North America was Red Fife (which probably made its way from Ukraine to Ontario via Galicia and Scotland). According to the most widely accepted account, David and Jane Fife of Otonabee, Ontario, selected and increased the grain stock from a single wheat plant grown on their farm in 1842. It was not introduced into the



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United States until the mid-1850s. Red Fife was the first hard spring wheat grown in North America and became the basis for the spread of the wheat frontier into Wisconsin, Minnesota, the Dakotas, and across the Canadian Shield into the Prairie Provinces.

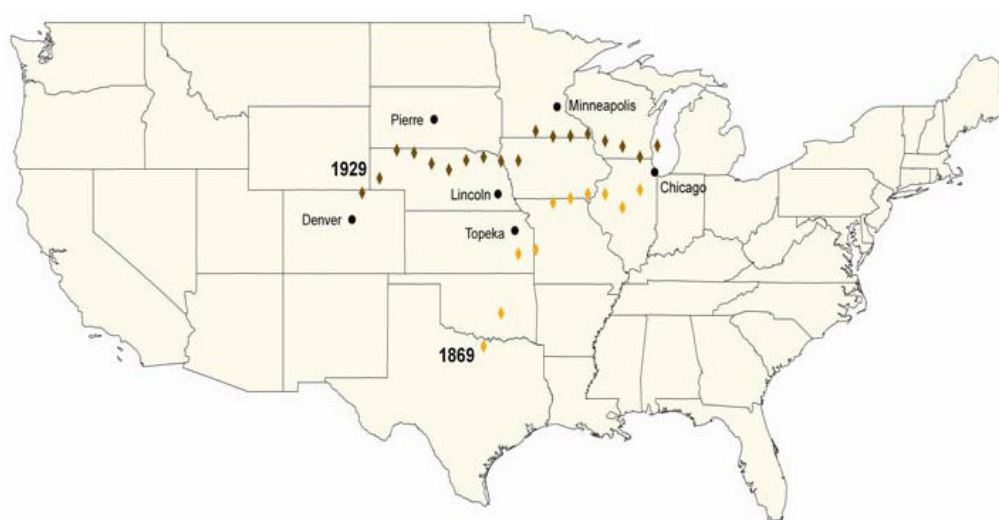
In both Canada and the United States many varietal innovations were the direct result of government research. In 1886 Parliament created the Canadian federal experiment station system. The most acclaimed Canadian breeder, William Saunders, introduced early maturing cultivars from around the world and commenced a systematic program of hybridizing early-maturing cultivars with high-quality cultivars. The value of earliness was reinforced by the virtual destruction of the western crop in 1888 by an early autumn frost. In 1903 William's son, Charles Saunders, took over the work. The most valuable result of their combined research efforts was Marquis, a cross between Red Fife and Red Calcutta, a very early wheat from India (20-22). Released in 1909, this cultivar soon accounted for over 80 percent of western Canada's wheat. The U.S. Department of Agriculture introduced and tested Marquis in 1912-13. By 1916, Marquis was the leading variety in the northern grain belt, and by 1919 its range stretched from Washington to northern Illinois (23). The rapid spread of Marquis was not an isolated case. Following extensive expeditions to the Russian Empire, the USDA's most prominent wheat breeder, Mark Alfred Carleton, introduced several durum varieties around 1900. These winter-hardy spring wheats proved relatively drought and rust resistant. By 1906 American durum production increased to 50 million bushels (24, 25).

Another notable breakthrough was the introduction of "Turkey" wheat, a hard red winter variety suited to the southern wheat belt. The standard account credits German Mennonites, who migrated to Kansas from southern Russia, with the introduction of this cultivar in 1873. Early settlers in Kansas had experimented with scores of soft winter varieties common to the eastern states, but these varieties could not survive the cold winters and hot, dry summers. The USDA expanded the Turkey-type gene pool in 1900 with Carleton's introduction of Kharkof from Russia. In 1919, Turkey-type wheat made up over 80 percent of the wheat acreage in Nebraska and Kansas, and nearly 70 percent in Colorado and Oklahoma (26-30). At this time, S. C. Salmon, who later introduced semidwarf wheat cultivars to the U.S., concluded that without Turkey varieties, "the wheat crop of Kansas today would be no more than half what it is, and the farmers of Nebraska, Montana and Iowa would have no choice but to grow spring wheat (31)." Turkey would play key role in the Green Revolution. It was exported to Japan from the U.S. around 1890, and in 1924 breeders crossed it with another cultivar (itself a cross of American and Japanese varieties) leading to the creation of the important semidwarf cultivar Norin10 (32, 33).

Wherever feasible, farmers prefer to grow winter wheat instead of spring wheat. Winter wheat generally offers significantly higher yields and is less subject to damage from insects and diseases, but in colder climates it suffers high losses to winterkill. Today, wheat breeders in the upper Great Plains are still working to extend the winter wheat domain. When the upper Midwest, the northern Great Plains, and the Canadian prairies were first settled spring wheat was generally the only option. Agronomists have long recognized that the development of hearty winter varieties that could be grown in harsher climates was an historic achievement. Our detailed production data allow us quantify the impact of this work.

Fig. 2 uses country-level data from the U.S. and Canada to map the spring-winter wheat frontiers for 1869 and 1929. The two lines plot regression estimates for each degree of longitude between 87° and 105° of the latitude where spring wheat output equaled winter wheat output. In all three years, spring wheat output generally exceeded winter wheat output north of the estimated frontier, and winter wheat dominated south of the frontier. Between 1869 and 1929 scientific advances allowed winter wheat production to spread northward across most of Kansas, Iowa, Nebraska, and Oklahoma as well as large regions of Illinois, Wisconsin, and Colorado. The area between the 1869 and 1929 spring-winter wheat frontiers accounted for over one-fifth North American wheat output in 1929. Since 1929 the winter wheat frontier pushed across much of South Dakota. This displacement of one wheat type by another represented an important case of agricultural adaptation to climate. There were also substitutions among crops—most importantly from wheat to corn. Faster ripening corn varieties allowed the commercial corn belt to move about 500 km northward between 1869 and 1929 (17).

Fig. 2: Shift in the North American spring-winter wheat frontier



Source: Compiled from (9-11, 13, 14).

### *A Global Perspective*

The biological transformation in the 19<sup>th</sup> and early 20<sup>th</sup> centuries grain-growing in Canada and the United States was part of a worldwide process. The farmers, who extended the wheat frontier in Australia, Argentina, and Russia in the 19<sup>th</sup> century, faced similar challenges of producing in new and harsh environments. In all of these areas, immigrants had to adapt to unfamiliar climatic challenges. Farmers and plant breeders scoured the globe for varieties that might meet local needs, they selected and increased the seeds from particularly promising plants, and by the end of the 19<sup>th</sup> century a number of scientists were creating hybrids that combined the favorable traits of varieties drawn from around the world. This was a purposeful and sophisticated process lead by scientists whom plant researchers today revere as the pioneering giants of their discipline. The challenges differed with farmers in Canada and in the northern Great Plains, requiring early and fast ripening hardy spring wheats. In Australia the innovations

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were more akin to those needed to confront global warming—the most important innovation was William Farrer’s breeding of Federation, which helped extend wheat into hot and arid regions previously too hostile for cultivation (34).

The global shift of wheat cultivation had dramatic effects on typical growing conditions, with on balance a movement onto drier and colder lands with more variable climates (34). Elsewhere we show that in 1926-30 median world production was distributed to lands that, on average, were 3 degrees C colder and received 11 fewer cm of precipitation than the areas where wheat had been cultivated in 1866-70. Given that production expanded in temperate Europe, the changes in the conditions facing farmers near the frontier were significantly greater than the changes in the average conditions (35). The reductions in transportation costs, together with biological learning, induced a global shift of wheat cultivation from maritime areas with temperate climates to interior regions with harsher continental climates.

### *Conclusion*

During the 19<sup>th</sup> and 20<sup>th</sup> centuries, scientists and agriculturalists created new technologies that allowed North Americans to repeatedly push wheat cultivation into environments thought too arid, too variable, and too harsh to farm. The climatic challenges that these farmers overcame rivaled the magnitude of the climatic changes predicted by the IPCC over the next hundred years. Most notably by 1929 the median wheat produced in North America received one-half the precipitation as that median in 1839—that is about 50 fewer cm. For the most part the settlement process required adapting cultivation to colder and more arid regions—not to hotter climates as predicted in the future. Farming with less water is more of a problem if the temperature is also hotter. However, biological innovations were crucial to the expansion of production in hot-arid areas such as Texas, Oklahoma, and central California. The main thrust of research in Australia focused on overcoming hotter and more arid climates.

The effects of climate change are likely to appear both in gradual terms and in episodic crises such as outbreaks of new pests and in the onset of severe droughts. This paper bears on the historic responses to the equivalent of gradual changes. The paper does not address related shocks that are the predicted dire consequences to agriculture of global warming include the depletion of already stressed aquifers, a worsening of insect and disease problems, an increase in wildfires, and possible atmospheric changes that will adversely affect crops. But the historical record does show that farmers were able to develop technologies to push crop production into areas previously thought unsuitable for agriculture because the harsh climatic conditions. There is little reason to think that future technological advances and crop substitutions will not partially offset some of the problems created by global warming. Plant scientists offer a mixed view on the prospects of breeding advances to stave off the consequences of global warming. The breeders of annual crops have expressed confidence they can employ both traditional and transgenic methods to develop varieties of maize and other crops to keep up with the gradual effects of climate change. However, their ability to deal with episodic events such as the introduction of new pests is far more problematical. The adaptation of perennial crops will be more difficult than adapting annuals in part because the breeding cycle is longer and many perennials prosper commercially only in small geo-climatic niches (36, 37). There will be enormous challenges to the agricultural sector associated with impending climate changes. As in the past, public and private research will be crucial in meeting the new environmental realities.

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J. M. Alston et al. demonstrate that there are long time lags between investment in research and payoffs, so reinvigorating stagnating public investment in farm productivity oriented agricultural research is a top policy priority given future challenges (38).

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- S1. Using county-level data allows us to capture local climatic variation. The U.S. production data for 1839 to 1909 are from Inter-university Consortium for Political and Social Research, *Historical Demographic, Economic, and Social Data, 1790-2000*, ICPSR 2896. The U.S. data for after 1909 were provided in an electronic form by Michael Haines and come from the *Censuses of Agriculture*. Canadian data are from *Agricultural Census of Canada*, supplemented by sundry provincial sources to fill gaps in the Census data between 1950 and 1976. To link the output data for the period before 1978, we combine the Canadian 1850 production with the U.S. production for 1849 and so on. We do not include Mexico in our analysis due to a paucity of historical data and Mexico’s relatively low wheat output for most of the period. In 2007 wheat production in Mexico composed about 3.5 percent of the combined production in the United States and Canada.
- S2. 1839 is the first year official U.S. wheat production data are available from the Census. The 1839 estimate of Canadian output is a crude indicator, based on partial data from nearby years. Specifically, in 1842 Upper Canada (Ontario) recorded about 3.2 million bushels, and in 1844 Lower Canada (Quebec) reported 843 thousand bushels. Evidence for Nova Scotia (1827 and

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1851), New Brunswick (1851), and Newfoundland and Prince Edward Island (1861) suggests that the output from these providences would not significantly change the estimate for 1839.

12. We calculated the mean center from census county-level production data linked to the county's location. For the U.S., we use the county's 1970 population centroid as reported in (13). For Canada the data are less standardized. We use production for county, census division, or agricultural district linked to a fixed location with each unit.

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## **Traditional knowledge and adaptation to climate change: lessons from the Mediterranean**

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### **Abstract**

Traditional knowledge are often based on long historical experience and deep insights into the dynamics of terrestrial ecosystems. Therefore, they are enthused by the behaviour and characteristics of animal and plant species of special economic, social, cultural, and spiritual significance for local populations. The management and conservation of traditional knowledge and cultural heritage related to them not only protects biodiversity that has been created by and is subject to human activity, but may also favours economic growth of such rural areas by preserving landscape and the environment, promoting local products, encouraging tourism development and eventually contributing towards higher quality of life for local populations. Considering the future scenarios presented by environmental change and especially by global warming, the conservation of traditional management practices, as well as their associated landscape-level adaptations to difficult environmental conditions, should be given priority attention. The efficacy in coping with challenging environmental conditions depends on the interactions between key factors that require careful consideration in order to understand their historical success. Many have been achieved through internal experience and logic that has rarely been formalized into formal science.

In the last few years both FAO, through the GIAHS project, (Globally Important Agricultural Heritage Systems) as well as the International Union of Forest Research Organization, with the Task Force on Traditional Forest Knowledge, have started actions to promote the implementation of traditional knowledge. However, some actions have been undertaken also at national level. The Mediterranean area has a long history of adaptation to difficult environmental conditions in order to develop agriculture. The presence of large flooded areas, as well as very dry regions and extended mountain areas has required the development of a large variety of techniques and practices in the last three millennium, creating also a great diversity of landscapes. Recently the Italian Ministry of Agriculture has started a project to study the historical development of traditional knowledge and their associated landscapes, locate and monitor traditional landscapes, but has also developed policies to support their conservation with economic incentives given to farmers and local communities.

### **1. The Italian rural development plan 2007-2013**

Despite the evident importance of the rural regions for landscape quality and socioeconomic reasons, we can easily conclude that rural policy in the past decades has favoured the degradation of cultural landscapes. Although the European Landscape Convention, the UNESCO World Heritage List and the recent MCPFE Vienna declaration for the forest sector, as well as other specific documents, clearly addressed these issues, there has not been any real policy to reduce

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this trend. The importance given to productive issues and technological development, and the favouring of set-aside<sup>ii</sup> and tree plantations in areas removed from production, have accelerated disappearance of traditional cultivation practices, homogenizing landscape and sometime introducing new landscape degradation. There has been little recognition not only of the importance of cultural landscapes, but also of the advantages coming from a closer relationship between local landscapes and production of typical products, as well as services supporting agritourism. Comparatively more emphasis has been placed on nature conservation, often identified with landscape conservation. The new EU countries of Eastern Europe will probably experience these same trends, with similar losses of cultural landscapes from their territories with the help of EU directives, while probably creating many protected areas.

In Italy policies promoting the conservation of rural landscapes and their associated traditional knowledge did not exist until recently. An important opportunity to address them was the National Strategic Plan for Rural Development 2007-2013, developed in the framework of the European Union new Common Agricultural Policy (CAP). These plans are required of all member states by the European Commission, and they represent the framework in which all the initiatives concerning the development of the rural territories are planned, supported by the EU funds of the Common Agricultural Policy. In the case of Italy, the plan is managed by the Ministry of Agriculture and Forest Policy. Five working groups were established, each with the task of addressing one relevant issue for the development of the rural territory. One of these was dedicated to landscape.

The creation of the landscape working group is a real innovation in the way rural development and landscape resources have been perceived and interpreted in recent decades. All the laws and regulations concerning landscape enacted between 1923 and 2004, including those to promote nature conservation, aimed at preserving portions of the territory by limiting human activities that are potentially damaging valuable landscape, and certain land use changes. The conservation of traditional knowledge and their landscape can be better achieved, however, not simply placing limits on private or public activities, but by including them in an economic development process in which the advantage of preservation are superior to the benefits of degradation. This can be done with initiatives acknowledging the importance of services linked to landscape and slightly changing the traditional role of farmers often seen simply as “producers”. The document produced by the working group on landscape presents a state of knowledge report based on a survey at the national scale, but also reports the results of more detailed analyses at the regional level, as the one carried out in Tuscany. The document also analyzed forest, agricultural and environmental policies and their influence on landscape, as well as the economic importance of landscape resources. The final chapter of the document includes a list of strategies and actions for preserving and developing landscape resources, related to each of the 4 main axes in which the Common Agricultural Policy is organized. It is the first time that Italy is developing a program like this, and while this is a positive step, there are inherent weaknesses that are related to the current situation of state-region relationships and the structure of the National Plan. Although the main frame of the document relates to all Italy it does not require the regions to accept all the strategies and actions. Therefore, the documents produced by each working group are basically providing a number of possible actions that the regions may choose to include in their rural development plans. This situation is due to the present constitutional framework of the Italian State regulating the relationship between the central government and the regional



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governments. Another problem is the inadequate coordination between the Ministry of Culture, officially in charge of landscape conservation, and the Ministry of Environment, which is in charge of protected areas, where 20% of Italian agriculture occurs. There is also insufficient interest of several public administrations that are still unaware of the role of landscape resources.

## **1.2 Measures for Improving the economy of agriculture and forestry sector.**

The strategy developed in this chapter considers the added value represented by landscape resources. The market value of wood products, but also traditional foods coming from the forest, cheese coming from wooded pastures, as well as tourism, can be strongly supported by the added value of the cultural landscapes from which they are derived. This is a crucial factor in the increasing competition at national and international market level. Landscape resources represent a unique factor of competitiveness for each country or region that cannot be reproduced by a competitor in another country. This is particularly important for local products produced by traditional practices. A cheese produced in a specific landscape pattern can increase its market value if the producer is also caring for the conservation of the cultural landscape. From this point of view, foods like raspberry, blueberries, honey, chestnut, mushrooms, as well as meat coming from wild animals, sheep and cows grazing in traditional landscapes can all be supported. An interesting case of this added value is the role played by woodlands in wine regions. Market studies shows that most of the reason why consumers buy a bottle of wine in Tuscany is not related to quality, but rather to the cultural values represented included in the bottle, recalling historical and cultural factors. In areas like the district of the Chianti in Tuscany is unthinkable to separate the landscape of coppice woods from the vineyards, not only for the stakes produced by these woodlands to support vines, but for the historical association that has always existed between forest and farming. Therefore, preserving historical landscapes is an economic action equivalent in importance to increased or improved production or the quality of wine. The economic actions proposed in this chapter support the conservation of the relations between landscape and products, but also services linked to the maintenance of landscape, offering subsidies not only to farmers but also to administrations and local groups for the promotion of typical products. The initiatives concern also training courses on traditional practices, teaching courses to develop local expertise, support is also given to the conservation of material evidence, rural architecture and the use of traditional raw materials in the farms.

## **1.3 Measures for improving the quality of the environment and the countryside**

This chapter is characterized by agri-environment and forest-environment measures, payments to farmers for constraints imposed by the NATURA 2000 network of protected areas, and afforestation of non agricultural and agricultural land. In the Italian context this axis has been interpreted as a way to recover the structure and the patterns of cultural landscapes, with a correct interpretation of the role of nature in the Italian landscape. The actions financed try to counterbalance not only the high rate of abandonment of the countryside, but also the consequences of inappropriate policies that deny the role of traditional forest landscapes for biodiversity. For this reason, and taking into account the rate of abandonment and the continuous

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growth of forest cover, a further extension of forest through afforestation is not always considered a positive action. Detailed studies based on a multitemporal approach must be undertaken to select the correct measures in order to avoid further degradations of landscape by inappropriate actions. These measures are at least partly consistent with those of the working group on biodiversity, which also stresses the need to reduce the increase of forest land on pastures and afforestation. However, the scope for restoration of landscape diversity is limited due to the legislation forbidding, or strongly limiting, the possibility of converting woodland to former pasture or field conditions.

Particular attention has been given to the conservation of distinctive, locally adapted, management practices and techniques that contribute to agricultural biodiversity, natural and cultural heritage, and sustained provision of multiple goods and services, food and livelihood security. The measures are organized in 18 actions for agricultural land, 4 actions for pastureland and 15 actions for woodlands.

#### **1.4 Measures for the quality of life in rural areas**

The conservation and development of landscape resources can play a crucial role in the Italian context, as most of the appreciation of rural areas by the public and tourists is related not to the environmental quality of single elements (e.g. air, soil, vegetation etc.) but to the integration of economic, social and economic aspects represented by the physical structure of the landscape and its cultural significance. What is of utmost importance in this context is the recognition of the cultural identity of the places and the development of a strategy to counterbalance globalization forces that are affecting landscape, putting together private and public administrations in order to develop common initiatives. Therefore the actions promote the development of economic activities for the conservation and promotion of landscape resources, infrastructures, services and marketing of landscape resources. In this respect activities concerning the realization of museums or public initiatives recalling traditional practices and economic activities strongly connected to local landscape are promoted. The actions are also supporting studies for management and planning of local landscape, but one of the most innovative tools proposed is landscape certification. Current certification standards, both in forestry or in agriculture, are inadequate to ensure the conservation of cultural landscapes. This initiative is also very closely linked to the current efforts to include cultural values in the criteria and indicators for sustainable forest management (SFM) by MCPFE, trying to resolve some contradictions. Concerning Italy it has been noted that the conversion of landscapes characterized by a relatively low presence of forest and trees, but very well known for their beauty and historical values into forest areas, could formally receive a certification from all the major forest standards existing in the world. The certification proposed does not take into account as a primary objective the quality of air, water or soil, but rather the maintenance of landscape assets representing the cultural identity of the areas. This tool could be applied to promote food and tourism, as well as for sustainable management strategies. There is also the hope to promote new jobs and open new sectors for foresters, not limiting their activity to planting or cutting, but developing the management and conservation of landscapes, as well as services and activities related to the promotion of historical and cultural heritage.

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## 2. Proposed new indicators for sustainable development

A first step for the assessment of sustainability according to the conservation of cultural landscapes and traditional knowledge is the development of new indicators for sustainable management, that can be applied to specific policies and to certification standards. The following set of indicator has been developed for the Ministerial Conference on the Protection of Forest in Europe and the Region of Tuscany in Italy. The set takes into consideration to three main categories often used in the conservation of cultural and natural heritage :

- 1 *Significance*
- 2 *Integrity*
- 3 *Vulnerability*

The indicators listed in each category are interlinked and can be used in combination. The same indicator (e.g., single land uses) can be described or measured in terms of significance, integrity and vulnerability.

### 2.1 Significance

This term is applied to sites expressing important values represented by a number of qualities that can be described by several indicators. Significance can be represented by a testimony to a cultural tradition or civilization either living or now lost; perhaps a type of building, architectural or technological ensemble, or landscape, an example of a traditional human settlement. It can be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works, representative of a culture (or cultures), especially when under threat.

#### 1. *Landscape patterns*

Cultural landscapes are highly significant for local and national cultural heritage. They are characterised by specific features of their matrix, in terms of vertical and spatial diversity, ranging from dense forest cover, to pastures or fields with trees. Changes induced in the historical structure of the matrix may degrade their significance. This indicator is particularly important also because it addresses biodiversity at landscape level; a feature rarely monitored but highly vulnerable in the context of the current rapid changes in rural areas.

