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Floods in the Mekong Delta:

A case study of Dong Thap Province

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Abbreviations and Acronyms

ADB	Asian Development Bank
CBA	Cost-Benefit Analysis
CCFSC	Central Committee for Flood and Storm Control
CTU	Can Tho University
FAO	Food and Agriculture Organization of the United Nations
GSO	General Statistics Office of Vietnam
ICEM	International Centre for Environmental Management
LMB	Lower Mekong Basin
MARD	Ministry of Agriculture and Rural Development
MDI	Mekong Delta Development Institute
MONRE	Ministry of Natural Resources and Environment
MRC	Mekong River Commission
NTP	National Target Program to respond to Climate Change
REDD	Reducing Emissions from Deforestation and Forest Degradation
SLR	Sea level rise
UNDP	United Nations Development Program
UNEP	United Nations Environment Program

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Executive Summary

In recent years, an ongoing debate has taken place over the costs and benefits from floods and how to manage flood occurrence in the Mekong Delta of Vietnam. This study presents a review of flood incidence in the delta over the past 15 years, with a specific focus on Dong Thap province. The study investigates the damage costs of floods and suggests that overall final losses should not be strictly related to the magnitude of hydrological variables but also to other factors such as inadequate coping measures and infrastructure. Also, it concludes that flood control procedures applied in Vietnam still need much improvement in terms of dissemination of information, investment in infrastructure, awareness-raising and aid monitoring.

I. Introduction

Vietnam is a country rich in natural resources due to its topography and geographic position. These characteristics have allowed the country to empower its agricultural-based economy, as well as to promote the rapid growth of its industrial and service sectors in the past years. However, the same conditions that contribute to the country's development are the ones that make it one of the most disaster-prone countries in the world (Tinh & Hang 2003, Dasgupta et al 2007). Droughts, severe floods, typhoons, sea level rise (SLR) and saline intrusion are among some of the problems constantly affecting the nation's inhabitants. Furthermore, water disasters are a very sensible issue for the country since most of its population lives in areas that are susceptible to floods (Nguyen et al 2007). This is derived from the fact that most of the country's agricultural activities are carried out by exploiting river deltas and coastal lands.

The southern part of the country, the Mekong Delta, gets its name because it is crossed by one of the largest rivers in the world, the Mekong River. This area undergoes flooding every year because of the water level fluctuations and also as a consequence of its low and plain land level. Floods are considered one of the main problems of the lower part of the delta (White 2002). For instance, the severe flood that took place in the year 2000 caused major devastation; not only in economic terms for the agriculture sector, but also in the number of human casualties, destroyed houses, and damage to infrastructure. Nevertheless, despite the fact that damage costs from floods have been very severe on multiple occasions, inhabitants from the area still tend to see floods as a source of livelihood and benefits (Be et al. 2007, MRC 2006, Nikula 2008, Sanh & Can 2009).

The purpose of this study is to present an overview of the flood situation over the past 15 years in the Mekong Delta of Vietnam. Damage costs, benefits and flood recurrence will be described for this area. Given the broad scope of research studies related to floods in the Mekong Delta, a specific province was selected to develop a case study. The research scrutinizes the province of Dong Thap, located in the northern part of the Mekong Delta. Its plain area and downstream position from the Tonle Sap River in Cambodia makes it one of the most flood-prone locations. Although Dong Thap cannot be considered a representative case for the entire Delta, mainly due to its diverse geographic and topological conditions, it was chosen to exemplify the consequences of floods in one of the most vulnerable areas to this phenomenon within the region. In addition to this, recent strategies from the Vietnamese government and from international organizations to cope with floods in the Delta will also be addressed.

This report is the result of a desk-study research built upon secondary data obtained from statistic departments in Vietnam, as well as from literature revision on the impact of floods in the Mekong Delta, governmental strategies and plans for flood control, and information on climate change in Vietnam. Statistics from Dong Thap were gathered from the General Statistics Office, Dong Thap's Steering Committee of Storm and Flood Prevention and the Central Committee for Flood and Storm Control (CCFSC).

The research was conducted in the Mekong Delta Development Institute (MDI) in Can Tho University (CTU), Vietnam. Meetings took place with researchers from the Institute and from different colleges at CTU, in which literature recommendations were provided to get useful insight on the current flood situation of the delta.

The study consists of five sections, including this introduction. Section II provides a description of the Mekong Delta, flood occurrence over the past 15 years, and the damages and benefits related to floods. Section III details the case study of Dong Thap, a very vulnerable province in the Delta to annual flooding and, therefore, an interesting case to analyze. The section includes the description of the province, its main economic activities, and the impact of floods in the economic activity of the agricultural sector, mainly focusing in the total damage costs due to this natural phenomenon over the period of 1995-2008. Section IV presents some of the current initiatives and programs for flood management and coping in the Mekong Delta region. Finally, Section V presents the most relevant conclusions and recommendations of the study.

The pertinence of the study relies in the creation of a concise and accessible "state of floods of the Mekong Delta" from the past years. It aims to work as a useful tool for researchers, students, and governmental authorities to consult when developing further studies and policies related flood occurrence in the Delta, not only in economic aspects, but also in social, environmental and political terms.

II. Floods in the Mekong Delta of Vietnam

A) Description of the Mekong River Delta

Location

The Mekong River is one of the longest and largest rivers of the world, with approximately 4800 km in length. Along its path, the river crosses 6 countries: China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam. The area surrounding the river is divided in two basins: the Upper Basin (24% of the basin's total area) in Tibet and China, and the Lower Mekong Basin (LMB) (76% of the basin's total area) from downstream China (Yunnan) to coastal Vietnam. It is in the latter country where the river divides in nine mouths, known as the "Cuu Long", or "Nine Dragons", before draining in the South China Sea. The Upper basin contributes only to 15-20% of the water flows in the Mekong River, and by the time the Mekong reaches Cambodia, over 95% of the flows have already joined the river. At this point, the land is flat and the movement of water across the landscape depends on water levels rather than flow volumes (MRC 2006).