#### 2. *Single historic land uses*

Single land uses due historical traditional practices (e.g. charcoal burning, pasturage, acorn production *etc*) can be considerably important for the local history. Entire landscape patterns may not be existing any more , due to changes occurred in the socioeconomic or natural conditions of a region , but single land uses can survive according to specific activities still occurring.

#### 3. *Material and evidences*

This indicator is suited to assess the significance of buildings or structures associated with traditional knowledge

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#### ***4. Documentary evidence***

Conservation of historical written or printed documents

#### ***4.Bio- cultural evidence***

Veteran trees and culturally modified trees for the production of acorns, fodder (e.g. pollard trees), tar, resins, or other products, as well as hedges, tree avenues *etc.* significant for local traditions.

#### ***5. Cultural traditions***

This refers to immaterial factors, such as events, ceremonies, place names, representative of ethnic groups or local communities

#### ***6. Traditional knowledge***

Traditional knowledge associated to the use of trees, herbs, woods, nuts, saps; forest utilization practices, hunting techniques, management practices *etc*

#### ***7. Social perception***

The perception of historical, aesthetic and spiritual qualities created by economic, social and cultural aspects, through time and space, is essential of the cultural identity of a place.

### **4.2 Integrity**

Integrity measures the state of protection and management of a cultural landscape, a monument, or a tradition. A landscape still showing all its functionalities, at historical, environmental, and social levels, satisfies the requirements concerning the conservation of integrity. In order to maintain integrity it is necessary to maintain the elements necessary to express significance, and to monitor and assess the factors negatively affecting significance. This concept can be applied to material factors, such as architectural elements or landscapes, but even to immaterial factors such as ceremonies or traditions.

#### ***1. Extension of cultural landscapes***

The integrity of a landscape is related also to the conservation of an appropriate extension of territory suited to maintain the elements needed to express significance

#### ***2. Integrity of landscape patterns***

The integrity of a landscape is related to the conservation of the historical features of its matrix. This can be characterized, among other qualities, by very fragmented patterns as those linked to many traditional agro-forestry systems, or by dense, homogeneous forest covers, as well as by mixed conditions.

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### ***3. Integrity of single historic land uses***

The integrity of single historical land uses is linked to degree of conservation of all their features (e.g. number, species, and health of trees in a wood pasture, *etc*)

### ***4. Integrity of material evidences***

State of conservation of buildings or structures associated with traditional knowledge

### ***5. Integrity of documentary evidences***

State of conservation of historical archives, collections or single printed and/or written documents.

### ***6. Integrity of bio-cultural evidence***

State of conservation and vitality of veteran trees, culturally modified trees, hedges, tree avenues in order to express integrity

### ***7. Integrity of cultural traditions***

State of conservation of immaterial factors such as traditions concerning events, ceremonies, place names *etc*

### ***8. Traditional knowledge***

State of conservation of traditional knowledge associated to the use of trees, herbs, woods, nuts, saps; forest utilization practices, hunting techniques, management practices *etc*

### ***9. Social perception***

Degree of conservation of the perception of historical, aesthetic and spiritual qualities created by economic, social and cultural aspects, through time and space.

## **4.3 Vulnerability**

Vulnerability represents the fragility of cultural factors due to the features of processes affecting significance and integrity. Vulnerability measure also resistance to change. Some landscapes and local knowledge are very vulnerable to abandonment, their features degrading in a relatively short time (e.g.. young coppice, shrub-lands, chestnut orchards *etc*), whilst others are less affected by the suspension of traditional practices and more resistant to changes (e.g. high stand of beech or fir). In the same way also immaterial factors such as traditions, ceremonies, or local knowledge can be more-or-less affected by changing socioeconomic conditions. Therefore, it is important to assess the different degree of vulnerability of each item representing significance, but also the factors that can be interpreted as potential dangers.

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## A- Vulnerability of the elements representing significance

### **1. Vulnerability of Landscape patterns**

Landscape patterns show fragilities and different degrees of potential degradation, according to their features and qualities of threats such as abandonment, climate change, socioeconomic development *etc.*

### **2. Vulnerability of single historic land uses**

Fragility and potential degradation of single land uses according to their features and qualities of threats.

### **3. Vulnerability of material elements**

Fragility of buildings or structures associated with forestry or forest operations (e.g. utilizations, transportation, woodworking *etc.*), trends of loss of knowledge of the existence of material proofs referring to the past (i.e.: ownership deeds of woodlands, historic statutes regulating forest management, *etc.*)

### **4. Vulnerability of documentary evidences**

Fragility of collections, archives or single documents related to printed or written evidences.

### **5. Vulnerability of Bio-cultural evidences**

Fragility of veteran trees, culturally modified trees, hedges, tree rows *etc.*

### **6. Vulnerability of Cultural traditions**

Intrinsic fragility of immaterial factors such as events, ceremonies, place names *etc.*

## B - Factors affecting vulnerability

### **1. Forest activities**

Vulnerability due to forest activities presenting a potential or direct danger for cultural factors (e.g. afforestations, inappropriate silvicultural methods, forest utilisation *etc.*)

### **2. Agricultural activities**

Risk due to farming activities presenting a real or potential risk for cultural values (e.g. extension of industrial cultivation on forest-land)

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### ***3. Industrial activities***

Risk due to industrial activities directly or indirectly affecting cultural values (e.g. industries polluting forest areas, or modifying the features of the forest according to market requests, as in the case of the spread of conifers for construction timber)

### ***4. Urban development***

Risk due to factors and process directly linked to expansion of urban areas or infrastructure, as well as planning activities negatively affecting the historical features of forest landscapes, architectural elements (single houses, villages), sites *etc.*

### ***5. Demography***

Risk due to demographic factors presenting an actual or potential risk for cultural values (e.g. landscape patterns very fragile to abandonment)

### ***6. Climate changes***

Risk due to the effect of possible climate changes negatively affecting cultural factors

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## Outline of the process of Red River hydraulics development during the Nguyễn Dynasty

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The history of development of the Red River Delta contrasts sharply with its equivalent in the Mekong Delta. Although the Southern Delta has long been a meeting place between the Khmer, Siamese, Malay, Chinese, Chăm and Vietnamese peoples, and was home to the former kingdom of Funan (site of *Oc Eo*), famed for its skill in water management, the process of large-scale hydraulics development is relatively recent and was instigated in the 17<sup>th</sup> century under the leadership of the Nguyễn lords. With the establishment of the dynasty of the same name at the beginning of the 19<sup>th</sup> century, colonization intensified through the foundation of villages and citadels, the digging of canals for purposes of irrigation, trade and defence, thus asserting the irrevocable status of the southern regions as part of the newly reunified Vietnamese national territory. This continued until the country's partition into two independent entities: in fact, the ultimate stage of the conquest of the Mekong basin was organized by the French colonizers. In counterpoint to the absolute priority given to building dykes in the north, land reclamation in the south depended upon drying and desalinating vast tracts of land by digging a dense network of canals draining water into the sea. It is therefore this latticework of primary canals, linked directly to the rivers, that shapes the contours of the “hydraulic land subdivisions” (*casiers hydrauliques*) into as many independent units, from the perspectives of irrigation and drainage. Finally, in the Mekong Delta, human activity is entirely focussed on the river or the canals and historically evolved along the waterways, a distinctive feature of the regional culture that inspired the expression “river civilisation” (*văn minh sông nước*) to the writer Sơn Nam in order to describe this multiethnic society.

In the Northern Delta, dyke building was the response adopted since the beginning of the Christian era by the Việt people to protecting themselves from violent river floods, particularly those from the Red River. This uninterrupted process of building and strengthening a network of ever more complex dykes had two main consequences. Firstly, it determined how rural areas were organized: villages grew up on the occasional outcrops rising above the Delta, protected by dykes, in a closed system where almost the only people having direct dealings with the rivers were specialized guilds, in particular those of boatmen (river transport) and fishermen. Secondly, this process contributed greatly towards structuring the relationship between the State and the rural population, if only because in this almost exclusively rural country, agricultural production represented the largest source of the Imperial State's revenue through the taxing of peasant farmers and land. For centuries, the State was therefore obliged to devote efforts towards protecting this source of income, one that was indispensable to its very existence. This in a region noted for its chronic agricultural insecurity, where the threat of drought hanging over crops harvested in the 5<sup>th</sup> month gave way to the risks of rapid rises in water levels and floods spelling the destruction of crops normally harvested in the 10<sup>th</sup> month. This accounts for a central characteristic of the Delta: it is a vast alluvial plain (14,700 km<sup>2</sup>) long paralyzed in its development by human intervention. The dyking up of the two main fluvial systems, the Thái Bình and Red Rivers, has immobilized for centuries irregularities in the topographical relief that were only temporary and that the natural spreading action of floodwaters would have



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progressively smoothed out if the rivers were not contained within a network of more than 2,000 km of dykes.

The aim of this paper is to examine the hydraulic policy implemented in the Red River Delta by successive emperors of the Nguyễn Dynasty until the beginning of colonization. Despite doubts raised by the continuation of costly dyking efforts that did not even guarantee satisfactory protection against floods and the changes of direction that were a characteristic feature of imperial policy, we will attempt to demonstrate that the emperors of this dynasty were in certain aspects precursors in the domain of water management and established the basis of an integrated development of the Red River Delta.

### **The Nguyễn Dynasty: working towards a fully dyked Red River Delta**

Before the Nguyễn Dynasty comes to power, considerable efforts at hydraulic development of the Delta have already been made by the preceding dynasties, in particular the Trần and the Lê. The Red River is thus completely dyked in from its entry into the Delta to its mouth. However, every year breached dykes and flooding affect entire provinces, frustrating the constant efforts of the rural population to ensure their subsistence. As for the other component of water management, irrigation, it must be admitted that initiatives taken since the 15<sup>th</sup> century by the imperial power have not brought about any notable improvements: no irrigation works drawing directly from the rivers are carried out before the 19<sup>th</sup> century.

Although the capital of the newly reunified country has been transferred to Huế, the first emperors of the Nguyễn Dynasty proceed to lavish special attention upon the socioeconomic recovery of the North of the country, on its knees after several decades of war and devastation. In order to demonstrate their power, they set themselves up as the instigators of major construction works, building roads, bridges and ports, but also powerful citadels with Vauban-style fortifications in order to contain peasant revolts. This is one of the major ambivalences of the first half of the 19<sup>th</sup> century: while the establishment of an absolute monarchy enables the modernisation of infrastructure in the Red River Delta, the increased control exerted over the population by a widely corrupt bureaucratic and mandarin administration breeds a growing discontent in the rural population that leads on several occasions to rebellion.

In the field of hydraulics, firstly Emperor Gia Long, then Emperors Minh Mạng and Tự Đức order major works aimed principally at managing the rises in the Red River's water levels. According to the figures of the inspection carried out in 1829 by the chief mandarin responsible for dykes (*Đê chính*), Lê Đại Cương, the total length of principal dykes in the Red River Delta (counted in 739 *xã* belonging to 38 *huyện* of 5 *tỉnh*) is 952 km (238,660 *trượng*) of which 144.5 km (36,127 *trượng*) built in 26 years by the first two emperors of the dynasty. (Đỗ Đức Hùng, 1979: 47). The efforts expended were such that P. Gourou considers that on the eve of colonization, the Red River Delta is completely dyked up, meaning that the network of dykes is almost as dense as that which he can observe at the beginning of the 1930s. It stretches to nearly 2,000 km of principal dykes and 2,000 km of secondary dykes (Gourou, 1936: 85).

In spite of this impressive overall appraisal, the Nguyễn's hydraulic policy comprises several U-turns and discontinuities that throw into relief the weight of unilateral decisions taken by each of

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the emperors and the severe dysfunctions of the mandarin administration. Two aspects worthy of mention are at once causes and consequences of this situation.

1<sup>st</sup> aspect - Instability of the administration of dykes

In 1809, Emperor Gia Long reforms the administration of dykes and creates a specialized central department placed under the authority of a mandarin of the Court “*quan Đô chính ở Bắc thành*”. Simultaneously, he enacts regulations structured into eight articles that deal with the execution of works and their inspection, with the protection of constructions and with planning of future works associated with an assessment of their costs. Finally, just as with the code of the Lê emperors, Gia Long’s code makes provisions for sentences up to and including the death penalty, for any person guilty of “*Secretly breaching river dykes – Art. 395*” and of “*Not acting in a timely manner and not repairing dykes – Art. 396*”, this last article echoing the main elements laid out in the code of the Lê emperors.

Despite this set of measures aimed at rationalizing the technical and human management of the dyke network, breaches and flooding continue apace under the reigns of Gia Long and Minh Mạng, with their share of deadly floods, famine and peasant revolts. Every year or almost, from the sixth month onwards, the *Đại Nam Thực Lục* makes a grim inventory of more or less extreme calamities brought about by the violence of flooding or, on the contrary, by drought, with the emperor granting emergency aid in the form of rice and money to the victims, along with total or partial exemptions from income tax.

Following the catastrophic floods of 1827, Minh Mạng issues, in the 8<sup>th</sup> year of his reign (1828), an order that removes responsibility for construction and upkeep of dykes from provincial mandarins accused of negligence and incompetence, bestowing it upon a specialized body of public servants. This text specifies with precision the dimensions of the various categories of dykes, that must be built up compared to the standard heights under Gia Long, and indicates where they must pass; it also orders that bamboos be planted at their base and that each year before the floods, provision be made of baskets and bamboo in order to facilitate repairs; finally, it gives provision for the construction at the confluence of the Red River (sông Hồng) with the Claire River (sông Lô) of a temple to the water spirit.

But this is all to no avail. So Minh Mạng decides once again in 1833 to completely reform the administration of the dykes. He disbands the specialized department that he had created six years earlier and retrocedes the administration of dykes to provincial mandarins who henceforth are responsible for the portion of river that crosses their respective territories. This complete reversal of policy is motivated by the following analysis: experience shows that the specialized mandarins concentrate solely on construction and repairs to the works, without a care for agricultural activities and in particular for possibilities of setting up drainage or irrigation ditches.

2<sup>nd</sup> aspect - Debate over the usefulness of maintaining and strengthening dykes

This administrative and technical reorganization must be placed within the context of a fundamental debate whose terms were laid out as early as 1803 by Emperor Gia Long: by decree, he orders the mandarins and inhabitants to discuss the usefulness of keeping the dykes or of levelling them off. For as the network of dykes and counter-dykes becomes ever denser, farmers and mandarins begin to realize the hindrance that can be caused to irrigation and drainage of

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Delta paddy fields. They witness the distressing sight of the Red River flowing in full spate while the rice wilts away in the paddy fields. People begin to wonder if it would not be wiser to simply remove these so costly and dangerous constructions to let the waters of the major rivers spread out freely during the summer months over the whole Delta like a slow and progressive flood and no longer like a cataclysm. This would result in a high level of moisture that would solve the irrigation problem while increasing the fertility of the soil with alluvium deposits. In other words, the question is to determine whether the dykes are not a cure worse than the sickness they are supposed to treat.

It is certainly the case that after each major flood, the inhabitants of the inundated regions demand the removal of the dykes: the main reason motivating such demands is that when floodwaters breach an upriver stretch of dykes, the downriver sections remain intact and prevent the waters from receding when the river water level goes down, thus eliminating any hope of a harvest. Although most fortunately no emperor of the Nguyễn Dynasty ever decided to order a Delta-wide destruction of dykes, this insistent question gave rise to complementary alternative solutions aimed at lessening the impact of imperfections in the dyke system.

This explains why when he reforms the dykes administration in 1833, Minh Mạng calls for the mandarins of the capital and the Delta provinces to make him propositions to improve water management and flood control. Some of these officials, drawing upon the opinions of local authorities and notables, consider it pointless and costly to seek perpetually to strengthen the dykes, and that a better course of action would be to widen the fresh arroyos opened up by the river's current where dykes have been breached, in order to improve run-off. Although sympathetic to this argument, the Emperor worries about the consequences of a solution that would inevitably cause flooding of low-lying areas and basins located below elevated riverbanks. For the famous mandarin and man of letters Nguyễn Công Trứ, the alternative solution to an imperfect dyke system is to dredge the Red River's natural distributaries and to dig artificial ones, in order to lower the river water level by an increased drainage capacity in its outlets. Although in his opinion the priority is to deepen the Sông Đuống, Minh Mạng decides in 1833, on the advice of two special mandarins, to dig and clear out the Cửu An River, which must at once serve as a distributary to the Red River at Hưng Yên and as an irrigation canal.

From 1835 to 1836, 20 km are dug in order to make the link between the Red River and the Cửu An River, of which the mean bed is also dredged and widened over more than 40 km. In tandem with this excavation work, the dykes of the low-lying areas of Hưng Yên Province are either greatly lowered or are simply flattened down to ground level.

The impact of this major construction project is the complete opposite of what was hoped for. Four months after the completion of work, the channel from the Cửu An River into the Red River is swept away in three places: Hưng Yên and Hải Dương Provinces are submerged under two metres of water and the town of Hưng Yên is completely under water. It is the most disastrous flooding ever experienced in these two provinces. Early in 1837, large-scale reinforcement work begins on the Cửu An River. In response to the pleadings of the inhabitants, the upriver channel of the Cửu An River is completely sealed off and its only remaining function is as a drainage canal. There is no other option but to rebuild and strengthen the dykes in Hưng Yên, Hải Dương and Nam Định Provinces, a task to which Emperor Thieu Trị sets himself during the six years of his reign (1841-1847).

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Yet despite this disastrous experiment, the debate is rekindled in 1847, then in 1852 by Emperor Tự Đức, who makes no secret of his misgivings over the continued dyking up of the Delta, as witnessed by an annotation written in his own hand in the margin to a passage of *Đại Việt sử ký* concerning the construction of the Đinh Nhĩ dyke: “*That was a poorly conceived undertaking responsible for countless disasters*”. Nevertheless, after five years of procrastination, it is finally those in favour of maintaining and strengthening the dyke system who carry the day, most dignitaries at the Court recognizing that attempts at abandoning certain dykes have led over the previous decade to flooding with a frequency and on a scale never seen before.

Once the matter has been decided, the dykes department is re-established in 1857. The new mandarin in charge of the department (*Đê chính*) makes a series of ten specific propositions consisting of as many priorities in terms of hydraulic and regulatory projects to control rises in water levels. On this basis and in tandem with new dykes and counter-dykes built along the Red River to keep it within its banks, dredging work is undertaken with the use of “harrows” (submerged booms) pulled by ships to deepen the river’s mouth and thus enable a more rapid run-off of its tumultuous waters. Efforts are also made to divert part of its flow towards the Thái Bình River in order to lower the river water level and thus to limit the violence of its spates. This is how, in 1858, Tự Đức comes to dig a new entry to the Sông Đương downstream from the former one, now completely blocked by alluvial deposits. But in 1862, before the work on the Sông Đương can be completed, the dykes department is once again dissolved and the policy of major hydraulic development work placed on hold. The Emperor justifies this decision by evoking financial problems and especially the serious disruption occasioned by French colonizing incursions into the North and the South of the country.

Finally, in 1871, the debate is once again activated by a petition from a mandarin, Nguyễn Thành, who argues in favour of the removal of all the dykes of Bắc Kỳ. The results of the consultation launched in 1872 by the Emperor among the various provincial governors shows a real diversity of understanding of the problem that actually reflects quite faithfully the diversity of hydrographical and geomorphologic situations in each of the Delta’s provinces. And it is this pragmatic approach, personified by Phạm Trăn Duật, that seems to have gained the upper hand: in nineteen petitions addressed to the Emperor between 1876 and 1878, he defends a logic of dyke consolidation combined with dredging of the Red River’s distributaries, since the problem of run-off waters in the Upper and Middle Delta cannot be solely attributed to the dyke system, as it also derives from the topographical configuration.

### **Public dykes, private dykes**

The coexistence of two categories of dykes is an historical reality intrinsic to the very process of dyke building in the Red River Delta. However, for the first time during the Nguyễn Dynasty, these two categories are explicitly dissociated. So in his survey carried out in 1829 in four Delta provinces, the chief mandarin in charge of dykes (*Đê chính*) Lê Đại Cương, counts 698 km of private secondary dykes and 16 sluice gates in the same category. The proportion of private dykes therefore represents at this period more than 40 % of the total 1,650 km dykes surveyed. On what criteria is this typology based?

Public dykes are built by order of the Imperial State under the direction of the provincial or specialized mandarin administration, according to different periods. They are considered

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strategic in the sense that they guarantee the protection of large geographical and human units, since their breaching can cause flooding affecting district administrative centres, provincial capitals and whole provinces. These are the most significant earthworks that line either side of the Red River's flood plain and the banks of its most unruly distributaries and whose construction and upkeep must scrupulously follow the standard norms defined by the State in terms of size and compactness. In order periodically to mobilize the large workforce needed to carry out such infrastructure projects, the State has two possible forms of recourse at its disposal. The first is to the mobilization of villagers through the *corvée* system (set by the Gia Long code at 60 days per year and per person enrolled). For major construction projects, thousands or even tens of thousands of rural inhabitants are mobilized in this way, often assisted by soldiers. The second recourse is to a paid workforce (money and rice) in the form of piecework, made indispensable by the considerable number of men and women needed during the few months of the dry season that separate the 10<sup>th</sup> month harvest from the first spring floods.

It is easy to appreciate that the combination of these two possible methods of mobilizing a workforce represents a source of tension between the financial means that the State is ready to invest in building and repairing dykes and their effective use in the field. While some reports presented to the Emperor make explicit mention of the reticence of rural subjects to participate in the works, it also appears that local notables embezzle money allocated by the State for paying workers by imposing upon inhabitants a financial contribution or a share of the work through the *corvée* system.