The Mekong River Delta comprehends an area of 5.5 million ha that is mainly located in Vietnam (3.9 million ha), but also covers a smaller part of Cambodia (1.6 million ha) (Ko & Lee 2000). The delta begins in Phnom Penh, where the river divides in its two main distributaries, the Mekong and the Bassac; then the Mekong divides into 6 channels and the Bassac into 3, forming the Nine Dragons. However, for the purpose of this study, future references to the Mekong Delta will strictly refer to the Vietnamese part of it. There are 17.6 million people living in the delta distributed between its 13 provinces, and they represent 21% of the total Vietnamese population (GSO 2008).

Agriculture

Due to its downstream position, the Mekong Delta benefits from optimal conditions for agricultural development, in combination with other activities such as fishing, livestock production and forestry. The floodplain is composed of eroded sediments that are carried downstream from the upper basin, giving place to the 4000 ha of cultivated area that, according to Tinh & Hang (2003, p.2), yields 50% of all staple food and 60% of the fish of Vietnam.

Agricultural activities are carried out both for commercialization and for subsistence. Often referred to as the "rice bowl" and "fish basket" of Vietnam, the Mekong Delta is a major contributor to the population's food security, with rice and fish as two of the main nutritional sources of the people's diet in the LMB.

After the implementation of the "*doi moi*" policy in Vietnam in the mid 1980s, which marked the transition from a central-oriented to a market-based economy, the country put into practice several additional policies to promote rice production for exports. Nowadays it is the fifth major rice producer in the world and ranks second among the major rice exporters worldwide (FAO 2008).

Figure 1. Satellite Map of the Mekong Delta

Source: http://www.mrcmekong.org/MfS/html/flash/1--L7_125-53a.jpg

Climate

The Mekong Delta is located in a monsoon-affected area which determines its 2 seasons: rainy and dry. The North-East monsoon generates the rainy season, consisting of 90% of annual rainfall, and the South-West monsoon determines the dry season that covers 10% of annual rainfall. The dry season lasts from November to April and the rainy season starts in May and lasts until the end of October. The highest temperatures are usually registered in the month of April, when temperature can reach up to more than 38°C, whereas the average mean temperature is of 25°C (Ko & Lee 2000).

Despite its favorable conditions for agriculture, the delta faces some constraints such as the impact of upstream hydrology and also the tidal fluctuations in the South China Sea and the Gulf of Thailand (Truong & Anh 2002). A large expansion of the tide in the dry season causes salinity intrusion, whereas the slow process of drainage during the rainy season causes heavy flood periods. These two natural phenomena are between the most common concerns of the inhabitants of the delta, among others such as typhoons and coastal erosion.

Annual average rainfalls over the Mekong Delta are usually around 1500-1700 mm, and August and September are the months with the highest rainfall; although lately a shift has been perceived in which more rain falls in September and October (MRC 2006).

B) Floods in the Mekong Delta: 1995-2008

State of floods in the delta

In describing the flooded area in the South, Sanh & Can state that

> *'The most flood-prone region is located in both Cambodian and Vietnamese Mekong floodplains, where hydrological conditions are strongly determined by the Mekong's flows and the Great Lake's water storage.'* (2009, p.3)

Several areas of the Mekong Delta become inundated by water coming from the Bassac River, the Mekong River, and the canals linking both of them. The flood prone area in the Mekong Delta is home to 8.5 million people, of which 17% live in urban zones and 83% in rural ones. From this population, 2.5 million live in the deep flood water area, whilst 3 million live in medium flooding area (Nguyen et al 2007, p. 6). The flood season takes place from June to the end of November, and encompasses around 85-90% of the total volume. The peak discharges of water usually occur during the end of September and the beginning of October, reaching around 35000-38000 m^3/s (Truong & Anh 2002), a value significantly higher than the annual average discharge of 14000 m^3/s (Ko & Lee 2000).

Due to the tropical monsoon, floods are about 25-30 times greater than the dry season flows (Ojendal 2000 cited in Be et al. 2007). Particularly in the North West of the Mekong Delta where the Long Xuyen Quadrangle and the Plain of Reeds are located, there is poor drainage capacity because they are depression areas. More specifically,

> *'(…) a large area in the North of the Mekong Delta is flooded, with an area of 1.2-1.4 million ha flooded by weak and medium floods and 1.8-1.9 million ha by high and historic floods.'* (Truong & Anh 2002, p.2)

The inundations in this area, depending on the year, can last from 4 to 6 months, causing river bank erosion, severe damage to infrastructure, transportation means, among others. Given its low altitude and downstream location, the delta receives almost all the flood volume of the Mekong. This condition, together with the increasing human activities taking place in the region, is considered the cause of most negative effects on economic development and the livelihoods of its inhabitants (MRC 2006, p.66).

Flood damage by sector

i. Agriculture and aquaculture

The delta is a highly dependent area on its natural resources for exports, households' income, nutrition, and habitat significance within the Mekong River Basin (Hoanh et al 2003, Be et al 2007). Vietnam's export-oriented economy[1] relies on the production of rice as one of its main commodities, among other marine products, and about 90% of total national rice exports originate from the delta (Duong et al 2005 cited in Be et al 2007). In general, the delta produces around 19.23 million tons of rice per year, which correspond to 54% of the total national production (Be et al 2007, p.72). Therefore, by being mainly an agricultural area, a high level flood can have tremendous impact in loss and damage to

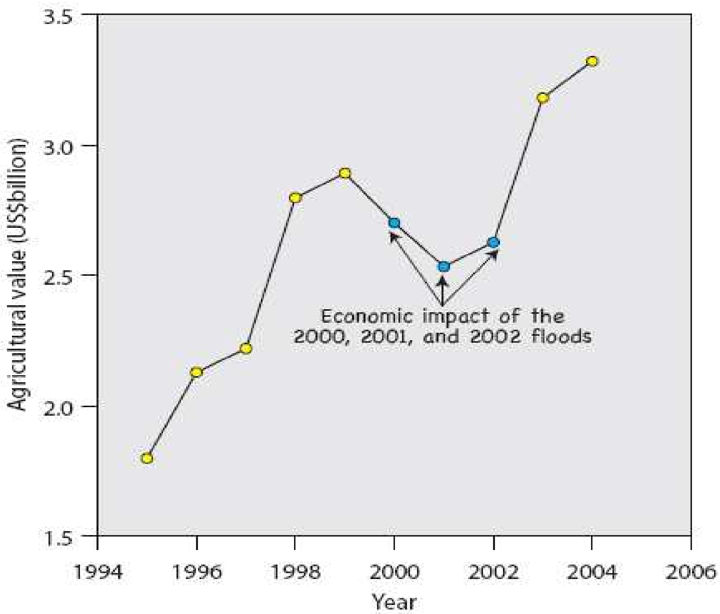
[1] Vietnam's exports represented 68% of GDP in 2007 (CIA, World Factbook).

crops in the Mekong Delta, and consequently, in the overall Vietnamese economy. This is why one of the damage components most frequently monitored in all countries of the LMB is the "loss of paddy fields". It is considered a good indicator to have an idea of the intensity of the flood and its duration because it shows the amount of rice yield that is lost due to flooded fields.

In recent years (for example, in 2005 and 2007) a new behavior has been observed: the beginning of the flood season has been delayed by one or two weeks. Consequently, there is a late appearance of flood peaks, which has a negative impact on agriculture since the harvesting calendar of rice and other crops are not adjusted for this occurrence.

Furthermore, in the aquaculture sector the key losses occur mainly because of water contamination (combination of brackish and freshwater that might kill the species), excess of sedimentation that affect fish reproduction, loss of fish ponds, and damaged fish cages.

Figure 2. Value of agricultural production per year in the Mekong Delta, period 1995-2004



Source: MRC 2009

Figure 2 shows that the value of agricultural production has a general increasing trend, with the exceptions of years 2000, 2001 and 2002, where the value of agricultural production diminished. Year 2002 already shows an upward but mild trend. It can be observed that the general economic growth was negatively affected in the years when flood discharges and water levels exceeded critical thresholds (MRC 2009, p. 8).

A simple regression to predict the impact of flood levels in the total value of agricultural production in the Mekong Delta shows that the correlation between the two variables is R=0.641 (Table 1). Since there is only one predictor taken into account (flood peak levels), this value represents the simple correlation between flood peaks and the value of agricultural production. Also, the value of R^2 is 0.410. This means that flood peak level accounts for 41% of the variability in the value of agricultural production of the delta. Therefore, around 60% of the variation in agricultural production must be explained by other variables not included in the regression.

Table 1. Model Summary- Regression for impact of flood peak levels in the total value of agricultural production

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,641[a]	,410	,263	,44794

a. Predictors: (Constant), Flood peak level (m3/s)

Source: author's elaboration with data obtained from MRC 2009

As for the analysis of variance, the F-value is 2.79 (Table 2). A good model requires a large F-ratio, and although this model does not represents that case, the value is still greater than 1. However, it is not large enough to be a chance result: it is not significant at $p<0.05$, since the value in the last column is 0.170. Hence, it cannot be stated that the model predicts the value of agricultural production significantly well. This could be explained by the fact that there is missing data on flood peak levels for 4 out of 10 years analyzed in the model.

Table 2. Analysis of variance- Regression for impact of flood peak levels in the total value of agricultural production

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,559	1	,559	2,785	,170[a]
	Residual	,803	4	,201		
	Total	1,361	5			

a. Predictors: (Constant), Flood peak level (m3/s)

b. Dependent Variable: Value of agricultural production (billion USD)

Source: author's elaboration with data obtained from MRC 2009

Finally, Table 3 shows that if flood peak level will increase in 1 m^3/s, then the total output value of agriculture will decrease in 0.000042 billion USD. More clearly, an increase of flood peak level of 10000 m^3/s would result in a decrease of 420 million USD in output of agricultural production (0.000042 * 10000).

Table 3. Coefficients- Regression for impact of flood peak levels in the total value of agricultural production

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4,719	1,331		3,546	,024
	Flood peak level (m3/s)	-4,2E-005	,000	-,641	-1,669	,170

a. Dependent Variable: Value of agricultural production (billion USD)

Source: author's elaboration with data obtained from MRC 2009

Nevertheless, only the significance of the ß value for the constant is less than 0.05 (the ß value for the flood peak level is 0.170). As a result, it cannot be stated that the flood peak level makes a significant contribution to predict value of agricultural output because ß cannot be considered significantly different from zero.

ii. Health and mortality

The number of deaths due to flood is another component in determining the magnitude of floods. Most of the reported deaths involve children, mainly because they are bathing in rivers with strong currents. Also, death tolls increase because of houses that are washed away by landslides.

Besides, floods cause poor sanitation levels: water becomes polluted, and water stagnation can lead to disease outbreak such as dengue, cholera, malaria, diarrhea and skin infections.

iii. Infrastructure

Damage to infrastructure includes all damage concerning irrigation systems (e.g. dikes and dams), houses, schools, health-care centers, among others. Most of these damages occur under the case of long periods of inundation, where infrastructure stands covered in water for extended periods of time. Assets and articles found within household, schools and health-care centers can become unusable, and the building structures can be weakened (Nguyen et al 2007). Also, there are costs of resettlement when households are severely impacted and the relocation of families has to be carried out. For instance, in 2006, 1400 properties were inundated and 800 households had to move temporarily (MRC 2007, p.46).

iv. Transport facilities and communication

As for the case of damage to public infrastructure -such as streets and bridges- houses in remote areas are left without access to the other villages. Damaged telephone poles hamper communication and finally, the loss of transportation assets such as ships and cars represent a major constrain for commercial activities and fishery.