Although the financial efforts made in the 19<sup>th</sup> century vary greatly from one emperor to the next and from one policy on major hydraulic works to another, investment in this field is never questioned, in spite of the continual destruction of constructions that feeds the debate concerning their usefulness. Let us quote this passage from the Annals of the reign of Minh Mạng in which the Emperor recalls the importance of the State's financial contribution and, using this as a starting point, levels bitter reproaches at mandarins of Sơn Tây, Sơn Nam and Nam Định Provinces following a series of breached dykes and serious floods: *"the dykes are of great importance to the inhabitants of your provinces. You are well aware that We are far from miserly, since every year We place at your disposal a credit of 100,000 ligatures (strings of coins), with payments in kind to watch over the proper maintenance of the dykes. [...] Why did you not take the necessary precautions in advance to avoid such catastrophes? Why did you not, when the violence of the waters increased, take fresh precautions? [...] This proves your negligence"* (quoted by Chassigneux, 1914: 100).

By default, the private dykes are considered as secondary and less strategic, because built along portions of water courses that are more stable and regular and of which potential rises in water level and overflowing only affect human settlements and restricted territories. The State therefore makes an empirical distinction between public and private domains, namely a sharing of tasks and responsibilities governed by its financial capacities at any one time and its political priorities for the governance of the kingdom in general, and for hydraulics management in particular. Private works projects are carried out at the initiative of peasant farmer communities and self-financed by them after they have secured, and this is a crucial point, the Emperor's agreement, since according to the land laws, the State is the sole legitimate and permanent

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landowner, peasant farmers being only franchise-holders whose rights to land use are conditional upon employing it to good effect and upon payment of tax.

The relative significance of public intervention compared to local initiatives follows the changes in the allocation of responsibility for dykes, and in fact reflects quite faithfully the fickleness of the relationship that successive emperors of the Nguyễn Dynasty maintain with the dyke building system for the main Delta rivers. For instance, the dissolution of the dykes department in 1833 and the search for alternative solutions to dyke building, particularly through efforts to discharge the Red River into the Cừu An River, coincide with a clear disengagement by the State with regard to its sovereign prerogatives in matters of hydraulic management that it temporarily entrusts to peasant farmer communities. But even during these periods of disengagement, in order to encourage local initiatives, the Emperor may grant total or partial exemptions from taxes for up to three years, mobilize the army to assist the people, grant rewards and honorary decorations to deserving notables and commoners, and compensate those whose paddy fields are covered over by earthworks.

### **Foreshore reclamation and irrigation: the first planned development**

Although successive emperors of the Nguyễn Dynasty concerned themselves above all with works to protect against flooding from the Red River, they also brought about technical innovations in the field of agricultural hydraulics.

The first concerns the reclamation of foreshores and offshore bars. Strictly speaking, this is not a 19<sup>th</sup> century innovation, since historical sources testify to foreshore reclamation since the 13<sup>th</sup> century, a development that may even have been the reason behind the first embankment works being built in the Delta, if some authors are to be believed. The novelty derives more from the rationalization of foreshore reclamation through dyking up land temporarily exposed by the sea, thus making large-scale land recovery possible. The first and largest undertaking of this kind is begun in 1828 and involves the foreshore of Thái Bình and Ninh Bình Provinces. The work carried out under the direction of Nguyễn Công Trứ enables the creation in 1829 of two new coastal districts, Tiền Hải and Kim Sơn. At the turn of the 20<sup>th</sup> century, these two districts total 20,000 ha of arable land and feed 120,000 inhabitants.

But the most significant innovation concerns irrigation. Not until the beginning of the 19<sup>th</sup> century does a technique for drawing water from the river see the light of day. Until this period, it seemed inconceivable that one might technically control an opening in a dyke without it degenerating into a full-scale breach synonymous with flooding. The principle consists of procuring the water directly from the river by using underground conduits set solidly within the dykes and easy to close, like pipes or sluice gates. This system, aimed at improving on the only palliative to drought available up until then, namely stored water, is designed using only gravity to solve problems linked to irrigation of paddy fields and drainage of excess water accumulated accidentally, following a breach in a dyke, or normally in low-lying areas of “hydraulic land subdivisions” (*casiers hydrauliques*) after heavy rains.

The first written records alluding to work carried out directly within the structure of dykes dates it back to the first years of Gia Long’s reign. The first constructions are of a rudimentary design, made from hollowed tree trunks that sometimes compromise the watertightness of dykes. Later, much more sophisticated installations, like vaulted aqueducts, are built of bricks using a very

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strong and sticky mortar made to last. In 1829, the inventory of hydrological installations lists 50 main sluice gates and 16 private sluice gates that all serve the dual purpose of drainage and irrigation, bearing in mind that the report made to Emperor Minh Mạng in 1833 by the three mandarins who initiated the reform of the dykes administration encourages the wider use of these mechanisms.

How effective are these sluice gates? They give satisfactory results in the areas near the sea where the insecurity of some crops is much more due to floodwaters from the Red River than to the excess of rainwater. On the other hand, as soon as one moves away from these coastal areas, it must be admitted that they bring much more limited improvement than expected. The first reason for this is of a technical nature: their insufficient dimensions when initially designed, aggravated by silting phenomena when water levels rise, do not allow these offtakes to let a sufficient volume of water flow through them. But above all, during the high water season, in the higher and intermediary areas of the Delta, the level of the dyked rivers in spate is much higher than the level in low-lying areas of the “hydraulic land subdivisions” (*casiers hydrauliques*), thus preventing the evacuation through the sluice gates of excess waters that continue to form vast lakes. As for the question of irrigation, the fall in the rivers’ water levels leaves most of the pipes out of the water for the winter season. In short, although the emperors of the Nguyễn Dynasty understood very well that the Delta’s rivers represented an inexhaustible reserve of water that agriculture must use, the topography of the Delta itself does not allow for irrigation by simple gravitational force: the absence of mechanical means of pumping prevents them from overcoming this difficulty.

For this reason, irrigation using arroyos and ponds filled by the natural flow of the rivers remained the norm until the construction of gravity-driven networks. In this system, each peasant farmer is responsible for the supply of water to his plots of land and bails from a specific place located on the side of an arroyo or a pond, called a bailing station. These stations being private, the owner has priority over any other villager wishing to irrigate his paddy fields. The bailed water is then either directly poured into the field, or goes into a canal that leads to the farmer’s land.

All the emperors enact incentive measures to increase water reserves available for the 5<sup>th</sup> month rice crop, whether they consist of clearing arroyos, digging irrigation canals or raising the height of *talwegs* (mini-dyke-dams). But even more than the construction of dykes, the fluctuations in investment granted by the Imperial State and a certain powerlessness to propose efficient solutions for irrigation are two factors that impel peasant farmer communities to design and make their own installations. Although it appears impossible to establish a quantitative assessment of these local initiatives, to obtain a general idea, let us note that at the end of the 19<sup>th</sup> century, combined public and private installations for irrigation and/or drainage enable a double annual rice crop on one-third of the total surface of the Red River Delta.

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Despite the transfer of the capital of the unified country to Huế that had as an immediate consequence the removal of the seat of power from the realities of the North after centuries of being embedded in the heart of the Red River Delta, the Nguyễn Dynasty allocated a massive financial investment to the domain of hydraulics that made it possible to dyke up the whole

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Delta. This unprecedented effort should not however mask the instability and ambiguity of the hydraulic policy pursued by successive emperors: discontinuity in the administration and management of dykes alternately entrusted to a specialized department or relegated to the responsibility of provincial mandarins; bureaucratic unwieldiness linked in part to the distance from the centre of power and to failures of the mandarin administration; alternate periods of involvement followed by disengagement by the State, giving up part of its prerogatives to peasant farmer communities, the latter finding themselves obliged to take sole responsibility for the construction and upkeep of a growing number of installations.

The inability of the emperors to fulfil the terms of the “celestial contract” that assigned to them the responsibility of protecting their subjects from the natural elements and in particular from flooding, contributed without any doubt to the popular discontent evidenced by the frequency of successive peasant revolts in the 19<sup>th</sup> century: 4 revolts a year under Gia Long; 11 revolts a year under Minh Mạng; 8 revolts a year under Thiệu Trị; 3 revolts a year under Tự Đức; in total, more than 400 rebellions in about 60 years.

But over and above this chequered appraisal whose objectivity is more than relative, given the incomplete nature of available sources, it can be considered that the Nguyễn Dynasty played a key part in the domain of hydraulics by creating the foundations for modern and planned development of the Red River Delta. In addition to widespread dyke building, Emperors Gia Long and Minh Mạng are the first to have tried to resolve the crucial problem of irrigation by tapping directly into the resource constituted by the practically inexhaustible reserves of water supplied by the rivers. Admittedly, the results obtained were mediocre, because in a deltaic region such as this one, the installation of hydraulic networks can only be carried out on a large scale in order to enable not only irrigation but also drainage of excess water during the monsoon: this calls for significant mechanical means for pumping water and for the digging of robust drainage and irrigation canals. For these precursors, limits were above all of a technical nature, whatever the opinion of Western observers; indeed, it was not until the 1920s that the colonial engineers and experts come up with effective and realistic irrigation projects for the middle and lower Delta, thanks to an increased reliance on thermal then electrical pumping stations. Despite this admission of powerlessness, the emperors of this dynasty nevertheless had an overall vision of the complexity of the hydraulic workings of the Delta and the sometimes harmful consequences of its development, as proved by the debate initiated as far back as 1803 by Gia Long about the possibility of either strengthening or, on the contrary, levelling off the existing network of dykes.

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## **The Transition from Conventional to Organic Rice Production In Northeastern Thailand: Prospect and Challenges<sup>1</sup> Natedao Taotawin<sup>2</sup>**

<sup>i</sup> *Academic Seminar on “Environmental Change, Agricultural Sustainability, and Economic Development in the Mekong Delta” held during 25-27 March, 2010 at Can Tho University, Can Tho, Vietnam.*

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### **Abstract:**

The paper examines the process of market integration and its effect on farmer livelihoods, environment and agriculture of the Northeast Thailand. Drawing on an anthropological approach and a fieldwork conducted in the Northeast Thailand during 2008-2009, the paper shows the way by which the farmers and the environment of the northeast Thailand are integrated into ethical niche markets of fair trade and organic foods. Key question is how the buyer-driven food chains have contributed to agrarian transformation in the Northeast Thailand. The paper illustrates the impacts of consumer's concerns about safety, healthy, environment and social justice on social-nature of the Northeast Thailand. The competition of organic niche markets depends significantly on the capacity to comply with the international regulations. As such, the paper focuses on the distinctiveness of socio-economic and ecological conditions of the northeast Thailand which has constituted to the competition of organic food commodity chains. Lastly, the potential capabilities and challenges of the export-oriented organic rice production to poverty reduction are assessed. The paper argues that the emergence of organic Jasmine rice commodity chain in the Northeast Thailand allows the farmers to maintain their farmlands. The conversion to organic rice farming is a strategy employed by the farmer to cope with the problem of deteriorated environment and reducing income. Yet, the emerging niche markets in the Northeast Thailand have found both to diminish and to accentuate rural inequality. Majority of farmers are excluded from the rise of new niche markets. The farmers incorporated into new markets gain benefit from the rise of new markets, but they confront some constraints associated with intensive labors, increasing transaction cost and increasing production cost.

### **Key Words:**

Market integration, livelihood, environment, agriculture, organic, fair trade, food supply chain, niche markets, regulation

### **I. Emergence of Export-Oriented Organic Rice Production in the Northeast Thailand**

Thailand is known as the most important exporter of rice to the world markets. However, there is a downward trend of volume and value of export non-organic rice since the 1970s onwards (Dawe 2002). The development programs initiated by the Thai government in the last five decades have contributed to economic inequality between the Central Thailand and peripheral regions through the extraction of natural resources and surplus from the rural regions

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to the Central. This has led to increasing rural poverty and deteriorated environment (Missingham 1996). Although the value of export rice has developed in a downward trend, the importance of agricultural sector to Thai economy is not eliminated. A large amount of populations still work within agricultural sector, the agricultural sector has capacity to absorb surplus labors in rural areas. For this reason, some scholars suggest the Thai government to shift to non-traditional foods which have high-valued instead of conventional products (Siamwala 1989). The Thai government's adoption of neoliberal economic policy since the 1980s has affected competition of the Thai agricultural sector in the world markets due to the free trade commitments to reduce domestic subsidy and export subsidy, to increase market access for oversea agricultural products, and to follow food safety standards (Henson and Loader 2001).

The Thai government's adoption of agricultural restructuring policy towards the high-valued food production since the late 1990s is an attempt to improve competition of the Thai agricultural sector in neoliberal contexts (Manarangsan and Suwanjindar 1992). The conversion to organic Jasmine rice production reflects an important way to shift towards the high-valued food production (Department of Agricultural Extension 2004). Export-oriented organic farming is promoted as a tool to eradicate rural poverty, to improve national economy, and to create food security and environmental sustainability ([http://www.ddd.go.th/link\\_fertilizer/home.htm](http://www.ddd.go.th/link_fertilizer/home.htm)).

In 2008 planted areas of organic were approximately estimated about 140,963 rai, of which 80 percent of total planted areas were used for growing organic rice, vegetables, fruits and herbs. The Thai government plans to increase areas for growing organic by 40 percent to 200,000 rai within 2010 to meet higher demand of organic foods in the world markets. The small area puts Thailand in 71st place out of 85 countries that grow organic produce, which earned only about one billion baht in export revenue. The figure represents less than 0.1 percent of the total value of organic products around the world, estimated at 1.3 trillion baht in 2006. World market demand of organic produce has been rising by 20 percent a year, especially in wealth countries in Europe, North America and Japan. The major organic product exporters are Argentina, Mexico, Brazil, India and China.

To capture the growing niche markets, the Thai ministry of agriculture had allocated a budget of 1.7 billion baht to improve organic plantations. The funds will be spent to improve land, and on research and development, in addition to marketing to promote Thai products. The ministry has a budget of 354 million baht for a Mentor Program, in which selected experts will be hired to advise farmers over organic farming. There are 40 centers for mentors that have proved successful in distributing information and advising farmers on the sufficiency economy and organic agriculture. The Thai ministry of agriculture plans to have 130 centers by the end of year 2008, which each one is expected to support at least 200 farmers. Therefore, the ministry of agriculture sets a goal to have around two million rai of chemical-used lands to turn to organic farming (Bangkok Post Newspaper, 9 Jan 2008, <http://www.biothai.org/cgi-bin/content/news/show.pl?0518>).

The Thai government has implemented a policy to promote organic Jasmine rice production in particular. In 2000 the Thai government allocated budget 1.7 billion baht to increase the planted areas for organic Jasmine rice production to be 119,707 billion tons in the year 1999/2000. The ministry of agriculture in accompany with other governmental bodies have set up a 'national rice strategy', implementing during 2004 to 2008. This strategy aimed to

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encourage the production of safety foods, to improve environmental management, and to create added value to rice production.

The Thai government considers standardization of organic foods as a prior condition for export organic agricultural products to the world markets. The standardization of organic farming in Thailand is made through the institutionalization of organic standards, marked by the establishment of the Office of Organic Agriculture Certification Thailand (ACT) in 1998, the establishment of formal ACT standards in 1999, and the improvement of ACT standards to fit with the International Federation Organic Agriculture Movement standards (IFOAM) in 2000 (<http://www.actorganic-cert.or.th/standard.html>). The Thai government established the National Bureau of Agricultural Commodity and Food Standards (ACFS) in 2002 to consolidate all national organic certifications under a single authority.

Although organic agriculture is promoted as a national agenda, the growth of organic food supplies in Thailand results from the engagement of agribusiness in organic production (Panyakul 2004). Majority of farmers do not convert to organic agriculture, even if they are willing to do so. Theoretically, a vertically integration of organic Jasmine rice opens the space of inclusion for all potential farmers who produce good quality products. In practice, however, contract is adopted as a way to mobilize conventional farmers to grow organic Jasmine rice for export. The local NGO links between local farmers and global niche markets. NGO has imposed criterions for selection of lands and labors to produce organic Jasmine rice commodity. Interviews of the farmers specified that they are connected to the producer group through their personal connections with the former farmer members, the NGO staffs, and committees of the producer group. NGO staff cites that the organization has extension service staffs, these staffs visit conventional farmers to convince them to apply for membership of the producer group.

Initially, the farmers engaged in the export-oriented organic rice farming were mostly small farmers. In the recent year proportion of medium-sized and large-sized farmers engaged in the export-oriented organic rice farming has increased. The reasons for farmers' decision to grow organic rice for export are quite complex. The farmers consider the conversion to organic rice farming benefits them in several ways. For instance, it allows them to cope with problem of cost-price squeeze and to gain premium price. Once the farmers are integrated into the niche markets, they can sell their produces at the minimum guaranteed price set by FLO. For the farmers who convert to organic rice farming in the first year and the second year, they can sell their produces for 11,000 baht per 1 ton or US \$ 335.64 and 12,000 baht per 1 ton or US \$ 16,237 respectively.

Although economic reason is an important factor for conversion to organic Jasmine rice production, social and cultural aspects are also involved. The farmers consider organic rice farming is safety, healthy and environmentally-friendly practices. The farmers consider organic rice farming creates food security, as it improves land fertility and generates safe foods for their own family members and consumers.

The export-oriented organic rice production in the Northeast Thailand is a response to emerging niche markets and a response to national agricultural restructuring policy. Additionally, the export-oriented production of organic Jasmine rice in the Northeast Thailand is a buyer-driven commodity chain<sup>ii</sup>. Gereffi argues that a buyer-driven commodity chain is a

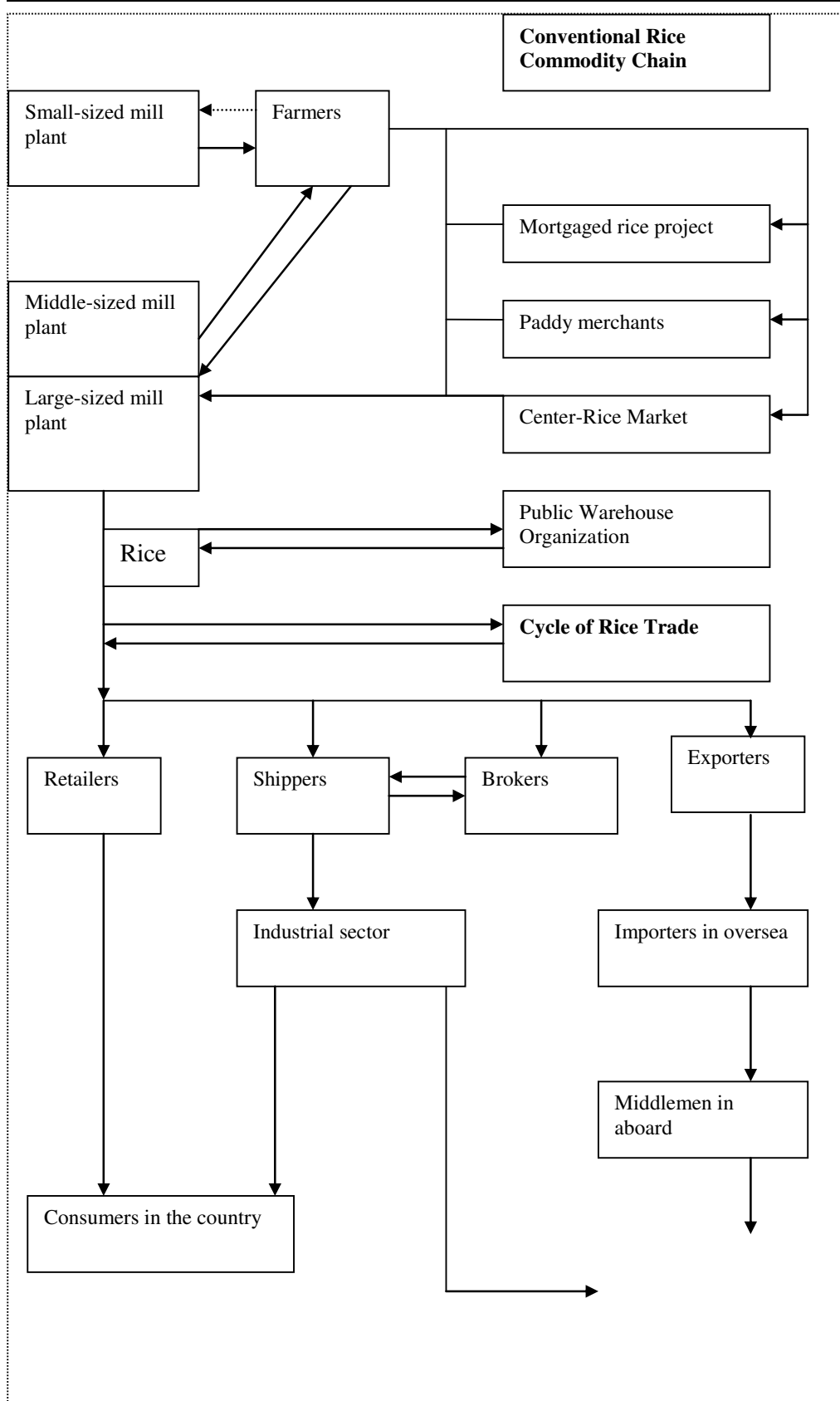
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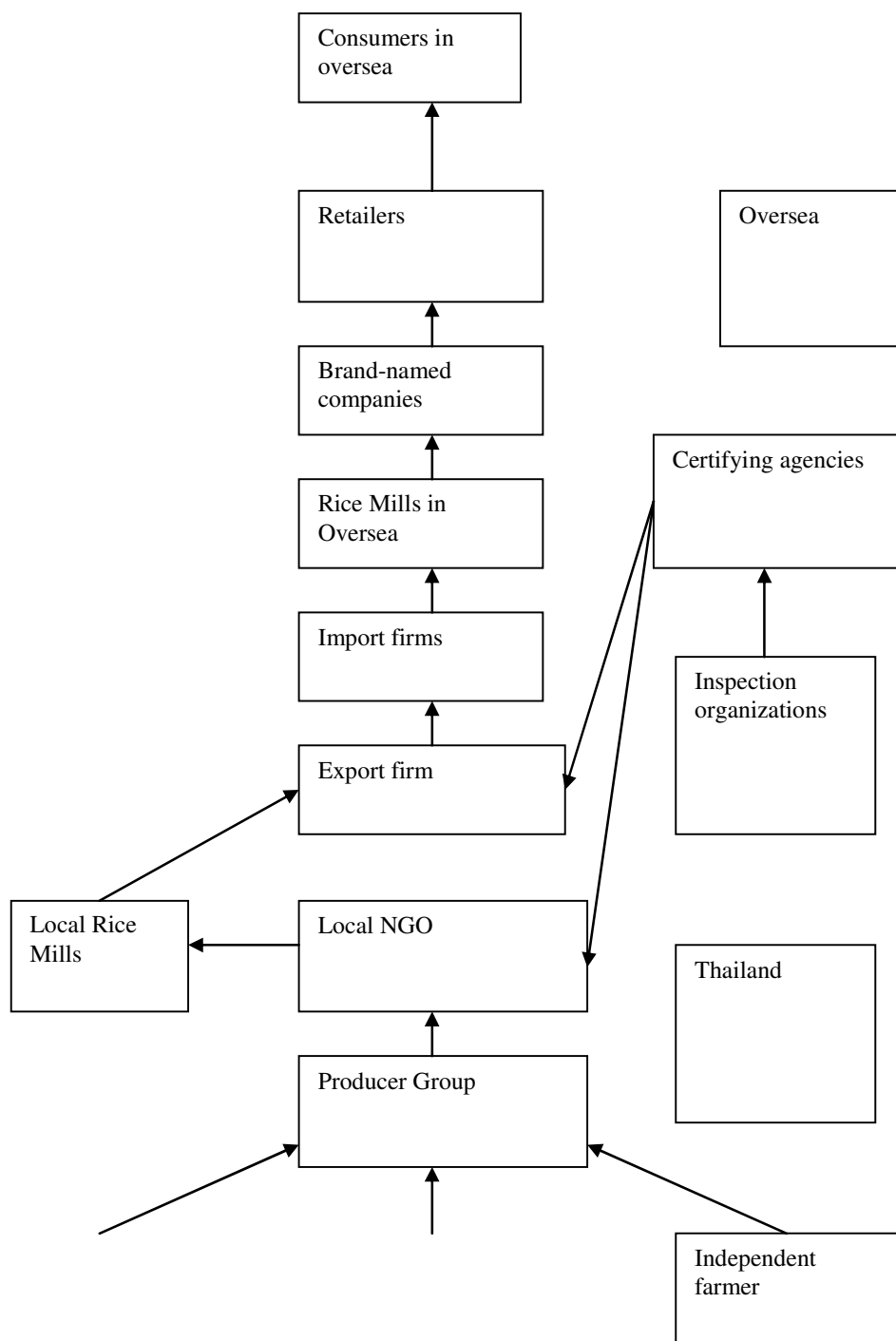
commodity chain in which large retailers, brand-named merchandisers and trading companies play the pivotal role in setting up decentralized production networks in exporting countries, typically located in the Third World. Buyer-driven commodity chains allow the buyers and branded merchandisers to act as strategic brokers in linking overseas factories and traders with evolving product niches in their main consumer markets. The buyer-driven commodity chains have a greater capacity to bear on changing conditions of doing business in a post-Fordist world, due to its characteristic concerning about the re-arrangement of organizations toward flexible specialization (Gereffi 1994).