Significant floods over the past 15 years

Different determinants play a key role in the magnitude and impact of floods in the Mekong Delta. According to Be et al:

> *'High floods are caused when three simultaneous factors happen: large water discharges occur originating from upstream as affected by typhoons or tropical low pressures; long and heavy rainfalls occur in the Mekong Delta itself; and, high tides that lead to high water levels in the rivers and canal systems prevent easy drainage.'*
> (2007, p.30)

In order to monitor water level and flow from the Mekong, there are two main stations in the Mekong Delta, Tan Chau and Chau Doc. These are located in the North-Western part of the delta, close to the boundary with Cambodia, as shown in Figure 3. From the information retrieved from such stations, the Hydro-meteorological Department of Vietnam can determine the magnitude of floods each year.

Figure 3. Water monitoring stations of the Lower Mekong River

Source: http://ffw.mrcmekong.org/south.htm

Although the peak water level thresholds to measure the flood intensity seem to vary between different sources, Be et al. (2007) mention that hydrologists consider that floods have a low level when the flood peak in Tan Chau station is not higher than 4.0 m., a moderate level when the flood peak is between the 4.0-4.5 m. interval, and finally when the flood peak reaches more than 4.5 m, it is considered a high flood.

Over the past 15 years, the most devastating floods in the Mekong Delta with respect to high water levels (more than 4.5 m as peak water level) took place in 1995, 1996, 2000, 2001, and 2002 (Be et al 2007). Year 2005 had a peak level high enough to qualify under the term of high flood. However, in the Mekong Delta it was perceived as "a balanced flood", being the year with the least damage recorded since 2000 (MRC 2006, p.67). Table 4 below shows the peak water levels registered in Tan Chau for the aforementioned years.

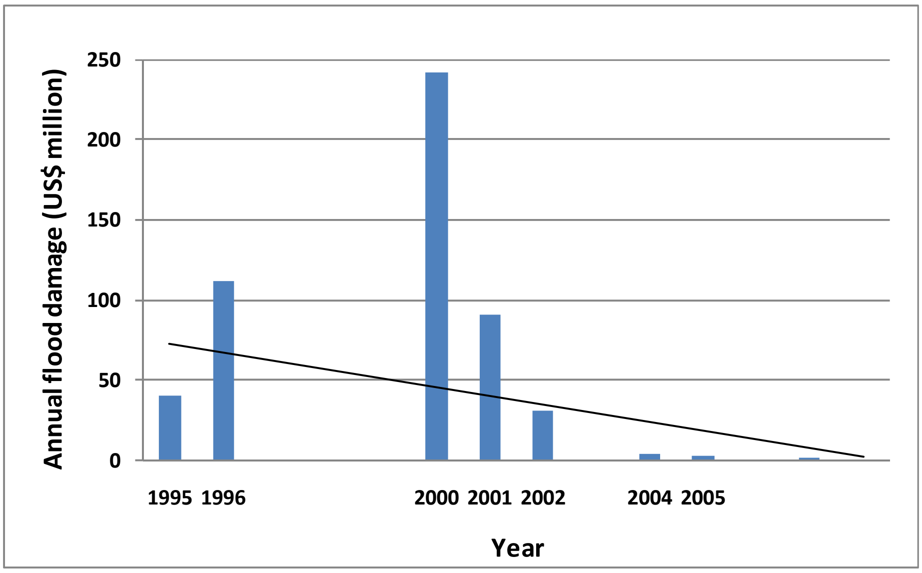
Table 4. Flood peaks at Tan Chau station for selected years

Year	Flood peak (meters)
1995	4.30
1996	4.87
2000	5.06
2001	4.78
2002	4.82
2005	4.53

Source: Be et al 2007 and MRC 2006

On the other hand, year 1995 was considered amongst the years with the highest economic impacts in terms of damage costs, even if its peak level was not under the high flood category (4.30 m). A possible explanation for this might be that although the peak level was not as high as other years, there could have been a more pronounced lack of preparation in terms of structural and non structural measures to cope with floods.

Figure 4. Annual flood damage, period 1995-2008



Source: author's elaboration with data obtained from MRC 2009

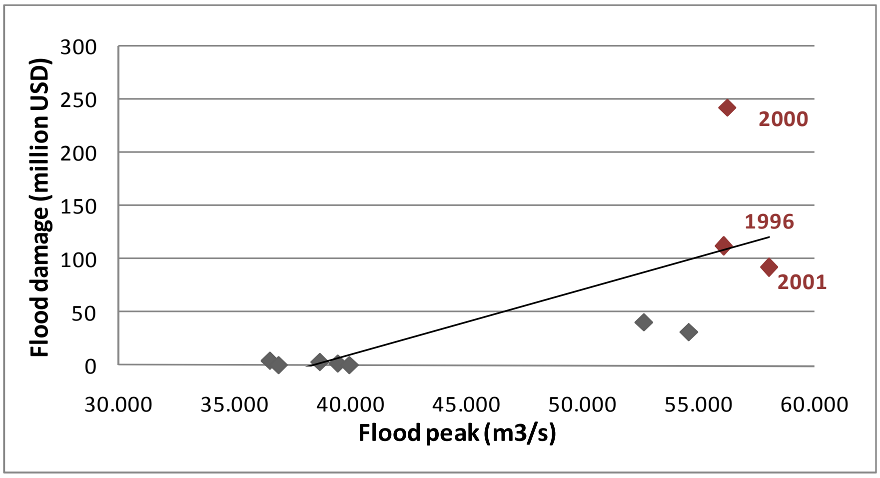
Figure 4 shows that the highest economic damage is linked to the flood of year 2000. This particular year had two significant peaks, one in early August when the water reached over 4.0 m, and the second peak of 5.06 in October, causing severe economic and social losses in the Delta (Das Gupta et al 2004). The average damage for the period 1995-2008 is of 37.5 million USD, and the value reached in year 2000 was 200 million USD higher than the average.

As a downstream area, water levels in the Mekong Delta are highly associated with the activity taking place in the upstream stations (both naturally and landscape/human driven). Hence, it is necessary to keep track of the activity in the upstream stations in order to study and control floods in the delta in a proper way. However, is important to keep in mind that:

> *'Although important, it would be incorrect to define these thresholds* [hydrological benchmarks] *simply in terms of water level or the associated discharge since these variables only describe one aspect of what is a multivariate random process.'* (MRC 2008, p.5)

Other variables such as depth of inundation, duration of flood, velocity of overland flow, amount of sediment deposited, flood frequency and timing or seasonality of the event should also be taken into account. Moreover, there is no single hydrological measure that can be systematically linked to the losses (MRC 2009, p. 32).

Figure 5. Total annual flood damage in the Mekong Delta with respect to peak levels, period 1996-2008



Source: author's elaboration with data obtained from MRC 2009

In Figure 5 it can be observed that year 2001 had a higher flood peak level than the one presented in 2000 (these flood peaks correspond to the one registered in Kratie station, not

Tan Chau), and still the economic damage in 2000 was much higher, indicating that other factors also determine the overall final economic impact of floods. One possible explanation could be the lack of preparation for the flood in 2000, after not having a high level flood since 1996. There were considerable effects in terms of damage and loss of infrastructure in general, and specifically they were probably more evident on deteriorated, low-quality infrastructure such as old houses, buildings, or dikes constructed without proper guidelines. Hence, by the time of the flood in 2001, infrastructure was already damaged or destroyed. Therefore, for that year, the economic damage due to loss in infrastructure might have accounted for a smaller part in comparison to what was registered in the previous year.

By running a simple regression, it is possible to observe the incidence of the flood peak levels in the total annual flood damage registered for the Mekong Delta. The R value of the model is 0.68, and the R^2= 0.46. This means that 46% of the variance in annual flood damage in the delta is explained by this model with only one predictor.

Table 5. Model Summary- Regression for impact of flood peak levels in the total annual flood damage in the Mekong Delta

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,680[a]	,463	,373	65,34407

a. Predictors: (Constant), Flood peak level (m3/s)

Source: author's elaboration with data obtained from MRC 2009

In the ANOVA results (Table 6), the F-ratio is 5.164. This value is not significant at $p<0.05$ (the value in the last column is 0.063), so it cannot be derived that there is an effect of the independent variable in the outcome one (in this case, total annual damage by floods). The same problem previously stated could be the reason: the sample is very small, including only 13 years (period 1995-2008). In addition to this, there are four missing values of flood peak levels out of those 13 years that were considered for the model.

Table 6. Analysis of variance- Regression for impact of flood peak levels in the total annual flood damage in the Mekong Delta

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22050,114	1	22050,114	5,164	,063[a]
	Residual	25619,081	6	4269,847		
	Total	47669,195	7			

a. Predictors: (Constant), Flood peak level (m3/s)

b. Dependent Variable: Flood damage (USD million)

Source: author's elaboration with data obtained from MRC 2009

Lastly, it can be observed through the coefficients in Table 7 that an increase in flood peak levels would have a positive effect in total annual damage costs due to floods. Therefore, according to the obtained values, if flood peak levels would increase in 10000 m^3/s, the total annual damage costs of floods would increase in 60 million USD (10000 * 0.006). However, the significance of the coefficients is not smaller than 0.05 and then probabilities of the t-values occurring if the ß values were 0 are not less than 0.001. Therefore, it cannot be said that the predictor has a significant impact over the total annual flood damage.

Table 7. Coefficients- Regression for impact of flood peak levels in the total annual flood damage in the Mekong Delta

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-236,352	134,878		-1,752	,130
	Flood peak level (m3/s)	,006	,003	,680	2,272	,063

a. Dependent Variable: Flood damage (USD million)

Source: author's elaboration with data obtained from MRC 2009

C) Beyond damage costs: Benefits from floods

It is common to observe that several studies and evaluations focus mainly on the perspective of floods as a negative phenomenon that affects the Mekong Delta on a yearly basis. However, even inhabitants from the region consider floods as part of their livelihoods, interpreting them as normal occurrences more than constant hazards. As a result, several recent studies have highlighted the positive aspects of floods and the importance of giving an impartial view of the overall impact of floods (Be et al 2007, MRC 2009, Nikula 2008). Studying floods merely under the damage scope leads to the underestimation of the natural benefits obtained from them, which could also wrongly lead to interventions and inadequate policies for flood management. For instance, if a farmer has devoted his whole working life to the cultivation of a specific crop, he might prefer to have access to credit as a way to cope with risk of floods instead of switching to a whole different activity (as some relocation programs might suggest). In this way, the expertise that he has earned over the years can be maintained and exploited.

Benefits of floods in the Mekong Delta

The annual Mekong flood is linked to the cultural and socioeconomic evolution of the region. Just as other distinguished civilizations that developed around a river basin, the Mekong region is a product of social organization and water management efforts as a way to exploit the benefits and avoid the risks brought by its annual flooding condition (MRC 2009). In the Mekong Delta, the perception of flood (which locally is referred as "high water season") is very different from the other areas of the Mekong Basin (MRC 2006, p.65). Inhabitants are already aware that every year they have to face high water levels and hence they prepare in advance for such an event.