Laura T. Raynolds identifies flexibility of post-Fordist systems of industrial organizations resulting from the change in three domains: (i) in the volume and differentiation of their products; (ii) in their management and internal factor mix; and (iii) in their relations with other firms as either suppliers or buyers. Raynold contends that by the 1980s oriental vegetables exporting from the Dominican Republic adopted the post-Fordist model of production in many ways. The production was organized by small enterprises linked through a network of contract producing specialty foods for niche markets. These firms in turn were tightly linked through personal as well as market ties to ethic marketing chains that served a growing U.S. niche market for exotic vegetables (Raynolds 1994). Alex Hughes argues that Kenya flower commodity chain is re-arranged in accordance with new demands of consumers. Hughes argues that the strategies employed by the corporate are executed in the name of the virtual consumer rather than real consumers. Moreover, the Kenya flower commodity chain is driven by the forces of abstraction rooted in the code of practices of international regulations and auditing (Hughes 2004).

Drawing on the works of Raynolds and Hughes, I argue that the organic Jasmine rice commodity chain which is an example food project is driven by consumers, retailers and the forces of abstraction from the international regulations. The rise of organic Jasmine rice commodity chain in the Northeast Thailand has led to the re-arrangement of the conventional rice commodity chain. Figure 1 illustrates the conventional rice commodity chain which is locally embedded whilst the organic Jasmine rice commodity chain is controlled at a distance by globally organizations.

Although the production system is organized by a local NGO through a local development scheme, the organic Jasmine rice commodity chain is a vertically network. Contract is the principle device through which the local farmers are incorporated into the global markets. Contract also makes possible the actions at a distance (Young 2006). Contract farming allows retailers and other global actors to control quantity and quality of organic rice produce. Under the contract, livelihood of farmers and farming practices are influenced by the global actors even if they are absence. As contract farming is employed by the capitalists to create flexible specialization, the role of contract in organic Jasmine rice commodity chain is a vital.







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Figure 2 illustrates the complex web of social relations between firms, NGOs and farmers within the organic Jasmine rice commodity chain. The farmers are organized as the producer group according to the fair trade standard. Moreover, the production system is re-arranged to comply with the NOP, EU 2092/91, BIO-SUISSE, JAS, ISO 22000: 2005 standards. Milling, processing and packaging processes are operated by a local rice mill. The auditing inspections are conducted by independent inspectors under the control of international certifying agencies such as FLO-CERT, IMO-control and INTERTEK. The organic Jasmine rice is exported by another export firm which has market ties to importers in oversea. These import firms are responsible for milling, processing and packaging organic Jasmine rice. After that, organic Jasmine rice is packaged by different brand-named companies and sold to ethic marketing chains oversea through the network of fair trade and organic niche market retailers.

## **II. The Condition of Flexible Specialization in Export-Oriented Organic Jasmine Rice Production**

The analysis of commodity chain is centrally concerned with the geographical embeddedness of production systems. The work of geographers like Harvey (1989), Massey (1984), Smith (1984) show how the production of space and spatial relations operates within the contradictory tendencies of capitalism. The work of Schoenberger argues that competition in the Fordist system is made by reducing the production time and by regulating the flow of production. By contrast, competition in the post-Fordist systems of industrial organizations is constituted through the time-space compression- the ability to manage time in production, and the closely integration between different firms and organizations from different geographical spaces (Schoenberger 1994).

I contend that the socio-economic, ecological and geographical conditions of the Northeast Thailand have contributed to construction of competition in the organic Jasmine rice commodity chain. The Northeast Thailand is known as a region which has insufficient infrastructure, deteriorated natural resources, low education and lack of capital. Rice farming in the Northeast depends mostly on rainfall, with the relatively low yields than other regions of the country. The degree of rainfall in the Northeast is not markedly lower than that of other regions, but the poor quality of soil reduces its effectiveness. The lands have lower nutrient and draught was a common occurrence. The poor quality of lands and draught are obstacles to agricultural intensification and expansion of agricultural territory, it is the key to the problem of poverty in the Northeast.

Socio-economic and environmental conditions of the Northeast have set a limitation for effects of the green revolution. As a result, the attempt to create modernization of agriculture in Northeast Thailand is far beyond success. The green revolution is identified as a package approach to increase productivity. The package includes a widespread use of high yielding varieties (HYVs), an intensified cropping, a high level of a reliance on irrigation systems, a high degree of a reliance on machinery and agricultural chemicals. Some researches argue that the green revolution is effective only if the package approach of the green revolution is undertaken. Within this perspective, the introduction of HYVs alone is not enough to create the green revolution effects, as water control, large inputs of fertilizers, and prevention of disease and insect management are also important (Pingali et al. 1997).

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The effects of the green revolution are obviously visible in the Central Thailand. The green revolution improves the rice yields per rai in every region. Yet, a variation in the characteristic of rice growing in different regions of the country is reported (Silcock 1970). Variations in the yields cultivated in different regions result from variations in the environmental conditions under which rice is grown than variations in the technological access. A close examination of the regional yield data in Thailand highlights the impact of environmental conditions on the yields, including the proportion of paddy lands under irrigation in different regions and the occurrence of floods or draught which damaged the harvested area and reduced yields on the areas (Hseith and Ruttan 1967). The Central Thailand had fairly high yields in part because of larger proportion of planted areas in access to irrigation systems. By contrast, the yields cultivated in the Northeast Thailand were only about two-thirds of those of the Central Plain, due to poor weather and soil conditions (Silcock 1970).

Moreover, the Northeast Thailand has few major rivers and these are subject to flooding. An inadequacy of water supply in the Northeastern Thailand has led to severe draught and set limited the effects of the green revolution. The high yield varieties (HYVs) depend on a combination of an adequacy of synthetic fertilizer, insecticide and water supply to allow the rice to be mature and ripen. An insufficiency of the irrigation systems in Northeast Thailand has directly affected the yields. However, Northeast farmers do not rely on rainfall alone; they try to channel at least some water onto their paddy lands. Some use the low-life pumps to convert water from canal or underground water onto their paddy fields in order to prevent their farms from draining away. In the beginning of the rainy season which the rainfall is unreliable, paddy fields that do not use as nurseries often serve as catchments' areas for the nursery fields. Each plot of the paddy fields has characteristically an equivalent to a small reservoir. Even so, water may be insufficient. In places with a limited catchment's area, or where the level of underground water is low and the soil is highly porous, the farmers' efforts bring little reward (Ishii 1975).

Without the adoption of package approach of the green revolution, I contend that the introduction of a single technological element of the green revolution into the traditional cultivation systems at the personal discretion and initiative of the farmers under certain limited environmental and socio-economic conditions often led to partial green revolution. At the early stage of attempt to create modernization of paddy fields in the Northeast, there was a report contended that the Northeast farmers did not rely on chemical synthetic fertilizers for two reasons. Firstly, the farmers face a difficulty associated with micro-credit, so they cannot afford for expensive cost of synthetic chemical fertilizers. Secondly, the farmers were not convinced to use synthetic chemical fertilizers in their paddy fields, because investment in chemical fertilizers in the Northeast did not generate dramatic yields and profitability as it is frequently claimed (Kolseus 1972).

I contend that the partial green revolution in the Northeast Thailand has become a comparative advantage for the conversion to organic rice farming, as risk of environmental contamination in the Northeast is conceived as less than other regions. Jasmine rice is called the 'Khao Dawk Mali 105' (KDML 105) (in Thai it is called 'ข้าวหอมมะลิ 105'). It is a photoperiod sensitive rice variety and can be grown in the wet season in every region of the country. Jasmine rice is known for specific grain characteristics, particularly aroma and low amylase content which makes the cooking of Jasmine rice differs from other rice grains. These

special characteristics are distinguished among Asian consumers and inevitably generate a premium price for the Thai Jasmine rice. Degree of aroma and grain quality of Jasmine rice grown in different geographical regions does not uniform, due to production environment, soil nutrients and cultural management. However, the Northeast is the most suitable place for growing Jasmine rice, due particularly to rainfall pattern and soil salinity. But, the production of Jasmine rice in this region is reaching the upper limit and spreading over the other regions in Thailand and neighboring countries (Isvilanonda and Seiichi 2005).

The social condition of the Northeast Thailand, to some extent, has contributed to comparative advantage of organic rice farming. The Northeast is known as a region in which a large number of residents live under the poverty line. Table 1 shows the poverty line, the proportion of poor people and the number of poor people found in the Northeast Thailand in 2004. Average income of the Northeast residents was approximately estimated 1,078 baht, the proportion of poor people was approximately estimated 17 percent, and number of poor people was approximately estimated 3,650 thousand. The data from the Bank of Agriculture and Cooperatives reports that 24.53 percent of farmers' families are landless who lack of stable land tenure. Additionally, there are about 4.86 million farmers' families (or 86.4 percent) which are indebted by an average amount of US\$ 24,742.3 or US\$ 642.7 per family.

Table 1 indicates the poverty line, proportion of poor people and the number of poor people in 2004.

Region	Poverty line (baht/person/month)	Proportion of poor people (percentage)	Number of poor people (thousand)
Bangkok	1,853	1.64	108.40
Central plain	1,339	5.09	757.40
Northeast	1,078	17.16	3,650.80
North	1,131	16.24	1,907.40
South	1,164	7.82	655.00
Total	1,242	11.25	7,079.00

Source: A survey by the Office of National Statistic, calculated by office of the National Economic and Social Development Board.

Considering social contexts of the Northeast Thailand, the farmers are typically regarded as flexible specialty labors. They are poor, vigorous, patient, honest, dutiful and flexible. The shift to organic rice farming is a high-valued food production. It is a livelihood strategy employed by the Northeast farmers to cope with vulnerability and to seek for security and better life in the context that the peasant movement in Thailand is becoming weakened. Within the last few decades, rural development in the Northeast focuses mainly on improvement of productivity and self-sufficiency to solve problems of environmental destruction and social inequality resulted from economic development in the previous few decades (Phatharathananunth 2002).

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Nevertheless, we are left with the question whether this strategy helps reducing vulnerability and poverty, particularly among poor farmers.

Rural diversification is an important strategy employed by the rural households of the South to reduce vulnerability and to create well-being (Rigg 2001). Livelihood diversification is defined as the process by which rural families construct a diverse portfolio of activities and social support capabilities in order to survive and to improve their standards of living. To know effectiveness of livelihood diversification, however, determinants and effects of livelihood diversification in the areas of poverty, income distribution, farm output and gender are required to examine (Ellis 1998). Empirical evidence shows that rural families of the South have been significantly relied on migration and non-farm livelihoods for survival. This has led to an argument that livelihoods of rural families of the South are de-linked from farming and lands. Within this perspective, wealth and poverty of rural families of the South are moved away from peasantization towards de-agrarianization (Rigg 2006).

It is true that non-farm livelihood is important for survival of rural families of the South in the context of neoliberalization. For instance, migration is a strategy employed by the young generations of the Northeastern Thailand to gain more incomes, freedom and pleasures in the city. Nevertheless, the reasons and the effects of out-migration to local economy are complex, but receive little attention. The work of Mary Beth Mills provides insight about the reasons of female migrant factory workers from the rural communities of the Northeast Thailand to work in Bangkok. For these women, migration provides them more than economic benefit, because it allows them to keep a distance from the male domination inherent in patriarchal culture of peasant communities (Mills 2001).

Gillian Hart insists that development of rural communities in the rural South is not linear, but must be regarded as multiple trajectories (Hart 1997). For this reason, the shift to organic Jasmine rice production in the Northeast Thailand is a result of complex drives. At the same time, it indicates a way that family farms of the Northeast Thailand struggle to take greater advantages from the rise of niche markets. In the context of neoliberalism the farmers have alternative options: (i) persistence in conventional rice farming plus wage labor, or non-farm activities; (ii) shift to organic rice farming plus wage labor, or non-farm activities; (iii) combination of conventional and organic rice farming, plus wage labor, or non-farm; (iv) abandonment of rice farming and turning into wage labors. Considering rural households' portfolio mentioned above, the shift to organic Jasmine rice points to the on-farm livelihood, but non-farm livelihoods are also significant. Yet, key question is how the farmers struggle to make possible the shift to organic rice farming. Therefore, issues of opportunities and constraints are involved.

It is worth to note that minority of the farmers shift to organic rice farming whilst majority of their fellow farmers are in pursuit of conventional rice farming. This fact points to social exclusion existed in the process of market integration. Frank Ellis argues that decision making is not freely-made choice, but it is a subject to economic constraints and social constraints. It means capability of people to change what they do is influenced by economic and social contexts. Some main determinants of diversification are seasonality, differentiated labor markets, risk strategies, coping behavior, credit market imperfections, and inter-temporal saving and investment strategies (Ellis 1998).

For the farmers who shift to organic rice farming, key questions are: who benefits from the new niche markets?; how much the farmers gain benefits from the rise of new markets?; and what are the transaction cost required? Consequently, the following section will explore the capacities and challenges met by the farmers in the transition to export-oriented organic rice production.

### III. Examining Capacities and Challenges in Recent Trend of Export-Oriented Organic Rice Production

To sell their produce at the premium price, there are criterions specified that the production system and agro-ecological environment must be re-arranged in compliance with the international regulations. As a result, the creation of competition for organic Jasmine rice depends significantly on the capacity of individual farmer to re-arrange time and space to comply with the requirements of international regulations such as the NOP, EU 2092/91, BIO-SUISSE, JAS, Fair trade standards. Distinct international regulation has a range of rules to follow, requirements to comply with and prohibition to avoid. Therefore, complexity and difference of requirements of the international regulations are frequently considered as non-tariff trade barrier for producers from developing countries to export their produce to global markets (Henson and Loader 2001).

Browne et al. compare between the fair trade and the organic trade. They argue that the two movements are identified as ‘ethical’ trade. In fact, the two movements have distinct origins, philosophies and requirements. The difference between the two movements is shown in table 2. Such difference creates conceptual and practical constraints to link between organic production and ethical trade (Browne et al. 2000).

Table 2 Contrast between organic production and ethical trade

Items	Organic	Ethical
Origins	As a method of agricultural production, originating in the 1930s	As a description of trade between the developed and developing worlds, becoming widely used in the 1990s
Focus	Focus on agricultural production systems that utilize biological rather than chemical inputs	Focus on people’s working conditions, especially in the developing world
Development	Is not a development issue but is concerned with sustainability of farming systems	Is a development issue, and many contribute to livelihood enhancement

Standards	Universal production standards, assured through accreditation and inspection	No universal standards. Voluntary codes of conduct and self-regulation becoming more common
Certification	Yes, based on regulation by the state. Assured by legally registered labeling symbols on market produce	Yes for fair trade, no for ethical. No legal status for ethical claims on marketed produce

Source: Brown et al. (2000)

The Fair trade standards concern about improvement of social conditions of production by paying the producers a guarantee minimum price which covers the overall production costs. Besides, the buyers are required to pay an additional social premium to support local development schemes initiated by producer organizations. For producers to get the fair trade premium, the producers are required to coordinate in the term of a producer group or an association or a cooperative. The group must consist of small farmers who depend on family labors to produce the fair trade products. Additionally, the group must be organized and operated along democratic lines and democratic decision making process. Lastly, financial information must be transparent. Producers and buyers are encouraged into long term contracts so that it offers greater economic stability to farmers ([www.fairtrade.net/standards.html](http://www.fairtrade.net/standards.html)). Recently, the Fair Trade Labeling Organization International (FLO) has recognized the importance of ecological well-being. Consequently, the fair trade producer group is required to reduce the negative environmental impacts in the production, post-harvesting and processing (Rice 2001).

Organic agriculture movement puts an emphasis on the commitment to environmental ideals. The principles of organic agriculture are rested on efforts to restore, maintain and enhance ecological harmony through an improvement of soil fertility, a prohibition of synthetic agro-chemical use, and a minimization of off-farm resource use (Darnhofer 2005). Indeed, organic regulations play a critical role both in determining the legally definition of organic and in providing the guideline for practices of organic (Guthman 1998). Regulating spaces for organic standards are the ecological conditions of production.

Since the competition of export-oriented organic Jasmine rice production in the Northeast Thailand is created through the compliance with international regulations. Key questions to be addressed are: (i) the way through which the international regulations are enforced on the ground; (ii) the way by which the production system is re-arranged to comply with the international regulations; and (iii) the degree to which the farmers comply with the international regulations. It is worthy noted that complexity and difference of the international regulations makes the enforcement of international regulations on the ground becoming difficult for both development practitioners and local farmers. For this reason, the international regulations are transformed by a key man of the development program into twenty locally-established rules. The primary reason for the simplification of the international regulations is to make the international

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regulations to be enforceable on the ground (Interview of a development programmer on 28 December, 2009).

These twenty locally-established rules are: (i) the farms must be complete conversion to organic agriculture in all plots, including in subsistence food plots. The transition-to-organic phase takes three years; (ii) mixture of animal farms and organic rice farm is forbidden. If the animals are kept on the farm; some measures are required to be implemented in order to assure animal welfare; (iii) the farmers are required to set aside at least 7 percent of total agricultural areas to be ‘natural’ space; (iv) the farmers must be applied to be memberships of the organic Jasmine rice producer group and the farmers are required to sell entirely of their organic produce to the development program only; (v) the farmers are required to sign their name in the contract; (vi) it is a compulsory to use certified organic rice seeds; (vii) use of chemical synthetic fertilizer and pesticide is prohibited; (viii) all production inputs must be made organically, must not be chemically treated, and must be approved by the development programmer; (ix) use of genetic modifying organisms (GMOs) is prohibited; (x) the farmers are required to grow multi annual rotation crop such as green bean to improve soil fertility; (xi) prevention of airborne and waterborne contamination is needed; (xii) rice must be handled in such a way to avoid mixing with other rice and to avoid mixing with rice from other non-organic certified producers in harvesting, threshing, rice storage, and rice containing; (xiii) harvesting and post-harvesting processes must be followed the instructions specified in the guideline; (xiv) the farmers are required to constant participation in a training program every year, otherwise their status as memberships of organic Jasmine rice producer group will be removed; (xv) farm record<sup>ii</sup> must be made to be clear, and original receipts of buying and selling items must be kept to be ready for checking by the internal and external inspectors; (xvi) the farmers are needed to allow internal and external inspectors to have field spot checking, house checking, rice storage checking, warehouse checking and other cropped checking. The internal and external inspections can be conducted at any time regardless of a need to inform the farmers in advance; (xvii) the farmers must attend the annual meeting at least once a year. If the farmers cannot attend the meeting for whatever reasons, they have to assign family members who engage in organic rice to replace his position otherwise their status as memberships of organic Jasmine rice producer group will be removed; (xviii) In the conversion period, the farmers cannot sell their produce at the minimum guaranteed farm-gate price set by FLO. The farmers are required to be verified by internal and external inspectors at least once a year during transition periods; (xix) the delivery of organic rice to the rice mills and cost of delivery are under the responsibility of the farmers; (xx) adjustment of production and post-harvesting as well as the pest epidemic must be informed the NGO organization.

These local rules represent codes of practices for on-farm management, and codes of practices for inspections both by the internal inspectors and external ones. The codes of practices for the export-oriented organic Jasmine rice production are: (i) careful on-farm management; (ii) proper documentation; (iii) crop protection strategy; (iv) prohibition of chemical pesticide and insecticide use; (v) application of organic inputs<sup>ii</sup> and methods; (vi) protection of worker rights; (vii) creation of animal welfare; and (viii) protection of the environment. These codes of practices follow the ideals of the fair trade and organic regulations aimed at changing the way by which the export-led rice farming is handled<sup>ii</sup>. Table 3 summarizes impacts of enforcement of the organic and fair trade regulations in the local communities of the Northeast Thailand.

Table 3 Summary of impacts of selected sustainable certifications found in the Northeast Thailand

	<b>Organic</b>	<b>Fair Trade</b>
Premium	Premium paid	High level of premium in current market, some premium always assured
Yields and quality	Short-time impacts on yields may be negative; possibly positive impact on quality	Only indirect impact on yields and quality (through higher income, thus increased possibility of purchasing inputs and hired labor)
Labor inputs	Intensive labor inputs	Higher labor inputs link to attending meeting, transport, coordination, etc.
Other income impacts	Possibility of selling other organic products from the farm; income diversification	Possible indirect impact through establishment of new links with wider trade networks, possibility of selling other Fair Trade products.
Market access, networking	Access to well-established and reliable market	Access to well-established and reliable market, technical assistance from fair trade, importers, development of new networks of contracts among participants.
Extension, credit	Possibly more effective extension from field staff supported by NGOs and some buyers, but limited support from public system	Access to trade financing and traditional credit sources due to the improved financial position of coordinative.



Organizational capacity, community impact	Potential increase in mutual support among farmers to solve management problems in the farms	Increased organizational capacity of participant farmers, access to training strengthened ability of organizations to serve their members, community projects.
Environment	Potential adoption of new farming techniques to improve soil fertility	Very limited or non-existence
Risk, planning capabilities	Risk reduction through reduced external inputs, no mono-cropping, improved soil resilience, planning may improve	Better planning for production and personal and household needs, guaranteed price reduces risk

Source: Author adapts from Giovannucci et. al (2005).

To achieve the ideals of fair trade and organic standards, the on-farm management and labor process are re-arranged according to these codes of practices. As a result, the farmers have to spend more time working in the fields, particularly in the transplanting and harvesting periods. The transplanting and harvesting in organic rice farming depend entirely on manual labors. Moreover, the farming practices must be handled in proper way to be able to meet the contract schedule. Delay of production processes like transplanting and harvesting would forestall the rice crops to be properly grown and generated fruitful yields, thereby affecting both quantity and quality of yields. In other seasons, organic rice farming<sup>ii</sup> still requires a spread of labor more consistently throughout the year. For instance, in the summer time which takes four months, beginning in January to April, most of the rice crops have been harvested and the paddy fields have been left without cropping, due to a lack of water supply. In the summer farmers who are in pursuit of conventional rice farming often seek for non-farm incomes<sup>ii</sup>. But, the famers in pursuit of organic agriculture are not allowed to do so. They have to work on farms to assure that the farms are properly managed to comply with the rules.

Though the farmers have strong intention to follow the regulations, some difficulties met by the farmers can prevent them from the compliance with regulations. In the meeting on 12 March, 2008 the farmers specified emerging difficulties are: (i) unqualified rice seeds cause low productivity; (ii) no compensation is provided to the farmers in the conversion period,<sup>ii</sup> even if the yields are significantly decreased; (iii) conversion to organic rice farming causes increasing production cost and transaction cost; (iv) social conflicts associated with lands and resource management are sometimes occurred between farmers in pursuit of non-organic and organic rice farming; (v) high degree of exposure to risk arising from insect epidemic; (vi) prevention of

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disease, weed control and pest management is difficult and costly; (vii) lack of water supply disallows the rice crops to be grown properly; (viii) animal manure is insufficient; (ix) tension arising from tighter control of more rules; (x) minimum guaranteed rice price is relatively low comparing to non-organic rice price; and (xi) unavailable of organic rice market (participatory observation in the meeting on 12 March, 2008).

The field study confirms the difficulties met by the farmers. The farmers always complain that doing organic rice farming '*gets more tired*' than practicing conventional farming. Such complaint reflects on the fact that organic rice farming requires extended time and intensive labors to work on farms rather than the farmers in pursuit of conventional farming are expected to do. In addition, the farmers in pursuit of export-led organic rice farming have to pay for high opportunity cost. According to the rules, the lands must be used for growing organic crops only. After that, land must be used for growing rotation crops. In this sense, the farmers earn from income derived from selling of organic rice alone, as they are not allowed to use their lands for growing multiple crops.

Generally, the farmers of the Northeast grow cash crops such as cassava after rice cultivation. Cassava tolerates for dried weather and can be grow up even in infertile lands. Moreover, cassava does not require intensive labors, and it takes only a few months to be cultivated. But, cassava requires a certain amount of synthetic chemical fertilizer to allow it to be properly grown. Mixture of organic and non-organic crops is prohibited in organic rice farming. Hence, the farmers in pursuit of organic rice farming are not allowed to use their paddy lands for growing cassava.

Among many difficulties met by the farmers, the transition period which takes three years is hardship for the farmers. The yields are dramatically decreased in the first year of transition to organic rice farming. Some farmers even claim that yields cultivated from organic rice plots in the first year of transition are approximately decreased for a half of total yields cultivated from conventional rice farming, but there is no compensation for such lost. If the farmers expect to be certified as organic, they have to pay for increasing production cost, transaction cost and cost of risk management arising from insect epidemic. Even though the yields generating in the second year of transition are fairly improved, we cannot say that the yields of organic rice farming can compete with the yields of conventional rice farming in the third year of conversion to organic rice farming.

As organic rice farming requires careful attention in overall procedures of pre-production, production and post-production, requirement of intensive labors in organic rice farming is crucial. However, the survey conducted by the author in 2007 finds that average number of family members within the small-sized farms, the medium-sized farms and the large-sized farms are 5 persons, 6 persons and 5 persons respectively. Majority of labors within the small-sized farms works on organic rice farming. In contrast, most labors of the large-sized farms earn from off-farm wage. Additionally, the survey finds that average age of farmers engaged in organic rice farming is 49 years. Since labors working on organic farms are not sufficient, the family farms depend considerably on wage labors to meet the labor demand. Households in pursuit of organic rice farming have to preserve at least one family labor to assure that the cattle are properly handled throughout the year. As manure of water buffalos and cows are prioritized in making of

organic compost, the allocation of time for animal husbandry is important to make sure that animal manure is sufficient.

The demand of intensive manual labors in transplanting and harvesting is vital. This forces the farmers to seek for hired labors to meet the labor demand. It is not uncommon to find that Lao labors are hired to work in many organic rice farms in the recent years. The substitution of Lao labors to the Thai ones is a strategy employed by the Thai farmers to cope with the problem of labor shortage in agricultural sector. This strategy helps the Thai family farms to reduce production cost and to survive in the context that family farms cannot depend on labors within the family farms.

Household incomes derived from non-farm wage and national remittances make possible the capabilities of family farms to hire labors to cope with problem of labor shortage. The survey conducted by the author in 2007 finds that the average household income derived from the remittances is approximately estimated 34,339 baht per year. And, the farmers depend significantly on the remittances to invest in the rice production. However, increasing reliance on hired labors means increasing production cost and uncertainty of organic rice farming system. In the year that seasonal migrant labors from Lao are not allowed to cross the border of Thai-Lao to work on the rice farms. The Thai farmers face more difficulties, since there is high competition in wage labors and the labor cost is high.

As the sustainability of export-oriented organic rice farming depends significantly on hired labors. Key question to be raised here is: how the large-sized, medium-sized and small-sized farmers act in response to such change? Table 4 shows the proportion of large-sized, medium-sized and small-sized farmers engaged in the organic Jasmine rice commodity chain in 2007.

Table 4 Classification of Farm Sizes Engaged in Organic Rice Farming for Export in 2007.

Farm sizes	Number of farm Households	Percentage of farms
Small-sized farmer (own lands 0-15 rai, or 0-2.4 hectares)	250	45.207
Middle-sized farmer (own lands 16-30 rai, or 2.5-4.8 hectares)	208	37.61
Large-sized farmer (own lands larger than 31 rai, or 4.9 hectares)	95	17.179
Total (11302.16 rai, or 1834.48 hectares)	553	100

Source: A Survey conducted by NGO.

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It is correct that the large-sized farmers have more lands and capital which allow them the economies of scale or capacity to access to innovative technologies which helps generating productivity. But, the large-sized farmers depend on high hired labors to work on their farms in order to assure their farms are handled in accordance with the international standards. The more reliance on hired labors creates higher production cost, thereby reducing economy of scale of the large-sized farmers. For this reason, the large-sized farmers have not much willing to engage in the export-oriented organic rice farming.

In contrast, the small-sized farmers have limited lands and capital, but they are the largest group in pursuit of organic rice farming. The small-sized farmers rely mostly on their family labors to work on organic farms. Hence, the shift to organic rice farming means self-squeezing. Yet, the small-sized farmers are more interested in organic rice farming, because they could gain premium rice price from improved lands. For the small-sized farmers, their decisions to engage in organic rice farming do not stem from economic benefit only, though economic benefit is an important factor for their determining decisions to do organic rice farming. The small-sized farmers receive less economic benefit from the rise of niche markets than the large-sized farmers, due to limitation of lands and capital. The ecological and social soundness is important for farmers' decision to do organic agriculture, since organic agriculture helps improving land fertility. Land is fixed cost, improvement of land fertility thus creates security for livelihoods of farmers.

#### **IV. Conclusion**

The market integration has effected on farmer livelihoods, environment and agriculture of the Northeast Thailand. The emergence of export-oriented organic rice production in the Northeast Thailand is a response to emerging niche markets and a response to Thai national agricultural restructuring policy toward the production of high valued food for export. The export-oriented organic Jasmine rice production in the Northeast Thailand is a buyer-driven commodity chain in which large retailers, brand-named merchandisers and trading companies play the pivotal role in setting up decentralized production networks in exporting countries, typically located in the Third World.

The buyer-driven food chains have contributed to agrarian transformation in the Northeast Thailand. The rise of organic Jasmine rice commodity chain has re-arranged the conventional rice commodity chain to incorporate demand of retailers, consumer concerns about safety, healthy, environment and social justice, and forces of abstraction from the international regulations. The organic Jasmine rice commodity chain is a vertically network, because contract is the principle means through which the local farmers are integrated into the niche markets. Contract farming allows retailers and other global actors to control quantity and quality of organic rice produce. Under the contract, livelihood of farmers and farming practices are influenced by the retailers and global actors even if these actors are absence.

The construction of competition of organic Jasmine rice commodity chain relies on the degree to which the farmers, agricultural practices and environment of the Northeast are re-formulated to comply with the demand of retailers, the demand of consumers, and the requirements of international regulations. The socio-economic, ecological and geographical conditions of the Northeast Thailand have contributed to the capabilities of the organic Jasmine

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rice commodity chain. On the one hand, socio-economic and environmental conditions of the Northeast have set a limitation for effects of the green revolution. The ineffective of the green revolution in the Northeast Thailand has made the environment become safety, and a comparative advantage for the conversion to organic rice farming. The environmental condition of the Northeast is benefit for the transition to organic rice farming. The socio-economic conditions of the Northeast have contributed to the construction of flexible specialization. The farmers of the Northeast are typically regarded as flexible specialty labors. They try to diversify livelihoods by combining farm activities, off-farm activities, and non-farm activities for survival and for making well-being.

On the other hand, the challenges of organic Jasmine rice commodity chain depends significantly on the capacities of the farmers to re-arrange time and space to comply with the international regulations. The international regulations are enforced on the ground through the twenty locally-established rules. These rules represent the codes of practices by which on-farm management and inspections are required to re-formulate. These rules reflect on the ideals of fair trade movement and the ideals of organic movement. However, the enforcement of the regulations on the ground has led to some tensions. The transition to organic rice farming requires intensive labors, increasing production cost and transaction cost. These conditions have affected capabilities of the farmers to integrate into the rise of new markets.

The debate about the disappearance/persistence of family farms is on going. Many family farms have been transformed within capitalism, because they have adopted various innovations by mechanization, by diversifying enterprises, and by adopting pluriactivity (Brookfield 2008). Technological innovation also makes possible land productivity and less-contested higher labor production (Kautsky 1899). Key question is ‘in what ways the family farms are made to alive in the post-Fordist world?’ Drawing on the arguments of Brookfield and Kautsky, I argue that persistence of family farms in Thailand in the post-Fordist capitalism is made possible through innovations used by the family farms. Among various innovations, diversification of livelihoods and technological innovation is important means that allow the family farms to survive.

However, capacities of the farmers to integrate into new niche markets and to adopt various innovations vary. The large-sized farmers have more lands and capital, thereby having capacity to hire labors and to access to innovative technologies which helps generating productivity. But, the more reliance on hired labors creates the higher production cost, thereby reducing economy of scale of the large-sized farmers. For this reason, the large-sized farmers have not much willing to engage in the export-oriented organic rice farming.

In contrast, the small-sized farmers have limited lands and capital, but they are the largest group in pursuit of organic rice farming. The shift to organic rice farming means self-squeezing, but they are more interested in organic rice farming, because they could gain premium rice price from improved lands. Though the small-sized farmers receive less economic benefit from the rise of niche markets than the large-sized farmers, they prefer practicing organic agriculture, because organic agriculture helps improving land fertility and creating livelihoods security.

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## **Rice Straw Burning in Central Luzon, Philippines: Assessment of Farmers' Practices and Perceptions of Effects<sup>ii</sup>**

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### **Abstract**

A survey of 171 respondents was conducted in two villages, Matingkis and Sto. Rosario in Nueva Ecija, Philippines in June 2009. The objectives of the survey were to determine the practice of rice straw burning and other uses of rice straw, estimate the amount of rice straw burned and understand farmers' perceptions on the effects of burning rice straw on the environment.

Around 67% and 58% of farmer respondents burned rice straw in dry season 2008 in wet season 2009, respectively. Of the total amount of rice straw produced, 52% was burned during the dry season of 2009 and 45% during the wet season of 2008.

Farmers perceived that burning rice straw has positive effects on rice farming. The positive effects were ease in land preparation and improvement in soil fertility. Farmers' own health and the health of the community were perceived to be not affected by burning of rice straw due to the distance of the field from their home. Hence, they considered themselves healthy despite the continuous practice of burning rice straw. The practice of burning rice straw did not cause any breakdown of social relationships in the neighborhood, although there were some minor complaints due to excessive smoke from the nearby fields. Some farmers perceived that burning rice straw has no negative effects on the climate and while others indicated uncertainties on the effects of the traditional practice of burning rice straw.

**Key words: Open burning, rice straw, perception, Philippines**

### **Introduction**

Rice straw is one of the main by-products in rice production. The amount of rice straw generated every rice cropping is equivalent to the rice production (IRRI Knowledge Bank, 2003). It is a potential source of income for farmers to improve their income.

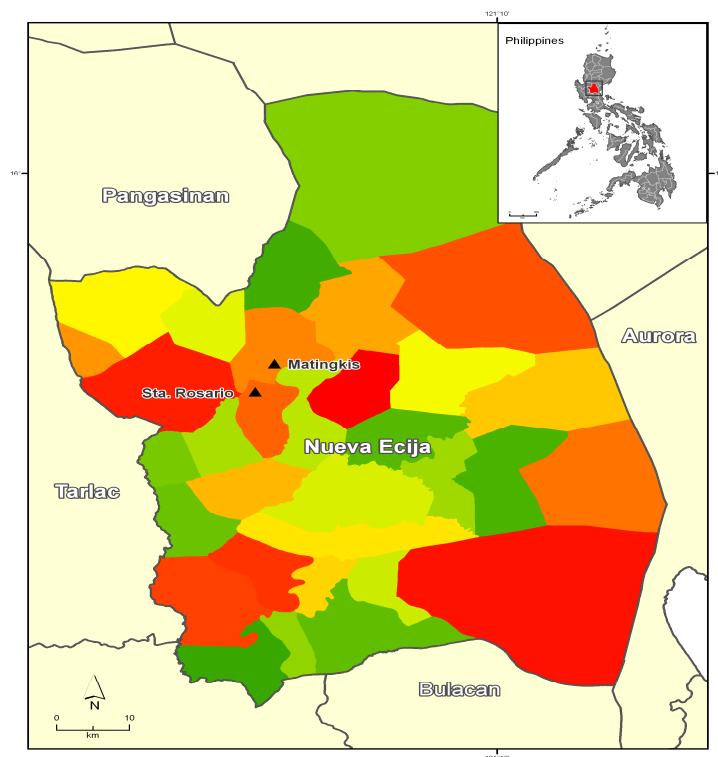
However, farmers perceived that using rice straw is difficult due to lack of manpower, difficult to collect, lack of transportation and time consuming (Diaz et al, 1994). The uses of rice straw in many rice production countries are limited. Burning rice straw is most common practice in many rice production countries.

In order to be find more sustainable alternative uses of rice straw, this study conducted a survey on rice straw uses with the following objectives: 1) to determine the practice of rice straw burning and other uses of rice straw; 2) to estimate the amount of straw burned; and 3) to understand farmers' perceptions on the effects of burning rice straw in the environment.

A survey was conducted in two villages (barangays), namely, Matingkis and Santo Rosario in Nueva Ecija, Central Luzon, Philippines in June 2009. A total of 171 farmer- respondents were interviewed using a structured questionnaire. The questionnaire was composed of three parts: socio-demographic information and cropping pattern of the rice based system; uses of rice straw and rice straw burning; and farmers' perception of the effects of rice straw burning.

### *The study site*

Nueva Ecija province is a land lock province of the Central Luzon, Philippines. Nearly half (47.8 percent) of the region's total area planted with palay (paddy) is in Nueva Ecija (249.9 thousand hectares) (NSO, 2004).



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Figure 1 shows the locations of two survey barangays. Matinkis is a village in the southern part of the city of Muñoz, Nueva Ecija while Santo Rosario is a village in the northern part of Santo Domingo municipality also in Nueva Ecija.

## Results and Discussions

This section consists of three parts: 1) sociodemographic information and cropping pattern of the rice-based system; 2) the uses of rice straw and rice straw burning; and 3) farmers' perception of the effects of rice straw burning.

### Sociodemographic information

The farmer-respondents were the one directly responsible in rice farming. About 92% of the respondents are male and their average age is 51 years old. Almost one third (29)% of them reached elementary level and graduate; 44% high school level and high school graduate and 27% with college and vocational course.

Table 1 presents the characteristics of the survey household. The average size of the household was 4 to 5 members and about 47% of the household was female. The working age group (15-65 years old) contributed to 69% of the surveyed household. The educational attainment of this working group shows that 15.5% had elementary education, 43.6% high school education and 40.8% entered college and vocational training. There was only 0.2% of this group had no education.

**Table 1. Characteristics of the survey household in Nueva Ecija, Philippines**

Characteristics of survey household	Matinkis (n= 70)		Santo Rosario (n = 101)		Total (n = 171)	
	No.	%	No.	%	No.	%
Household size (persons)	3.84		4.47		4.21	*
Sex						
Male	147	54.4	232	51.6	379	52.6
Female	123	45.6	218	48.4	341	47.4
Age						
<15 years old	70	25.9	104	23.1	174	24.2
15-65 years old	183	68.8	317	70.4	500	69.4
>65 years old	17	6.3	29	6.5	46	6.4

Educational attending of  
working group (15-65 years  
old)

- No education	1	0.6	0	-	1	0.2
- Elementary school (grade 1- grade 6)	24	13.2	53	16.8	77	15.5
- High school (grade 7 – grade 10)	87	47.8	130	41.1	217	43.6
- College	63	34.6	126	39.9	189	38.0
- Vocational training	7	3.8	7	2.2	14	2.8

*Source: Survey, June 2009*

### Cropping pattern and rice production characteristics

Table 2 presents the characteristics of cropping pattern and rice production.

**Table 2. Characteristics of cropping pattern and rice production in Nueva Ecija,  
Philippines**

Characteristics of cropping pattern and rice production	Matingkis			Santo Rosario			Total			
	N	Mean	SD	N	Mean	SD	N	Mean	SD	
Farm size (ha)										
Dry season 2009	70	0.87	0.82	101	1.91	1.57	171	1.49	1.41	*
Wet season 2008	70	0.91	0.84	101	1.99	1.74	171	1.55	1.53	*
Rice area (ha)										
Dry season 2009	64	0.89	0.85	101	1.92	1.57	165	1.52	1.42	*
Wet season 2008	70	0.91	0.84	101	1.99	1.74	171	1.55	1.53	*
Other crop area (ha)										
Dry season 2009	14	0.28	0.21	0	-	-	14	0.28	0.21	
Wet season 2008	0	-	-	0	-	-	0	-	-	
Own farm (%)										

Dry season 2009		90.2			77.1			80.2			
Wet season 2008		88.5			71.7			75.6			
Average rice yield (tons/ha)											
Dry season 2009		64	6.4	1.3	101	6.1	1.0	165	6.2	1.1	ns
Wet season 2008		70	5.2	1.3	101	4.7	1.0	171	4.9	1.2	*
			*			*			*		

*Source: Survey, June 2009*

*Note: \*: significant at 5%, ns: not significant at 5%; SD: Standard Deviation*

Rice production is the main farming activity of the households in both Matingkis and Santo Rosario. Besides rice farming, in Matingkis farmers grow onion, and vegetables such as chili, bitter guord, etc. Majority of the farmers plant onion and vegetables during the dry season. The average farm size in Santo Rosario (1.57-1.74 ha/household) is higher than those of Matingkis (0.87-0.91 ha/household). The owner tenure occupied 75.6% in dry season and 80.0% in wet season.

Both survey areas are irrigated lowland areas with two rice crops per year (Dry season from January to April and Wet season from June to October). There are 1.5-2 months fallow period between the two seasons. Some farmers grows vegetables starting from November in one or two months then start the dry season rice crop in late January or start the second crop of vegetables in Matingkis.

Two major types of rice seed varieties are used namely: inbred and hybrid. For the inbred varieties, the seeds come from own stock, exchange with other farmers. Hybrid seeds are obtained from seed growers, the Department of Agriculture and PhilRice (Philippines Rice Research Institute). Transplanting is the most common method of crop establishment. Only a few farmers applied direct seeding. Farmers transplant the seedlings about 20-30 days old with the amount of 40-200 kg/ha.

The paddy yield of the dry season 2009 was higher than the wet season 2008 in both Matingkis and Santo Rosario. There was no significantly difference between the average paddy yield in Matingkis and Sato Rosario in the dry season 2009. In the wet season 2008 the paddy yield (5.2 tons/ha) in Matingkis was significantly higher than in Santo Rosario (4.7 tons/ha).