Agriculture and aquaculture

Some of the benefits from floods in the agriculture sector are the increase in the supply of fresh water for irrigation, improvement of navigation transport for commodity trade, soil enrichment due to water containing minerals (acting as a natural fertilizer for crops), and the reduction of insects and other species that endanger crops. Also, people living in the Long Xuyen Quadrangle and the Plain of Reeds practice fishing during flood season in the very deep flooded areas. Profits of capture fishery are positively linked to flood extent and duration (MRC, 2009a). In the dry season, fish retreat to river channels and lakes, but when the flood season approaches, they take advantage of the feeding grounds for reproduction and migration (White 2002, p.15).

There is a very special characteristic with respect to fish migration in the LMB. The Great Lake, located in the Cambodian floodplain, acts as a natural regulator for water flows downstream. During the flood months, the excess of water flows up from the Mekong mainstream into the Lake via the Tonle Sap River, increasing water levels in the lake. As soon as the water level decreases in late September, the water starts to flow out of the lake and takes the opposite direction, going from the Tonle Sap down into de Mekong mainstream. This flood reversal is the cause of massive fish migration in the area, and nowhere else in the world is there a flow reversal of this magnitude (MRC 2006, p. 6). Also, this flow reversal act as a scattering method for alluvial sediments that can serve as a source of nutrients for aquatic life.

Many other benefits have been attributed to flooding effects, but they are more difficult to quantify in economic terms. Some of them are wetland conservation, removal of excess nutrients and pollutants, pest control, reduction of fire risk, sulfate dilution, and fertile sedimentation of the floodplain. Improvement of navigation and freshwater access for irrigation and domestic consumption are other benefits directly related to water availability.

It is possible to find studies on estimations of flood damages and losses over the past years, but it is not the same case for the benefit data. The lack of information makes it difficult to carry out a proper cost-benefit analysis (CBA) of floods. However, that is not the only constraint in when comparing costs and benefits of annual floods:

> ‘*Some level of benefit accrues in all years but significant costs do not. For costs to arise the flood, in terms of peak discharge and water levels, has to exceed a certain threshold. The costs are then a function of the magnitude of the exceedance and the consequent depth of inundation, its duration and areal extent and the value at risk in the flooded area (…) Average annual regional flood costs do not therefore provide a statistic that is directly comparable to the financial benefits.’* (MRC 2009, p.35)

Even under this statement, the Mekong River Commission Secretariat does affirm that the low frequency of loss and damage occurrences in the LMB over time results in benefits exceeding the costs of floods by a very large margin (2009, p. xiii).

From this chapter it is possible to summarize some relevant points. The Vietnamese economy is highly dependent on agriculture and aquaculture activities, and two of the most important ones, rice and fish production, are carried out in the Mekong Delta. Consequently, the occurrence of heavy floods in this area on a frequent basis (resulting in severe inundations) represent a major threat for agriculture and therefore for the overall economy of the country. During 1995-2008 there were five years that registered high water levels, with the year 2000 being the most significant one in terms of economic damages. Nonetheless, peak water levels is only one of the many variables that can play a role in the extent of loss after floods, given that economic damages cannot be linked to only one hydrological measure.

A possible hypothesis derived from the available information is that the lack of preparation for floods in terms of efficient coping measurements and infrastructure might have enhanced the overall negative impact of such incidents. Furthermore, in spite of the risks that flood season comprises, the inhabitants of the Delta also perceive floods as a constant and normal phenomenon that can bring several benefits. However, it is difficult to gather quantitative data in terms of benefits arising from floods, which hinders the proper development of a CBA. Government authorities and local committees in charge of flood control should keep in mind that underestimating these benefits can lead to inadequate interventions, such as targeting damage costs of floods without taking into account the positive outcomes derived from them.

III. Case Study- Flood impact in Dong Thap province: 1995-2008

A) Description of the area

Dong Thap province is one of the 13 provinces located in the Mekong Delta. Its population is of 1.7 million people (10% of the Mekong Delta) and its area is of 3375 km^2, which represents around 9% of the total area of the Mekong Delta[2] (GSO 2010). It is divided in 12 administrative units: Cao Lanh, which is the capital city of the province; two main towns, Sa Dec and Hong Ngu; and 9 districts. With a strategic position bordering Cambodia, Dong Thap has seen a great surge in commercial investment, growth of economic services and the development of international trade in the past years.

Figure 6. Map of Dong Thap province. Mekong Delta, Vietnam

Source: http://www.dongthap.gov.vn/utility/map-dtnew/dtmap1.htm

Dong Thap represents a rich area in natural resources because of its geographical characteristics. The eastern side of the province is mostly part of the "Dong Thap Muoi", or the Plain of Reeds of Vietnam. This plain is a flat lowland region mainly composed of acid-

[2] Preliminary data on Population and Employment for 2008

sulphate soils that, between September and October, turns into a vast lake as some areas are flooded to a depth of nearly 4m (Mekong Wetlands Programme, n.d). Originally, the plain was covered in dense vegetation with small natural streams, but nowadays the massive agricultural expansion has changed most of the natural areas into rice production fields.

At present time, Dong Thap is focusing on increasing workers' incomes. Their current approach is to create jobs for the development of the industry and service sectors in rural areas. The province is investing in programs to expand vocational colleges and centers, training 1200-1500 students annually (Dong Thap Province Website). Its focus relies on training programs for economic development of the region, business activities and human resources, and international economic integration.

B) Main economic activities

Dong Thap's economy has been rising at a vigorous pace. In 2007, the GDP growth was of 15.26% with respect to 1997, a value that exceeded initial projections (14.5%). Although the main economic sector of the province is Agriculture (51.48%), both the Industry (19.7%) and Service-Trade (29.35%) sectors have displayed a positive growth trend over the past years. Particularly in 2007, Agriculture, Forestry and Fisheries increased in 8%, Industry and Construction in 31.04% and Commercial Services in 19.97%, in comparison to 2006 (Dong Thap Province Website).