### **Rice straw uses and rice burning**

The most common method of burning rice straw is “dump burning”. After threshing, rice straw is left in the field in pile. For one hectare of rice field, there are about 10 to 12 piles of rice straw.

In the local dialect, a pile is referred to as “*tumpok*.” Burning of straw is done by putting fire (with the use of match or lighter) on either the side of each pile or at the lower portion of the pile. Soon, the fire will spread easily, especially if there is wind until the whole pile of straw is burned completely. This procedure of burning straw is called “*dump burning*,” since burning is done on every pile of the straw. “Dump burning” is practiced during the dry and wet seasons. There is no difference in the method of burning between the dry and wet seasons. If rain comes especially in the wet season, farmers wait until the rice straw becomes dry before they burn the rice straw.

There is another way of burning rice straw, called “scatter burning”. When farmers do not burn rice straw right away after threshing, they often scatter the straw at the edge of the field and the dike in between paddy field and burn after threshing from 10-20 days, sometimes up to 30 days. The purpose of scatter burning is to let straw burn easier, especially in the wet season. The time of burning rice straw from 9:00 AM to 3:00 PM aims to take the advantage of the sun to dry straw before burning.

### *History of rice straw burning*

In order to investigate the history of rice straw burning in the study sites, the respondents were asked with a question “Have you ever burned rice straw?” Overall, about 87% of the farming households burned rice straw (**Table 3**). The proportion of farmers who burned rice straw in Santo Rosario was higher than in Matingkis.

**Table 3. No. of household burned rice straw in Nueva Ecija, Philippines**

Have you ever burned rice straw?	Matingkis		Santo Rosario		Total	
	No. of HH	%	No. of HH	%	No. of HH	%
Yes	55	78.6	94	93.1	149	87.1
No	15	21.4	7	6.9	22	12.9
<b>Total</b>	70	100.0	101	100.0	171	100.0

*Source: Survey, June 2009*

Burning rice straw has been a common practice for a long time. Majority of the farmers indicate that they have been burning their field even since they started farming. In the case of farmers in Santo Rosario, they reported that they have been burning rice straw before 1950 (**Table 4**).

However, the practice of burning rice straw has reduced substantially due to the information that farmers received from training and mass media about the benefits of not burning rice straw. As we can see in Tables 3, 5 and 6 there was a decrease in the number of farmer burning rice straw. Unlike before, they tend to leave straw in the field instead of burning their field.

**Table 4. History of rice straw burning, Nueva Ecija, Philippines**

Year	Matingkis		Santo Rosario		Total	
	No.	%	No.	%	No.	%
Burned since farming, cannot remember exactly	1	1.8	19	20.2	20	13.4
before-1950	0	-	4	4.3	4	2.7
1951-1960	4	7.3	9	9.6	13	8.7
1961-1970	3	5.5	14	14.9	17	11.4
1971-1980	12	21.8	12	12.8	24	16.1
1981-1990	12	21.8	18	19.1	30	20.1
1991-2000	12	21.8	13	13.8	25	16.8
2001-2005	8	14.5	0	-	8	5.4
2006-today	3	5.5	5	5.3	8	5.4
<b>Total</b>	<b>55</b>	<b>100.0</b>	<b>94</b>	<b>100.0</b>	<b>149</b>	<b>100.0</b>

Source: Survey, June 2009

**Rice straw uses and rice straw burning in 2008-2009 in Nueva Ecija, Philippines**

**Table 5. Rice straw uses\* by household in dry season 2009, Nueva Ecija, Philippines**

Rice straw uses	Matingkis (n=64)		Santo Rosario (n=101)		Total (n=165)	
	No. of HH	%	No. of HH	%	No. of HH	%
Burning	42	65.6	69	68.3	111	67.3
Feeding cattle	11	17.2	30	29.7	41	24.8
Feeding their own cattle	8	12.5	21	20.8	29	17.6
Give to others for feeding	3	4.7	9	8.9	12	7.3
Mulching	7	10.9	-	-	7	4.2
Own mulching	6	9.4	-	-	6	3.6

Give to others for mulching	1	1.6			1	0.6
Leave in the field	29	45.3	40	39.6	69	41.8

*Source: Survey, June 2009*

\* *multiple responses*

Burning rice straw or open burning is the most common practice of using rice straw in the field. In dry season 2009, 67 % farmers burned rice straw in two study sites (**Table 5**) and 58 % household burned rice straw in wet season 2008 (**Table 6**). Burning rice straw is a source of air pollution. When burning rice straw, about 74 - 100% C will be lost (236-391 kg C ton straw<sup>-1</sup>) in form of CO<sub>2</sub> and CO after burning (Truc, 2005). Miura and Kanno (1997) reported that the percentages of CH<sub>4</sub> - C and N<sub>2</sub>O - N in total C and N in rice straw were in the range of 0.43-0.90 and 1.16-1.50%, respectively.

Aside from burning, rice straw, it is commonly used as feed for cattle. Each household has one to three cattle and the local buffalo, which is called “carabao”, is used for land preparation and hauling paddy from the field to their house. To store rice straw for use as animal feed the whole year round, they make a pile, called “mandala”. The percentage of farmers who used rice straw for feeding animals was about 22-25% in wet and dry season 2008-2009 (**Table 5 and 6**). Using rice straw to feed cattle has low nutrient content and difficult for cattle to digest (Drake et al 2002). It also has a possibility that this alternative will release high amount of greenhouse gases, especially methane (Wassmann and Vlek, 2004).

In Matingkis, farmers use rice straw to mulch onion and other vegetables. Straw and stubbles were cut and used to cover the surface of soil to avoid weed growth and keep moisture. More farmers who used rice straw for mulching in wet season 2008 (41%) than in dry season 2009 (11%) because more farmers grow onion and vegetables during dry season 2009. Mulching for upland crop is a promising alternative use of rice straw for mitigating greenhouse gases (Bijay-Singh et al, 2008).

Leaving rice straw in the field in both dry and wet seasons become more popular when farmers reduce their practice of burning and do not have any other alternative uses of rice straw. The advantage of leaving straw in the field is that it provides additional organic matter and nutrient in the field. The rest of the period between two rice crops is from one and a half month to two months, therefore, it gives sufficient time for the straw to be decomposed. However, it created difficulties in plowing the field.

In dry season 2009, 42% of all farmer-respondents left rice straw in the field while during the wet season of 2008, 50% farmers left rice straw to decompose in the field. Rice straw left in the field after harvest (e.i. one month after harvest) emits both CO<sub>2</sub> and slight increase imperfect combustible gases of CO and CH<sub>4</sub> during burning. Leaving rice straw in the field in wet season creates the condition of anaerobic straw decomposition which releases high emissions of methane (CH<sub>4</sub>) and causes immobilization of N and lead to N deficiency (Yadvinder-Singh et al., 2004).



**Table 6. Rice straw uses\* by farming household in wet season 2008, Nueva Ecija, Philippines**

Rice straw uses	Matingkis (n=70)		Santo Rosario (n=101)		Total (n=171)	
	No. of HH	%	No. of HH	%	No. of HH	%
Burning	32	45.7	67	66.3	99	57.9
Feeding cattle	13	18.6	25	24.8	38	22.2
Feeding their own cattle	9	12.9	19	18.8	28	16.4
Give to others for feeding	4	5.7	6	5.8	10	5.8
Mulching	29	41.4		-	29	17.0
Own mulching	25	35.7		-	25	14.6
Give to others for mulching	4	5.7		-	4	2.3
Leave in the field	34	48.6	51	50.5	85	49.7

*Source: Survey, June 2009*

\* multiple responses

In dry season 2009 about 67% farmers burned their straw (40% burned all and 27% burned partly their field) and 33% farmers did not burn their field (**Table 7**). On the other hand, in wet season 2008 about 58% farmers burned their straw (26% burned all and 32% burned partly) and 42% did not burn their field (**Table 8**).

**Table 7. Number of farming household who burned rice straw in dry season, 2009, Nueva Ecija, Philippines**

Characteristics of burning	Matingkis		Santo Rosario		Total	
	No. of HH	%	No. of HH	%	No. of HH	%
Burned rice straw	42	65.6	69	68.3	111	67.3
Burned all	27	42.2	39	38.6	66	40.0
Burned partly	15	23.4	30	29.7	45	27.3
Did not burn	22	34.4	32	31.7	54	32.7

<b>Total</b>	<b>64</b>	<b>100.0</b>	<b>101</b>	<b>100.0</b>	<b>165</b>	<b>100.0</b>
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*Source: Survey, June 2009*

**Table 8. Number of farming household who burned rice straw in wet season, 2008, Nueva Ecija, Philippines**

<b>Characteristics of burning</b>	<b>Matingkis</b>		<b>Santo Rosario</b>		<b>Total</b>	
	<b>No. of HH</b>	<b>%</b>	<b>No. of HH</b>	<b>%</b>	<b>No. of HH</b>	<b>%</b>
Burned rice straw	32	45.7	67	66.3	99	57.9
Burned all	10	14.3	34	33.7	44	25.7
Burned partly	22	31.4	33	32.7	55	32.2
Did not burn	38	54.3	34	33.7	72	42.1
<b>Total</b>	<b>70</b>	<b>100.0</b>	<b>101</b>	<b>100.0</b>	<b>171</b>	<b>100.0</b>

*Source: Survey, June 2009*

Table 9 shows the estimated amount of rice straw generated in two wet and dry season 2008-2009. The amount of straw was calculated by the ratio of rice : straw = 1 : 1 (IRRI Knowledge Bank, 2003). In dry season 2009 the total amount of rice straw was about 1,577.3 tons from 250.7 ha of 164 households and in wet season 1,290.2 tons of straw from 265.6 ha of 171 households. Of the amount of rice straw produced in wet season of 2008, 45% was burned compared to the 52% burned during the dry season of 2009 (Table 10).

**Table 9. Amount of rice straw produced in Nueva Ecija, Philippines, 2008-2009**

<b>Rice straw uses</b>	<b>Matingkis</b>		<b>Santo Rosario</b>		<b>Total</b>	
	<b>Area (ha)</b>	<b>Amount of straw (tons)</b>	<b>Area (ha)</b>	<b>Amount of straw (tons)</b>	<b>Area (ha)</b>	<b>Amount of straw (tons)</b>
Dry season 2009	57.1	372.9	193.6	1,204.4	250.7	1,577.3
Wet season 2008	64.3	331.8	201.3	958.4	265.6	1,290.2
<b>Total</b>	<b>121.4</b>	<b>704.7</b>	<b>394.9</b>	<b>2,162.8</b>	<b>516.3</b>	<b>2,867.5</b>

*Source: Survey, June 2009*

*Note: Amount of rice straw = total rice production (ratio rice: straw = 1:1) (IRRI Knowledge Bank, 2003)*

**Table 10. Amount of rice straw burned in Nueva Ecija 2008-2009**

Rice straw uses	Matingkis		Santo Rosario		Total	
	Amount (tons)	% straw burned	Amount (tons)	% straw burned	Amount (tons)	% straw burned
Dry season 2009	228.9	61.4	591.4	49.1	820.3	52.0
Wet season 2008	106.5	32.1	479.2	50.0	585.7	45.4
<b>Total</b>	<b>335.4</b>	<b>47.6</b>	<b>1,070.6</b>	<b>49.5</b>	<b>1,406.0</b>	<b>49.0</b>

*Source: Survey, June 2009*

*Note: % straw burned is calculated by % burned in each household \* amount straw*

### ***Reasons for burning rice straw***

There were several reasons that explain why farmers need to burn their field after their harvest. The most agreed reason was to be ready to prepare land for the next crop. Farmers also reported that using rice straw was laborious in collecting and hauling rice straw. It is also difficult to decompose, so burning rice straw is the easiest way to dispose rice straw. Lack of alternative uses of rice straw also leads more farmers burned their rice straw. When more farmers are informed about the effects of rice straw burning and there will be more strict regulations, farmers will shift from open burning to leave straw in the field.

### **Farmers' perception of rice straw burning effects**

In order to determine farmers' perception on the effects of burning rice straw, they were asked the effects of rice straw burning on their cropping, the health of the farmer respondent and community health, soil, climate and environment in general.

### ***Effects on cropping or agronomic effects***

About 49% of the respondents was not aware on the effects of rice straw burning on their crops. A few (15%) of the respondents opined that burning rice straw helps to clean the field from weeds, insects and rats (**Table 11**). Moreover, it is easy to plow and it provided additional nutrient to the soil.

**Table 11. Farmers' perception of the effects of rice straw burning in Nueva Ecija, 2008-2009**

Effects of rice burning	Matingkis (n=70)			Santo Rosario (n=101)			Total (n=171)		
	With effects	With out effect	Don't know	With effects	With out effect	Don't know	With effects	With out effect	Don't know
	In percent			In percent			In percent		
- Cropping	22.9	31.4	45.7	9.9	39.6	50.5	15.2	36.3	48.5
- Own health*	27.1	35.7	37.2	22.8	62.4	14.8	24.6	51.5	23.9
- Health of the community	37.1	20.0	42.9	13.9	64.4	21.7	23.4	46.2	30.4
- Soil	34.3	24.3	41.4	53.5	28.7	17.8	45.6	26.9	27.5
- Climate	22.9	18.6	58.5	21.8	32.7	45.5	22.2	26.9	50.9
- Environment	48.6	18.6	32.8	35.6	33.7	30.7	40.9	27.5	31.6

*Source: survey, June 2009*

*Note: (\*): refers to the health of the farmer respondent*

### ***Effects on human health***

Respondents were asked about their perception on their own health and also on the community health due to burning of their field. Approximately 25% mentioned that burning rice straw affected their health due to the smoke that can cause cough, red eyes, suffocate, affects their lungs. However, 46% respondents said that burning rice straw does not affect on their health because they could leave the field any time to avoid the smoke while burning and the residential areas were also far from the rice fields. They also don't know exactly the impact of burning rice straw on their own health as well as their community health (**Table 11**).

There are several studies about air pollution and the impacts of rice straw burning on the human health, especially on children (Solomon et al 2000, 2001, 2002; Gadde et al 2009; and Lai et al 2009). The government of the Philippines banned burning rice straw since 2000 through ecological solid waste management. However, the local government are reluctant to implement it and do not penalize those who continue to burn their fields.

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### ***Effects on soil***

Less than half (46%) of the farmer respondents perceived that burning rice straw is good for the soil due to the ashes produced after burning (**Table 11**). However, there are farmers who mentioned about the problem that the soil become compact and harder after burning rice straw.

In reality, burning results in the loss of almost nutrients in the rice straw i.e., nearly all of the N, 25% of P, 50% of S and 20% of K present in straw are lost due to burning (Dobermann and Fairhurst, 2000) and 99.86% N, 19% P and 44% K in rice straw (Truc, 2005). Besides, when burning rice straw, 74 - 100% C will be lost (236-391 kg C ton straw<sup>-1</sup>) in the form of CO<sub>2</sub> and CO after burning (Truc, 2005). This is an important C source that could be stored in soil.

### ***Effects on the climate and environment***

Farmers perceived that burning rice straw could cause pollution to the environment due to the dust and smoke emitted from burning. It made the environment become hotter. However, their fields were far from the residential areas and can not affect the community. They also mentioned that the ozone layer become thinner.

### ***Farmers' opinion about the alternative uses of rice straw in the event that they will no longer be allow to burn rice straw***

Farmers expressed their willingness to use rice straw as fertilizers by scattering the straw and feeds for livestock, give to farmers who have onions and vegetables, produce mushroom as alternative use of rice straw in the event that they will no longer be allowed to burn rice straw by the local authority.

## **Conclusions and recommendations**

Burning rice straw or open field burning is the most common practice of rice straw uses in Nueva Ecija Philippines. 67% and 58% of the households burned rice straw in dry season 2009 in wet season 2008 in Nueva Ecija, Philippines, respectively. Of the total amount of rice straw produced, 52% was burned during the dry season of 2009 and 45% during the wet season of 2008. Aside from burning, they used straw for feeding animals, mulching onion and leaving straw in the field. There were still limited alternative uses of rice straw in the two study areas.

Farmers perceived the effects of rice straw burning to their crops, their health, soil and local environment. However, they still avoid to effects of air pollution in burning and perceived wrongly that burning provides nutrient to their fields.

The trend of leaving straw in the field especially in the rainy season might contribute to methane emission.

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To reduce the practice of rice straw burning, we suggest that the government a) provides information to the farmers and the general public about (i) the benefits of rice straw, (ii) the negative impacts of rice straw burning, and (iii) more alternative uses of rice straw to improve farmer's livelihood, and at the same time, minimize greenhouse gases emissions; and b) enforce the regulations of rice straw burning.

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## **Economic and Efficiency Analysis of Selected Farming Patterns: The Case of Irrigated Systems in the Mekong River Delta, Vietnam.**

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### **ABSTRACT**

The objective of this study is to measure the technical efficiency (TE), allocative efficiency (AE) and cost efficiency (CE) as well as the profitability for farmers who cultivate the crops either following the continuous rice patterns or applying the crop rotation patterns in the non-flooded and flooded areas of The Mekong River Delta (MRD), Vietnam. The non-flooded areas are located within irrigated boundary systems and the flooded areas are located outside these systems. Along with this, the author tries to make the conclusions from the findings more valuable by computation of scale efficiency from which we can infer whether the farm households are operating at the technically optimal productive scale (TOPS) or not. Besides, the determinants of the household income and the productive efficiencies are identified in the study.

With regard to the profitability and the determinants of farm household income, the calculated results indicate that mean net benefit is greater for farmers applying the crop rotation patterns in comparison with farmers following the continuous rice patterns in the non-flooded and the same for farmers with both patterns in the flooded areas. The household income is found to be impacted by the productive factors such as land, labor, seed, fertilizer and pesticide.

Related to the production efficiency, the measured results show that the crop rotation farmers are more efficient in terms of technical, cost and scale efficiency than the continuous rice farmers and vice versa for allocative efficiency, for the case of non-flooded areas. Similarly, the mean efficiency score is greater with respect to technical, allocative and cost efficiency for farmers applying the crop rotation pattern in compare with farmers following the continuous rice pattern.

For the factors influencing efficiencies, the case of non-flooded areas, the estimated results show that although there are some differences in determinants of each component of total productivity, but sex, age, education, share of female labor and farming pattern are found to be the main factors that can make changes in most of the components such as technical, allocative and scale efficiency. For the case of flooded areas, all components of total productivity in terms of the technical, allocative, cost and scale efficiency are impacted by the changes of sex, age and education.

**Key words:** technical efficiency, allocative efficiency, scale efficiency, data envelopment analysis, continuous rice pattern, crop rotation pattern.



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## 1. INTRODUCTION

Vietnam is an agricultural country. About 80% of the population living in the rural area and more than 74 % of the workforce are employed in agricultural sectors. Agricultural products dominate exports and home consumption. They contribute a significant percentage to Vietnam's economy growth rate. The Mekong River Delta (MRD) region<sup>ii</sup> which is located in the south of Vietnam with its area of 4 million hectares covers about 12% of the country's total area. It has a big potential for developing agriculture. Particularly, the MRD contributes about 55% to 60% of the nation-wide agricultural production and about 65% of exported agricultural products. Of which, about 60% of Vietnam's total rice production and 65% of rice exports are provided from this region (Statistical Yearbook, 2006).

In recent years, farmers in the MRD wanted to shift from a *continuous rice pattern* to a *crop rotation pattern*<sup>ii</sup> in response to encouraged policy of the government and in order to be able to increase their profit because almost monoculture-rice farmers in fact get low productivity, and subsequent to a low income. However, they also have some difficulties in this transition due to some reasons. The first reason is that the agricultural sector tends to be small-scale to use traditional technology and extension services which are inadequately funded as well as a shortage and poor distribution of agricultural inputs. The second one is the low level of technical efficiency and the lack of appropriate knowledge in the shift of cultivation from traditional rice crops (called continuous rice patterns) to crop rotation patterns, which farmers tendentiously wanted to apply in recent years.

In addition, some provinces such as Long An, Tien Giang, Vinh Long, Dong Thap, Can Tho, and An Giang which locate along two large rivers namely Tien and Hau which were derived from Tay Tang highland (China) flowing through Lao, Thailand, Myanmar, Cambodia, and Viet Nam before running into the Pacific Ocean. Every year from September to November, the levels of water of these rivers are risen about from 1 to 2 meters higher than the normal levels in a year. This leads to some areas of these provinces to be under water levels (these areas are called flooded areas). Such characteristics make farm households in those areas so difficult in their production during flooded time period.

The central and local governments have issued some policies to prevent impacts of floods on agricultural production by building boundary-irrigated systems (called prevented-flood dikes) in the regularly flooded areas. The effects of these policies, however, need to be evaluated in terms of profit and production efficiency of farm households who live within boundary irrigated systems in comparison with those of farm households who live outside the systems.

Farmers in the MRD are facing the chance between traditional rice and crop rotation pattern and the government is considering whether continuing to build boundary irrigated systems or not. The profit and production efficiency comparative analyses of the continuous rice and crop rotation patterns within and outside boundary irrigated systems therefore seem appropriate and useful.

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## 2. DATA

The heads of farm households were personally interviewed by trained interviewers who are junior staff members of the School of Economics and Business Administration of Can Tho University under the supervision of the author.

Primary data were collected with the use of interview schedules designed to collect information on quantities and prices of inputs and outputs as well as socio-economic/ environmental factors of the selected farm households using multi-stage random sampling techniques. Prior to actual data collecting, the permissions to conduct the interview in the sample villages were secured from the municipal and local executives. Such permissions were necessary to establish good relationship and cooperation with the respondents.

The surveys covered four provinces in the MRD, of which An Giang and Long An selected from the flooded areas, Tien Giang and Tra Vinh selected from the non-flooded areas of the MRD. The choice of the provinces was due to the fact that they have large areas of agricultural production land, together with a large number of mono-rice and crop-rotation farmers.

For each of the selected provinces, one district was then randomly chosen except An Giang province in which two districts were selected, giving a total of five selected districts namely Moc Hoa (Long An province), Cay Lay (Tien Giang province), Cau Ke (Tra Vinh province), Cho Moi and Tri Ton districts (An Giang province).

In the last stage, as it is impossible to examine all farmers, the samples were drawn to select farmer representatives from populations of farmers who followed continuous rice patterns and adapted crop rotation patterns in the 2004/2005 agricultural year. Through this sampling scheme, two groups of farmers were randomly selected for each of the five districts. Of these two groups, one consists of 60 farmers who followed the continuous rice pattern and the other consists of 60 farmers who applied the crop rotation pattern. The surveys gave a total of 600 selected farmers, of which 300 farmers for continuous rice patterns and the other 300 for crop rotation patterns. However, the analyses were carried out using the responses from 262 and 242 farmers respectively for the continuous rice and crop rotation patterns. The remaining farmers were rejected due to inconsistencies in their responses.

Although the surveys were randomly conducted, in order to avoid any bias in the analyses, households were only selected if they used the same agricultural land areas in their production of crops throughout the year. This was consistent for both continuous rice and crop rotation patterns.

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### 3. METHODOLOGY

#### 3.1. Calculation of Scale Efficiency using the Constant and Variable Returns to Scale - Data Envelopment Analysis (CRS and VRS-DEA Models)

Data envelopment analysis (DEA) is another approach to frontier estimation, which is based on the mathematical programming method instead of econometric method to measure the production efficiency of a firm. DEA was first proposed by Farrell (1957), then by Boles (1966), Shephard (1970), and Afriat (1972). However, the idea was quite strange so it was not received with much attention. This lasted until the publication of the comprehensive papers of Charnes et al. in 1978, in which the DEA model strongly focused on the input-oriented approach (i.e. firm has more controls on inputs than on outputs) and relied on the constant returns to scale (CRS) circumstance. This model is called the CCR model and also known as the CRS-DEA model.

In recent decades, many studies have decomposed the technical efficiency (TE) scores obtained from a CRS- DEA model into two components, one due to “*pure*” *technical efficiency* and one due to *scale efficiency* (SE). The TE reflects the ability of a firm to produce maximal output from a given set of inputs together with available production techniques and the best use of experience, infrastructure and policy supports, whereas a SE measure can be used to indicate the amount by which productivity can be increased by moving to the *technically optimal production scale* (TOPS).

To measure SE in DEA the additional DEA model under the variable returns to scale (VRS) situation must be specified because SE is measured by the ratio of  $TE^{CRS}$  (TE under CRS) to  $TE^{VRS}$  (TE under VRS). This model was developed by several authors among which Banker et al. in 1984. This model allowed us to measure the efficiency of a firm which operates with the VRS in both input and output-oriented situation. This model is called the BCC model and also known as the VRS-DEA model. Many more papers have been published since then such as Lovell (1993), Battese and Coelli (1998) and Coelli et al. (2005).

Follow Lovell (1993), the evaluation of the efficiency of a DMU is based on a comparison between observed and optimal values of its output and input. The comparison can take the form of *the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output*. In these ratios the optimum is defined in terms of production possibilities, and efficiency is technical. The former ratio corresponds with the *output oriented* approach while the later is appropriate for the *input oriented* approach.

The ratio is easy to calculate if the unit uses a single input to produce a single given output. However, it is no longer simple when the unit uses several inputs  $\{x_j, j = (1, 2, \dots, m)\}$  to produce a given output. In which case, the inputs must be aggregated, so that the efficiency remains the scalar (*say*  $\lambda$ ). Therefore, for a particular unit  $p \{ (p \in N, N = (1, 2, \dots, n)) \}$  under input orientation, the ratio is written as follows:

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$$\left( \frac{\sum_{j=1}^m \lambda_i x_{ji}}{\sum_{j=1}^m x_{jp}} \right), \quad i = 1, 2, \dots, n)$$

In economic view, this ratio is to be minimized and forms the objective function for that unit. Generally, consider the situation with a sample of  $N$  decision making units (DMUs),  $\{N=(1, 2, \dots, n)\}$ , each of the DMUs produces  $S$  outputs  $\{S=(1, 2, \dots, s)\}$  by using  $M$  different inputs  $\{M=(1, 2, \dots, m)\}$ . Following Lovell (1993), Charnes et al. (1994) and Coelli et al. (1998 & 2005) together with the references to the empirical studies discussed in the preceding chapter III of Literature review (e.g., C. Paul et al. (2003), P. Fandel (2003), M. Oren et al. (2006) and H. Linh (2006)), the relative TE for the particular DMUp ( $p \in N$ ) under the CRS circumstance and input oriented approach, is measured by calculating the optimal weights ( $\lambda_i^*$ ) from solving the following linear programming (LP) problem<sup>ii</sup>:

$$\min_{\theta_p, \lambda} \left( \frac{\sum_{j=1}^m \lambda x_{ji}}{\sum_{j=1}^m x_{jp}} \right) = \theta_p$$

subject to:

$$-q_{rp} + \sum_{i=1}^n \lambda q_{ri} \geq 0, \quad r = 1, \dots, s$$

$$\theta_p x_{jp} - \sum_{i=1}^n \lambda x_{ji} \geq 0, \quad j = 1, \dots, m$$

$$\lambda_i \geq 0, \quad i = 1, 2, \dots, p, \dots, n$$

where:  $i$  = parameter presented number of DMUs ( $i = 1, 2, \dots, p, \dots, n$ );

$j$  = parameter presented number of inputs ( $j = 1, 2, \dots, m$ );

$r$  = parameter presented number of outputs ( $r = 1, 2, \dots, s$ );

$\sum_{j=1}^m \lambda x_{ji}$  is the minimum feasible/ potential input quantity *{determined by a weighted combination (i.e. the  $\lambda_i$ ) of input of all DMUi}* that could be used to produce a given output level;

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$\sum_{j=1}^m x_{jp}$  is the observed input quantity using by the DMUp to produce a given output level. Note that this observed input is fixed;

$\theta_p = \frac{\sum_{j=1}^m \lambda x_{ji}}{\sum_{j=1}^m x_{jp}}$ , is the ratio of the minimum feasible input to the observed input of DMUp required to produce a given output level. This ratio is considered as the efficiency score of DMUp and has a value  $0 \leq \theta \leq 1$ . The DMUp is more efficient corresponding to value of  $\theta$  is closer to the unity;

$\lambda_i$  = an  $N \times 1$  vector of weights which defines the linear combination of the DMUi and subsequently creating a *projected/ virtual point* of the DMUp lying on the frontier. This projected point is the fully efficient potential point produced by the radially contraction of the input vector with unchanged output level;

$q_{rp}$  = amount of output  $r$  produced by the DMUp;

$x_{jp}$  = amount of input  $j$  utilized by the DMUp;

$q_{ri}$  is  $(N \times S)$  matrix of  $S$  outputs of each of  $N$  observed DMUs;

$x_{ji}$  is  $(N \times M)$  matrix of  $M$  inputs of each of  $N$  observed DMUs.

The TE under the CRS circumstance ( $TE^{CRS}$ ) and the CRS-DEA model are presented so far. The CRS is only appropriate when all units are operating at an optimal scale. In fact, there are several factors such as imperfect competition, constraints on finance, etc. which may cause some units not to operate at their optimal scale. To overcome this problem a DEA model with VRS situation has been developed for estimation of the TE score ( $TE^{VRS}$ ).

Technically, scale efficiency (SE) of a farm household is measured by the ratio of the  $TE^{CRS}$  to the  $TE^{VRS}$ . Therefore, the  $TE^{VRS}$  must be calculated. To do this a VRS production frontier must be defined for envelopment the observed data. In other words, a convex curve to the CRS production frontier must be constructed by the linear programming technique. This is done simply by adding the convexity constraint  $\sum_{i=1}^n \lambda_i = 1$  to equation (1). This constraint makes sure that the technical inefficiency is only compared among similar farm households (i.e., in this case the projected point is defined by a convex combination of the peer households on the frontier). This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS and thus produces a VRS envelop/ frontier. The DEA approach for measurement the TE based on the VRS frontier is called the VRS-DEA model. For such characteristics, TE scores of farm households under the VRS frontier are greater than or equal to those obtain under the CRS frontier.

Similarly, with regard to the situation with a sample of  $N$  farm households (HHs),  $\{N=(1, 2, \dots, n)\}$ , each of the HHs producing  $S$  outputs  $\{S=(1, 2, \dots, s)\}$  by using  $M$  different inputs  $\{M=(1,$

2,..., m)}. A linear programming (LP) problem based on the VRS and input-oriented circumstance to measure efficiency for the particular HH $p$  ( $p \in N$ ) is specified as follows<sup>ii</sup>.

$$\min_{\theta_p, \lambda} \left( \frac{\sum_{j=1}^m \lambda x_{ji}}{\sum_{j=1}^m x_{jp}} \right) = \theta_p$$

Subject to:

$$-q_{rp} + \sum_{i=1}^n \lambda q_{ri} \geq 0, \quad r = 1, \dots, s$$

$$\theta_p x_{jp} - \sum_{i=1}^n \lambda x_{ji} \geq 0, \quad j = 1, \dots, m$$

$$\sum_{i=1}^n \lambda_i = 1,$$

$$\lambda_i \geq 0, \quad i = 1, 2, \dots, p, \dots, n$$

The choice of the VRS Input-oriented DEA model (2) is similar to several empirical studies such as the studies of C. Paul et al. (2003), P. Fandel (2003), M. Oren et al. (2006) and H. Linh (2006).

The LP problems (1 and 2) can be solved by using a number of different computer programs, for simplicity, the DEAP<sup>ii</sup> version 2.1 provided by Coelli (1998, 2005) is used in this study.

### 3.2. Calculation of Technical Efficiency, Allocative Efficiency and Cost Efficiency using Constant Returns to Scale - Data Envelopment Analysis (CRS-DEA Model)

In agricultural cultivation, productivity of a farm household consists of not only the technical component as TE or component of operation scale like SE but also the other components such as effects of resource allocation (allocative efficiency- AE) and the use of productive costs (cost/economic efficiency - CE). The AE measure is used to evaluate the farm household's ability in allocating and utilizing mix of inputs in the optimal way with given relative prices and production technology. The CE is calculated by combination of TE and AE, and hence, may be used to estimate the possibility of costs savings by the household when moving to the technically and allocatively efficient point with given input prices and technology.

In the case of available information on input prices, the TE, AE and CE can be measured by using the CRS Input-oriented DEA Model (T. Coelli et al., 2005 and W. Krasachat, 2007). Consider to the situation with  $N$  observations of farm households, each of the households

produces  $S$  outputs using  $M$  different inputs. The LP problem must run  $N$  times, one for each household. For the particular household  $p$  ( $p \in N$ ), the DEA model is specified<sup>ii</sup>.

$$\begin{aligned} & \min_{\{\lambda, x_{jp}^*\}} \{w'_{jp} x_{jp}^*\} \\ & \text{subject to:} \\ & -q_{rp} + \sum_{i=1}^n \lambda q_{ri} \geq 0, \quad r = 1, \dots, s \\ & x_{jp}^* - \sum_{i=1}^n \lambda x_{ji} \geq 0, \quad j = 1, \dots, m \\ & \lambda_i \geq 0, \quad i = 1, 2, \dots, p, \dots, n \end{aligned} \tag{3}$$

where  $x_{jp}^*$  is the input vector  $j$  utilized by the household  $p$  with respect to production cost minimization,  $x_{jp}^*$  are calculated from the LP,  $w_{jp}$  is the input price vector  $j$  paid by the household  $p$ , and all notation used is as previously defined in the LP problem (1).

The LP problem (3) can be analogously explained as the LP problem (1) except that the problem (3) must find the optimal values for  $\lambda$  and  $x_{ij}$  (i.e.,  $\lambda^*$  and  $x_{ij}^*$ ) in order to be able to obtain the efficiency of the farm household  $p$  with respect to production cost minimization.

Similarly, the LP problem (3) can be solved by using specific computer programs. For simplicity, the DEAP version 2.1 is used.

### 3.3. Metafrontier and Relative Positions of Group Frontiers

In the preceding sections, the DEA models used to calculate the efficiency of farm households are provided with two separate specifications, i.e. the CRS-DEA model and the VRS-DEA model. Actually, the score of production efficiency of a given household is measured by comparing its real position to the frontier of the observed data of particular group (sample) to which it belongs. Different groups, however, may differ from each other in various respects such as size of land, labor, capital together with other characteristics of the soil quality and socio-economic environment. Thus, every group has a specific production frontier and differs from each other. This specific frontier is called “*group frontier*” (O’ Donnell, Rao and Battese, 2008). The idea behind is that we just can evaluate and compare the efficiency score of a farm household with others within a group of farmers.

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In this study, apart from a comparison of efficiency from each farmer within a group of farmers of a farming pattern, the efficiency of farm households should be compared with farmers having adopted other farming pattern (i.e. between the two selected farming patterns – continuous rice and crop rotation pattern). To do this, all farm households in both continuous rice and crop rotation patterns, besides facing their specific *group frontier*, are assumed to share a common frontier. This may be done due to although each farming pattern has specific characteristics, but both of them may be involved in the same aspects with respect to agricultural infrastructure and supported policies. The common frontier is called the *metafrontier*. Generally, the metafrontier is defined to be the boundary of a set of all specific group frontiers (O’ Donnell et al., 2008).

Given the DEA models along with the metafrontier technique, the TE scores of farmers can be compared not only with those of farmers within the group to which they belong but also with those of farmers from other groups (i.e., between two groups of farming patterns such as the continuous rice and crop rotation patterns) by calculating the *metatechnology ratio* (MTR) for each farming pattern. This ratio is defined by the following equation:

$$MTR_i(x, y) = \frac{E_i(x, y)}{E_i^g(x, y)} \quad (4)$$

where:  $MTR_i(x, y)$  = metatechnology ratio for the  $i$ -th household ( $i = 1, 2, \dots, n$ );

$E_i(x, y)$  = technical efficiency of the  $i$ -th farm household using the input vector,  $x$ , to produce the output vector,  $y$ , in comparison with the metafrontier;

$E_i^g$  = technical efficiency of the  $i$ -th farm household with respect to the frontier of group  $g$ .

The relative position of each group frontier (i.e., farming pattern frontier) in comparison with the metafrontier is specified based on its mean MTR. Therefore, the relative positions of farming pattern frontiers are determined by comparing the mean MTRs of different groups of farming patterns. A specific group with higher mean MTR, has evidently a closer position to the metafrontier.

## 4. FINDINGS AND DISCUSSIONS

### 4.1. Household Profit Evaluation



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Production costs of rice and cash crops such as soybean and water-melon basically consist of expenditures for seed, fertilizer and pesticide along with the rental services of hired machines, hired land, the wages of hired labor, and the interest charges on bank loans.

Seed is very important input factor and strongly impacts on productivity and efficiency of crops. Based on the responses of farm households during the interviews, the amounts of seed used in production process are normally depended on own experience and that of neighbors. This can be explained by some reasons such as (i) most farmers in the MRD have not been trained for new knowledge of production, (ii) farmers in the MRD are characterized by their friendly behavior and closed relationships, and (iii) they are in the habit of sharing production experience with each other in the village. The calculated results show that farmers who adapted the crop rotation pattern use more costs for seed in their cultivation than those of farmers who followed the continuous rice pattern. This is quite straightforward due to prices of water-melon seeds are higher than those of rice seeds.

Fertilizer and pesticide are of course to be considered as the important factors. They provide necessary nutrients for crops and protect them from harmful insects. Farmers usually used some kinds of common fertilizer named UREA, NPK, and DAP in cultivations of rice, soybean and water-melon. In Table 1, it can be seen that there are differences in applied amounts of fertilizer and pesticide per hectare between the continuous rice and crop rotation patterns. About 7,080 thousand VND of fertilizers and 3,243 thousand VND of pesticides are spent for the continuous rice pattern, while corresponding values of 9,664 and 4,172 thousand VND for the crop rotation pattern. The cause of the differences is referred to higher demand of fertilizer and pesticide for water-melon crops than those for rice crops. In fact, natural growth of water-melon requires more nutriment and protection from insects than rice.

During the cultivation processes of rice, soybean and water-melon in both continuous rice and crop rotation patterns, labor is normally used for land preparation, seeding, weeding, fertilizing, pesticide spraying, watering, threshing, harvesting and transportation. Labor here includes hired and family labor. The results computed from the surveyed data show that the costs of working labor are higher for the crop rotation pattern in comparison with those for the continuous rice pattern.

Another factor that also affects agricultural crops is the use of machinery. Actually, machinery is used for preparing land, pumping water and harvesting crop's products. The statistics in Table 1 show that farmers spend relative large amounts of money on these activities for both of the two farming patterns. Of which, the lower level of costs is involved in the crop rotation pattern (e.g., 3,097 and 2,439 thousand VND per hectare, respectively for the continuous rice and crop rotation patterns). In fact, in order to cultivate the cash crops of the crop rotation patterns such as soybean and water-melon, farmers have to do by themselves without machine supports for some activities of crop such as preparation of land and harvest.

The total production costs and profits between two selected farming patterns are relatively different. In which, the crop rotation pattern is considered as the better one with higher profit than the other. There are two explainable reasons for this such as (i) the prices of rice products in

the MRD are stable but low, due to the poor quality of rice (price of rice is about 2.2 thousand VND per kg, on average), while the prices of cash-crop products tend to be unstable - but mostly high, as in the case of soybean (price of soybean is about 5.2 thousand VND per kg, on average) and (ii) the productivity of water-melon crops is greater than that of rice crops (on average, productivity of water-melon is 20 tons per hectare whereas only 5.7 tons for rice crop). This somewhat reflects and interprets why farmers in the MRD now tend to shift their cultivation from traditional rice production system (i.e., continuous rice pattern) to crop rotation pattern.

**Table 1: A calculation of costs and profits (1,000VND/ ha) of the households by farming pattern in the non-flooded areas of the MRD, Vietnam.**

	<b>Continuous rice pattern</b>	<b>Crop rotation pattern</b>	<b>Continuous rice pattern</b>	<b>Crop rotation pattern</b>
<b>Net benefit</b>	<b>17,112.07</b>	<b>24,537.92</b>	<b>12,538.59</b>	<b>14,559.49</b>

Source: Computed from the surveyed data.

Note: HH=household.

#### **4.2. Household Efficiency Measurement using CRS-DEA Model**

In this section efficiency analyses of farm households are presented in terms of the following aspects:

- Measuring and analyzing the production efficiency scores of the farm households based on the estimated results of the CRS-DEA models.
- Comparing the technical efficiency scores of the farm households between the two selected farming patterns relied upon the calculated results of the MTRs.

The average efficiency scores, the number of fully efficient households and efficiency distributions of the farming patterns are depicted in Table 2.

**Table 2: Production efficiency of households and their distributions by farming pattern**

Parameters	Continuous rice pattern			Crop rotation pattern		
	TE	AE	CE	TE	AE	CE
<b>Non-flooded areas</b>						
<b>Efficiency scores</b>						
1.00	41	2	2	57	5	5
0.90 - 0.99	19	19	11	34	9	7
0.80 - 0.89	26	55	21	39	38	17
0.70 - 0.79	41	42	20	14	31	31
0.60 - 0.69	25	33	33	2	37	32
0.50 - 0.59	5	6	50	0	24	41
0.40 - 0.49	0	0	17	0	2	12
< 0.40	0	0	3	0	0	1
<b>Mean</b>	0.83	0.78	0.65	0.92	0.73	0.67
<b>Min</b>	0.52	0.53	0.36	0.60	0.47	0.34
<b>Max</b>	1.00	1.00	1.00	1.00	1.00	1.00
<b>SD</b>	0.14	0.11	0.16	0.09	0.13	0.15
<b>No. of households</b>	157			146		

**Source:** Measured from the surveyed data using DEAP software.

**Note:** SD=standard deviation.

**Household technical efficiency distributions of the two selected farming patterns.**

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For farmers in the MRD, cultivations of crops are considered as the main jobs to earn their living. However, productivity of a crop varies due to differences in production technology, differences in efficiency of the production process, and differences in the environment in which production occurs. In this section, I would like to present the result which reflects the ability of the farm households to use the best practice and available technology in the most effective way. This effect is referred to the technical contribution (i.e., TE) to its productivity.

In Table 2, the average TE score is less than one for both continuous rice and crop rotation patterns. The estimated TE scores of farmers of continuous rice pattern range between 0.52 and 1.00, with the mean and standard deviation of 0.83 and 0.14, respectively. Similarly, the TE scores of farmers adapted crop rotation pattern vary from 0.60 to 1.00 together with the mean of 0.92 and standard deviation of 0.09.

With regard to the TE distributions, for the continuous rice pattern, about 41 households are found to be fully technically efficient. The remaining households mostly get high scores of TE that range between 0.70 and 0.90 and a few of them have low TE scores (from 0.50 to 0.70). Analogously, most farmers applying the crop rotation pattern attain very good achievements corresponding to the TE score of 1.00 for 57 households and values between 0.70 and 0.90 for the remainders.

Given such results together with the average MTR for the TE listed in Table 3, we may conclude that farmers applying the crop rotation pattern are little more technically efficient than farmers following the continuous rice pattern. This result is consistent with the studies of Latruffe et al., 2000 (livestock farmers get higher TE scores than crop farmers) and Linh, 2006 (diversified farmers are more technical efficient than mainly rice farmers).

According to the analyses of the responses from the surveys and local authorities, there are some main causes for the difference such as (i) the crop-rotation farmers have more reachable opportunities of production technology than the continuous-rice farmers (e.g., about 52% and 42% of interviewed farmers have been trained on appropriate technology of production for the crop rotation and continuous rice patterns, respectively), (ii) the formal education levels of the crop-rotation farmers are somewhat better than the continuous-rice farmers, and (iii) the number of male household heads is relative greater for the crop-rotation farmers. These factors in fact have positive effects on the TE of the farm households (refer to the estimated results of the Tobit model that are presented in Table 5 in the later section).

**Table 3: Mean metatechnology ratio of households by farming pattern**

<b>Farming pattern</b>	<b>Non-flooded areas</b>	<b>Flooded areas</b>
Continuous rice pattern	0.96	0.91
Crop rotation pattern	0.98	0.98

**Source: Calculated from the surveyed data.**

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Household allocative efficiency distributions of the two selected farming patterns.

This section focuses to discuss the calculation of allocative efficiency (AE) that is used to measure how optimal the input resources are allocated for production process with given relative prices and production technology.