Agriculture and aquaculture

Dong Thap is one of the main contributors to Vietnam's rice production for export and food security. According to the MRC, the province has two dominant growing cycles per year, except in some small areas were three rice cycles are grown (2009a, p.16). However, statistics from the GSO register paddy production only for the spring and autumn crops, as information for the winter crop is only available from 1995-1996. According to the GSO, the Dong Thap region can yield over 2.5 million tons of rice per year.

Other agricultural goods such as soybean and diverse vegetables are grown in nearly 38.000 ha of agricultural land. Straw mushrooms and lotus species are among other crops cultivated for export. Furthermore, Dong Thap specializes in the production of flowers and ornamental plants for commercialization around the Mekong Delta and Ho Chi Minh City.

At present, the investment in the province focuses not only on the improvement of the quality of the flowers, but in the promotion of Dong Thap as an attractive and ecological destination for foreign tourists.

Aquaculture and fishery is considered the second most relevant economic activity in Dong Thap after rice production. Among the main fish types that are bred in the province are catfish, basa fish, crayfish, and river crabs. Also, some farmers are now practicing the combined rice-shrimp farming system.

Industry

Dong Thap's industry has focused on building infrastructure to attract national and foreign investors. There are 3 industrial parks and 30 primary industry centers. This area is closely positioned near the river bank, and its active port gives it more value because of its transportation facilities. It is considered an attractive place for investment due to its natural geographic advantages, raw material and natural resources, and workforce. Some of the most developed industries are seafood processing, rice husking, clothing, pharmaceutical and the construction materials industry (ceramic, bricks, tiles).

Services

The service sector has had a strong development in Dong Thap. The import-export turnover of the province reached more than 740 million USD in 2007. Some of the key export items are rice, seafood, frozen shrimp and garments. As for tourism, the temples and beautiful scenes of the province attract many visitors each year. The primary forests of Malaleuca are a main attraction, as well as ecotourism in Gao Giong, the "green lung" of the Plain of Reeds.

C) Damage costs and benefits from floods in Dong Thap

As mentioned before, since Dong Thap is located in a flat lowland region, during the rainy season it is one of the provinces most affected by floods. In general, the flood season lasts from 3.5 to 5 months, with inundated areas that reach depths of 0.5 to 4 m. Three flood periods are recognized: a) the early flood (July-August), when flows from the Mekong River flood paddy fields; b) the main flood that combines high water levels from the river and overland flooding coming from Cambodia; and c) the receding flood (October-December), when overland floods from Cambodia diminish (MRC 2009a, p. 141).

Economic damages in the area have varied throughout the past 15 years depending on the intensity and duration of the floods. In this section some statistics of the province from the period 1995-2008 will be presented in order to determine the impact of floods in the economic activity of the agriculture sector, and in general, in the total damage costs due to this natural phenomenon.

Damage costs of floods

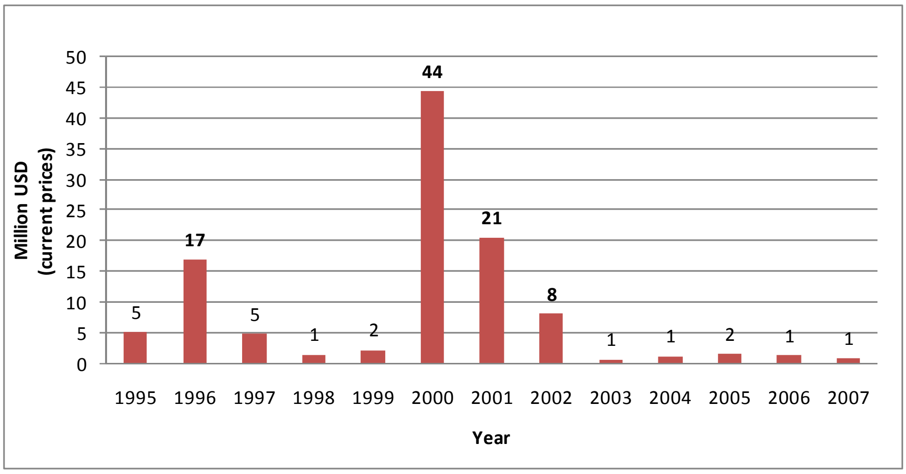
Several documents regarding general research conducted in the Mekong Delta mention the difficulty of obtaining precise figures from governmental authorities because of the lack of information or the inconsistency between data gathered at the national level and the one collected locally (MRC 2006, Sneddon & Hang 2001, White 2002). For the case of Dong Thap, there are some discrepancies in the damage cost figures from the Provincial Steering Committee of Storm and Flood Prevention (a local organ of each provincial People's Committee) and those from the Central Committee for Flood and Storm Control (CCFSC). This was an unexpected finding since statistics and data from each provincial People's Committee are gathered nationally in order for other entities (such as the CCFSC) to access them for various uses. Therefore, for the purpose of this study, only the data from Dong Thap's Steering Committee was used given that this is assumed to be the primary data.

Although each of the two aforementioned committees has different names for the categories in which they classify flood damages, they commonly refer to the same sectors. The main categories are: People; Housing and Property[3]; Agriculture and Forestry; Water Resources; Transportation; Fishery[4]; Telecommunications; Energy and Others. The reports on damages caused by floods in the Mekong Delta and on storm and flood prevention are not written every year, they are produced only for the years in which there is significant damage due to floods.