As the results in Table 2, the average AE score of the farm households is 0.78 and 0.73 corresponding to the continuous rice and crop rotation patterns. For the continuous rice pattern, although only two households get fully AE, most of the remaining farmers are rather efficient in making optimal decision on allocation of input mix. This is illustrated by the AE scores which concentrate on values between 0.60 and 0.90. There is somewhat different from this pattern, five households among the crop-rotation farmers are found to be allocatively efficient and the variation of AE scores of other farmers is relative large with the range between 0.50 and 0.90.

The allocative inefficiency is likely derived from low levels of education and lack of market price information on agricultural products (most farmers just obtain primary school and get price information from relation and neighbor). Education is also found to be positive statistically significant for explanation in change of AE from the Tobit's estimation (refer to Table 6 in the later section).

Household cost efficiency distributions of the two selected farming patterns.

Lastly, an overall effect of technical and price factors on production of farm households can be determined by calculating a combination of TE and AE. This measure indicates the amount of money by which farmers can save if they implement the production process at the technically and allocatively optimal production technology (i.e., cost minimization).

The CE scores and their distributions for both farming patterns are presented in Table 2. The variations of CE are quite large by the ranges between 0.36 and 1.00 for the continuous rice pattern, and from 0.34 to 1.00 for the crop rotation pattern. The results imply that there are *cost inefficiencies* in their operation. Particularly, the scores of cost inefficiency range from 0.00 to 0.64 and from 0.00 to 0.66 corresponding to the continuous-rice and crop-rotation farmers. This is also the substantial opportunity for farmers in both farming patterns to increase their profits by reducing the costs related to technical and allocative inefficiency.

Refer to Table 2, we see that the average CE scores are 0.65 and 0.67 respectively for the continuous rice and crop rotation patterns. It means that if the average efficiency household in the sample of continuous-rice farmers is to achieve a cost efficiency level at the highest efficiency of its counterpart, then that average household can receive a cost saving of 35 % (i.e.,  $1 - [0.65/1.00]$ ). The same calculation for the lowest efficiency household suggests a gain in cost efficiency of 64 % (i.e.,  $1 - [0.36/1.00]$ ). Similarly, the average household and the most inefficiency household in the sample of crop-rotation farmers can realize a cost saving of 33 % and 66 %, respectively (i.e.,  $1 - [0.67/1.00]$  and  $1 - [0.34/1.00]$ ).

#### **4.3. Household Scale Efficiency Measurement using VRS-DEA Model**

In practice, it seems difficult for farm households to operate at an optimal scale (i.e., constant returns to scale – CRS) due to several reasons such as lacking of capital, low level of production knowledge and formal education as well as limitation of agricultural market information. Hence, they often operate in a situation of either increasing returns to scale (IRS) or decreasing returns to scale (DRS). Both of these lead to decreasing efficiency. This reduced amount is considered as scale inefficiency and being discussed in the following subsections.

The mean SE, the share of households with respect to the CRS, IRS and DRS, the range and standard deviation of SE scores for both farming patterns are depicted in Table 4.

**Table 4: Household scale efficiency of the two selected farming patterns in the non-flooded area of the MRD, Vietnam**

Parameters	Scale efficiency			
	Continuous rice pattern		Crop rotation pattern	
Non-flooded areas				
Number of households in IRS	80	51.0%	40	27.4%
Number of households in DRS	35	22.3%	47	32.2%
Number of households in CRS	42	26.7%	59	40.4%
Number of households	157	100.0%	146	100.0%
<i>Mean SE</i>	0.94		0.98	
<i>Min</i>	0.55		0.71	
<i>Max</i>	1.00		1.00	
<i>SD</i>	0.09		0.04	
Flooded areas				
Number of households in IRS	43	41.0%	27	28.1%
Number of households in DRS	29	27.6%	18	18.8%
Number of households in CRS	33	31.4%	51	53.1%
Number of households	105	100.0%	96	100.0%
<i>Mean SE</i>	0.94		0.98	
<i>Min</i>	0.46		0.79	
<i>Max</i>	1.00		1.00	

<i>SD</i>	<i>0.10</i>	<i>0.05</i>
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Source: Measured from the surveyed data using DEAP software.

Notes: SD = standard deviation.

Generally, mean SE score is less than one for both farming patterns indicating that farmers are confronted with *scale inefficiency*. However, the amount of inefficiency is small, hence, the farmers seem to be rather efficient with respect to scales of operation (e.g., 0.94 and 0.98 is the mean SE for the continuous rice and crop rotation patterns, respectively).

The estimated results listed in Table 4 indicate that the mean *scale inefficiency score* (1–scale efficiency score) is not so much with the values of 0.06 and 0.02 corresponding to 73.3% and 59.6% of farm households operating under either the IRS or DRS circumstance for the continuous rice and crop rotation patterns, respectively.

The variations of SE between two patterns are somewhat different. The crop-rotation farmers are rather better due to a relative large number of farmers obtain value of 1 in comparison with the continuous-rice farmers. The results show that there are about 26.7%, 22.3% and 51% of the respondents who followed the continuous rice pattern are operating in the situations of the CRS, DRS and IRS respectively, while the corresponding values of 40.4%, 32.2% and 27.4% for farmers with the crop rotation pattern.

#### 4.4. Identifying the Sources of Production Efficiency using Tobit Model

The TE, AE, CE and SE of farm households for both farming patterns have been measured and analyzed so far. These results provide us with significant information related to the abilities of farm households with respect to using the best practice and technology, making optimal decisions on the input mix, minimizing the cost of production as well as increasing productivity by moving towards the point of technically optimal productive scale. However, they do not tell us anything about the causes for these efficiencies. Therefore, this section focuses the discussions on the determinants of production efficiency.

##### 4.4.1. Variables and practical model for calculation of source of production efficiency

In our estimations, ten socio-economic/environmental variables are included in the Tobit regression function. They are age, education, training, share of female labor, area, credit, land ownership, sex and two district dummy variables (local\_1 and local\_2). The model is defined as the following form.

$$\text{Efficiency} = \beta_1(\text{Age}) + \beta_2(\text{Education}) + \beta_3(\text{Training}) + \beta_4(\text{Share of fe\_labor}) + \beta_5(\text{Area}) + \beta_6(\text{Credit}) + \beta_7(\text{Land\_ownership}) + \beta_8(\text{Sex}) + \beta_9(\text{Local\_1}) + \beta_{10}(\text{Local\_2}) \quad (5)$$

The meaning and expected sign of the variables are described as follows.

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*Efficiency* denotes the components of productivity such as TE, AE, CE and SE that have been obtained in the previous sections from the DEA models. The efficiency scores have values between zero and one.

*Age* reflects the age of the household head. There is different from old farmers, the advantage of young farmers is that they are active and have reasonable levels of formal education, which may help them in understanding and applying new technology and skills of production. They, however, likely lack experience and are impatient in their decisions about cultivation and vice versa for the older farmers. For this reason, farmers may get higher efficiency in production if they are not too old. Therefore the expected sign of coefficient for this variable is negative.

*Education* expresses the number of formal school years of the household head. The expected sign of this variable is positive according to clear effects of low and high levels of education of farmers in fact.

*Training* represents the hours of agricultural advice received by the household head. This variable is often used to calculate the effects of training courses provided by the agricultural extension centers. We expect that farmers obtain higher efficiency if they have taken part in training courses. The more training hours they learn, the higher the efficiency levels reached. Hence, the expected sign for this variable is positive. It is clear that, when farmers regularly attend training courses they likely get more new knowledge of production technology and apply these in their cultivation activities.

*Share of female labor* is measured by the ratio of the number of female laborers to the total number of laborers in production. This variable is used to capture the different effects between male and female labors. In rural areas of the MDR, men often tend to undertake field-work while women do the homework. Therefore, male farmers probably have more cultivation experience than female farmers. This leads to production efficiency may be increased with the increased use of male farmers. Thus, the expected sign of this variable should be negative.

*Area* is the size of land under production. This variable is used to determine the influences of differences in operation scales on efficiency. Normally, the larger land areas may result in the higher productivity.

*Credit* is a dummy variable which consists of 1 if the household has a bank loan and zero otherwise. Basically, efficiency will increase with the use of credit. The availability of credit will reduce the constraints of production with respect to limited finance in order to get the input resources on time, and hence, may help farmers increase their cultivation efficiency. In addition, when farmers get loans they have to pay interest to the banks, which may induce them to work harder. Therefore, the positive sign of this variable is appropriate.

*Ownership of land*, which is designed as a dummy variable with value one if at least part of the land farmed is based on a tenancy arrangement and zero otherwise. In fact, there are two main reasons for farmers in the MRD to hire land, i.e. that they have no land to culture and/ or that they want to expand their scale of operation. In both cases, efficiency is likely to be increased because farmers often tend to work hard when their cultivation land is hired, and they have more



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opportunities to use the best practice and available technology in the most effective way with larger scales of operation. Thus, the expected sign is positive.

*Sex* is a dummy variable for gender, which has value 1 if the household head is male, and zero otherwise.

The last two factors are related to the *district dummy variables*, *Local 1* and *Local 2*, which are used to explain the impacts of different locations (Cho Moi, Cay Lay and Cau Ke districts) on production efficiency. Local 1 obtains value one if farmers are located in the Cho Moi, and zero otherwise. Similarly, Local 2 gets value one if farmers are located in the Cay Lay, and zero otherwise. The production efficiency can vary due to differences in the natural factors which are not included in the model such as soil fertility and weather.

The model (5) runs four times separately for identifying the determinants of TE, AE, CE and SE of the farm households.

#### **4.4.2. Empirical results**

First, the adequate representation of the data for the Tobit regression models must be verified. Using  $\alpha = 0.05$  together with 303 observations ( $N=303$ ) and 11 variables (including the dependent variable,  $M=11$ ), the absolute value of the test statistic ( $z$ ) is greater than the critical value  $t_{1-0.025}(303-11)$  for all of the four models. Therefore, the Tobit regression functions are all statistically accepted for identifying the determinants of production efficiency.

For simplicity, the analyses will be conducted separately as the following sections.

##### ***Determinants of technical efficiency***

The results of the t-test show that four variables are found to be statistically significant for explanation of changes in TE. They are sex, age, education and local\_1.

The positive relationship between TE and sex is quite appropriate in fact. This indicates that TE can increase if the production process is implemented and managed by male farmers. Normally, male farmers likely reach a higher efficiency than the female due to some reasons as: (i) male farmers are probably more robust and have more farming experience than female farmers, (ii) male farmers often obtain higher education levels than the female and (iii) as a traditional culture characteristic of the MRD, most main decisions are definitely made by the male farmers. Such characteristics help male farmers can improve their ability in terms of using experience, skill, knowledge and available technology in production process. The estimated result is similar to the results reported by Illukpitiya (2005), Linh (2006), Oladeebo et al. (2007) and Shehu et al. (2007).

The sign of age parameter is somewhat surprising. The positive sign of its coefficient means that the TE probably tends to increase with an increase in age of the farmers. However, the surveyed data show that the average age of household heads in the non-flooded areas is about 45 years old. At this age, farmers seem to be not very old. They can enjoy a relatively good health and have

enough experience which is also accumulating. Such statistics can be used to interpret for the positive relationship between TE and age in this case. Some empirical studies reported similar results, such as Oladeebo et al., 2007 (age has a positive impact on TE for both men and women rice farmers in Nigeria). However, other researches indicated contradicted results such as H.V.Linh, 2006.

With regard to the positive impact of education on TE, the result tells us that the higher education level of the farmers, the higher efficiency reached. Obviously, when they obtain higher levels of formal education, they will master more basic knowledge and have better thinking, hence, they can study new production technologies independently and/ or by attending training courses. This estimate is quite consistent with the empirical studies of Illukpitiya (2005), Linh (2006), Oladeebo et al. (2007) and Shehu et al. (2007).

Related to the variation of TE due to differences in natural properties of the cultivation areas such as climate and soil quality, the positive sign of coefficient of local\_1 implies that farmers in the Cho Moi district are more technically efficient than farmers in the Cay Lay and the Cau Ke districts.

**Table 5: The truncated estimates for the sources of technical efficiency of farm households in the non-flooded area**

Variables		Technical efficiency					
		Non-flooded areas			Flooded areas		
		Coef.	Z	P[   Z   > z]	Coef.	Z	P[   Z   > z]
Sex	$\beta_1$	0.334*	10.413	0.000	0.237*	6.168	0.000
Age	$\beta_2$	0.008*	13.567	0.000	0.008*	10.436	0.000
Credit	$\beta_3$	0.034	1.624	0.104	0.053**	1.909	0.056
Land ownership	$\beta_4$	0.054	1.435	0.151	0.019	0.298	0.766
Education	$\beta_5$	0.020*	7.147	0.000	0.024*	6.425	0.000
Training	$\beta_6$	-0.001	-1.062	0.288	0.000	0.356	0.722

Share of female labor	$\beta_7$	-0.002	-0.564	0.573	0.079	1.104	0.270
Area	$\beta_8$	-0.012	-0.763	0.445	0.005	0.756	0.450
Local 1	$\beta_9$	0.083*	2.848	0.004	0.091*	3.001	0.003
Local 2	$\beta_{10}$	-0.025	-1.036	0.300			
Sigma	$\sigma$	0.171	24.617	0.000	0.181	20.050	0.000
Log likelihood function	LLF		104.774			58.696	

Note: \* and \*\* is significant at 1% and 5%, respectively.

### ***Determinants of allocative efficiency***

The estimates of the explanatory variables with respect to coefficients, statistic values (z) and p values are presented in Table 6.

Making comparisons between the statistic values (values z in Table 6) and the critical value obtained from the statistical table of Student distribution at 5% significance for the data on 11 variables of 303 observations indicates that four variables appear to have positive effects on the AE of farm households such as sex, age, education and district dummy variable local\_1.

The estimated results show that the AE tend to be increased in the case of the production process that is implemented and managed by male and higher education farmers. In fact, farmers with higher levels of education likely have more opportunities to make better decisions in allocating input resources, given relative prices and production technology. This may lead to higher AE scores. The other reasons are as previously interpreted.

Two other factors which also impact on the AE with positive directions are age of household head and cultivation location (local\_1). Obviously, it is difficult for farmers living in different locations can hire and buy resources of production at the same prices, hence, there is different from making proportional combination of resources in production process by farmers between different areas. Explainable reason related to effect of age is similar to the previous discussion.

**Table 6: The truncated estimates for the sources of allocative efficiency of farm households in the non-flooded area**

Variables		Allocative efficiency					
		Non-flooded areas			Flooded areas		
		Coef.	Z	P[   Z   > z]	Coef.	Z	P[   Z   > z]
Sex	$\beta_1$	0.211*	7.622	0.000	0.196*	6.040	0.000
Age	$\beta_2$	0.008*	15.133	0.000	0.008*	11.651	0.000
Credit	$\beta_3$	0.019	1.069	0.285	0.065*	2.768	0.006
Land ownership	$\beta_4$	0.009	0.289	0.773	0.046	0.881	0.378
Education	$\beta_5$	0.019*	7.796	0.000	0.017*	5.499	0.000
Training	$\beta_6$	0.000	-0.476	0.634	0.001	0.944	0.345
Share of female labor	$\beta_7$	-0.003	-1.098	0.272	0.089	1.472	0.141
Area	$\beta_8$	0.006	0.428	0.669	0.009***	1.712	0.087
Local 1	$\beta_9$	0.118*	4.686	0.000	0.063**	2.469	0.014
Local 2	$\beta_{10}$	0.004	0.207	0.836			
Sigma	$\sigma$	0.147	24.617	0.000	0.153	20.050	0.000
Log likelihood function	LLF		150.101			92.414	

Note: \*, \*\* and \*\*\* is significant at 1%, 5% and 10%, respectively.

### ***Determinants of cost efficiency***

Table 7 shows that CE of farmers is influenced by effects of five different factors such as sex, age, education and two district dummy variables (local\_1 and local\_2).

Sex, age and education are found to have positive impacts on the changes in CE of farm households. We are not surprised with these estimates because CE is a combination of TE and AE, so that the factors which affect TE and AE probably affect CE. The reason for this can be explained similarly as in the cases of TE and AE before.

Related to the district dummy variables, the positive effect on CE belongs to local\_1 and vice versa for local\_2. The estimated coefficients indicate that farmers in Cho Moi are most effective

with respect to cost minimization, then by farmers in Cau Ke. The lowest CE is found with farmers in Cay Lay district.

**Table 7: The truncated estimates for the sources of cost efficiency of farm households in the non-flooded area**

Variables		Cost efficiency					
		Non-flooded areas			Flooded areas		
		Coef.	Z	P[   Z   > z ]	Coef.	Z	P[   Z   > z ]
Sex	$\beta_1$	0.234*	8.375	0.000	0.199*	5.652	0.000
Age	$\beta_2$	0.006*	11.471	0.000	0.006*	8.894	0.000
Credit	$\beta_3$	0.024	1.309	0.191	0.049**	1.921	0.055
Land ownership	$\beta_4$	0.011	0.348	0.728	0.042	0.728	0.467
Education	$\beta_5$	0.016*	6.553	0.000	0.018*	5.305	0.000
Training	$\beta_6$	0.000	-0.564	0.573	0.001	0.879	0.379
Share of female labor	$\beta_7$	-0.001	-0.243	0.808	0.016	0.242	0.809
Area	$\beta_8$	-0.008	-0.593	0.553	0.007	1.231	0.218
Local 1	$\beta_9$	0.153*	6.002	0.000	0.079*	2.869	0.004
Local 2	$\beta_{10}$	0.044**	-2.082	0.037			
Sigma	$\sigma$	0.149	24.617	0.000	0.165	20.050	0.000
Log likelihood function	LLF	146.681			76.750		

Note: \* and \*\* is significant at 1% and 5%, respectively.

### ***Determinants of scale efficiency***

Different from previous sections that discuss about the factors influencing the ability of farm households in terms of using the best practice and available technology as well as making the optimal decisions on resource allocation at given relative prices, this section focuses on analyzing the effects of the factors affecting the farmers' ability with respect to evaluating the optimality of operation scales.

Overall, five factors appear to have the impacts on SE of farm households according to the results of the t-test. The statistics related to these factors are presented in Table 8 below.

Sex is found to be statistically significant for explaining the change of SE with positive effect. It implies that the SE of a household is likely higher if its production process is to be conducted by the male household head. As discussed in the preceding sections, men are characterized as robustness, much experience and higher education, which can support them to adjust scale of operation more effectively.

Age variable shows a positive relation with SE. There is somewhat strange, but this estimate can be as previously interpreted. Basically, with the average age is about 45 years old, farmers are not too old so that SE may still tends to be increased with an increase in the age of farmers.

Education is discovered as a significant factor affecting the SE of farms in positive way. Actually, the higher education levels farmers reach the more knowledge and access to new information and appropriate technology. These advantages may help them evaluate the optimality of operation scale and adjust in case of need.

The last two factors which have positive effects on SE scores are credit and ownership of land. These estimates seem to be appropriate in fact. Reaching for a bank loan together with renting an area of productive land can lead to an increase in SE. It may be the case because of the percentage of farmers operating in IRS area is greater than that of farmers involving in DRS situation (refer to Table 4 above).

**Table 8: The truncated estimates for the sources of scale efficiency of farm households in the non-flooded area**

Variables		Scale efficiency					
		Non-flooded areas			Flooded areas		
		Coef.	Z	P[   Z   > z]	Coef.	Z	P[   Z   > z]
Sex	$\beta_1$	0.316*	10.588	0.000	0.279*	7.751	0.000
Age	$\beta_2$	0.010*	17.621	0.000	0.009*	12.188	0.000
Credit	$\beta_3$	0.029***	1.496	0.135	0.075*	2.866	0.004
Land ownership	$\beta_4$	0.074**	2.102	0.036	0.042	0.720	0.472
Education	$\beta_5$	0.023*	8.560	0.000	0.022*	6.436	0.000
Training	$\beta_6$	-0.001	-0.779	0.436	0.000	0.353	0.724

Share of female labor	$\beta_7$	-0.003	-1.340	0.180	-0.139**	-2.072	0.038
Area	$\beta_8$	0.005	0.360	0.719	0.001	0.218	0.827
Local 1	$\beta_9$	0.029	1.051	0.293	0.045***	1.596	0.111
Local 2	$\beta_{10}$	0.013	0.563	0.573			
Sigma	$\sigma$	0.159	24.167	0.000	0.169	20.050	0.000
Log likelihood function	LLF		126.786			71.516	

Note: \*, \*\* and \*\*\* is significant at 1%, 5% and 15%, respectively.

## 5. CONCLUSIONS

This study focuses to estimate the profit of farm households and the determinants of their income, the production efficiency with respect to TE, AE, CE and SE as well as the causes for these efficiencies for the farm households who were either following the continuous rice patterns or applying the crop rotation patterns in the non-flooded and flooded areas of the MRD, Vietnam.

Profit is calculated for farmers in both selected farming patterns as well as in both non-flooded and flooded areas. The empirical results show that the mean profit of crop-rotation farmers is higher than that of continuous-rice farmers, for the non-flooded areas. Similarly, mean profit of households applying the crop rotation patterns is a little greater than that of households with the continuous rice patterns, for the flooded areas, but this difference is not statistically significant accepted according to the result of the *Independent-Samples T-Test*. Particularly, mean profits of farmers in the non-flooded areas are 24.5 and 17.1 million VND per hectare, respectively for the crop rotation and continuous rice patterns and the corresponding values of 14.6 and 12.5 million VND for farmers in the flooded areas. Moreover, the financial ratios indicate that the continuous-rice farmers are more efficient with respect to labor productivity but less efficient in terms of benefit-cost ratio than the crop-rotation farmers.

Related to the efficiency of farm households in both non-flooded and flooded areas, crop-rotation farmers are more likely efficient than continuous-rice farmers in terms of TE, according to the mean MTRs. This is consistent with the computed results of similar studies that conducted by Latruffe et al., 2000 (livestock farmers get higher TE scores than crop farmers) and Linh, 2006 (diversified farmers are more technical efficient than mainly rice farmers). Regarding other components of productivity such as AE, CE and SE, farmers of both patterns mostly attain high efficiency in comparison with the best performance farmers of their own farming pattern.

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With regard to the factors influencing efficiencies, for the case of non-flooded areas, the estimated results show that although there are some differences in determinants of each component of total productivity, but sex, age and education are found to be the main factors that can make changes of all components (TE, AE, CE and SE). Similarly, all components of total productivity are impacted by the changes of sex, age, credit and education, for the case of flooded areas.

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