[3] Divided in Housing, Education and Health Care by the Steering Committee of Dong Thap

[4] Namely Aquaculture by the Steering Committee of Dong Thap

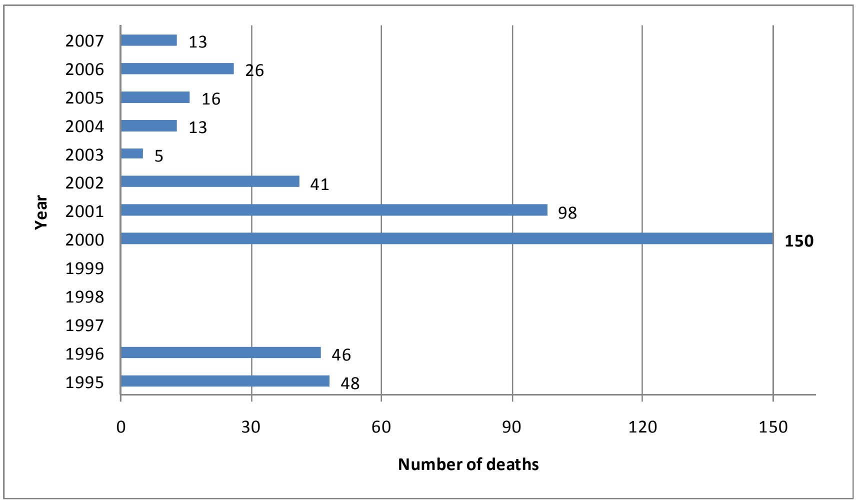
Figure 7. Total economic losses due to damages caused by floods in Dong Thap province, period 1995-2007



Source: author's elaboration with data obtained from Dong Thap People's Committee[5]

Figure 7 shows the total economic damage from floods in the Dong Thap province for the period 1995-2007. As in the rest of the country, the most significant flood in terms of economic costs occurred in 2000, leaving a total damage worth 44.2 million USD. Year 2000 witnessed one of the biggest floods of the century in Vietnam. It led to the largest regional loss of life and socio-economic damage in recent decades (MRC 2007, p.29). High damage costs were also registered in 1996, 2001 and 2002.

Figure 8. Deaths caused by floods in Dong Thap province, period 1995-2007



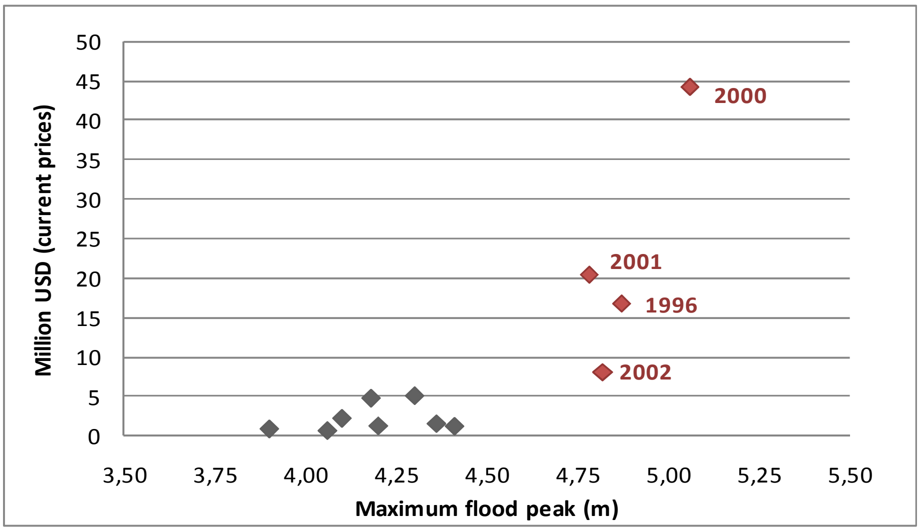
Source: author's elaboration with data obtained from Dong Thap People's Committee

[5] 1 USD= 18.800 VND

As mentioned in Section 2, the number of deaths is considered an indicator of the magnitude of the flood. Figure 8 shows that year 2000 registered 150 deaths caused by the floods in the province, tripling the numbers from other years with high flood levels such as 1996 and 2002. Year 2001 also had a high level of mortality, with 98 deaths. According to the statistics, almost all deaths correspond to children.

Concerning the relationship between damage costs and peak flood levels in Tan Chau station, Figure 9 shows that year 2000 registered the highest flood peak in the period, this being 5.06 m. Even if the maximum flood peak in 2001 (4.78 m) was lower than the one in 1996 (4.87 m), the total damage costs were higher (20.5 million USD).

Figure 9. Damage costs and maximum flood peaks registered in Tan Chau Station for Dong Thap, period 1995-2007



Source: author's elaboration with data obtained from Dong Thap People's Committee

Furthermore, 2001 and 2002 had similar flood peak levels but differed significantly in damage costs (2002 had an economic loss of 8 million USD, 12.5 million USD less than in 2001). In a study carried out by the MRC, it is mentioned that 2001 featured more winds that created higher waves, possibly causing more damage (MRC 2009a, p.16). Also, they state that after the big floods from 2000 and 2001, governmental organizations and people learned to take more precautions to avoid damage and cope with floods (prevention programs, infrastructure reinforcement, etc), which could be reflected in the lower damage costs registered for 2002.

According to the regression model, the value of R^2 is 0.426. This explains that the flood peak levels can account for 43% of the variation in damage costs of the province, as it is shown in Table 8. Therefore, the other 57% of the variation must be explained by other variables that are not taken into account in the model.

Table 8. Model Summary- Regression for impact of flood peak levels in the total damage costs in Dong Thap Province

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,653[a]	,426	,374	9,90347

a. Predictors: (Constant), Maximum flood peak (m)

Source: author's elaboration with data obtained from Dong Thap People's Committee

The ANOVA results reveal that the F-ratio has a value of 8.16, with a significance level of 0.016 (Table 9). Because the value is not significant at $p<0.001$, it cannot be state that the regression model is more accurate in predicting the damage costs of floods in the province that if the mean value of damage costs would be used. However, with 1(df_m) and 11(df_R) degrees of freedom, the critical value at $p=0.05$ is 4.84. The observed value, 8.16 exceeds the critical value and therefore is significant at a 0.05 level of significance, meaning that there is an effect of flood peak levels in the damage costs of floods when $\alpha=0.05$.

Table 9. Analysis of variance- Regression for impact of flood peak levels in the total damage costs in Dong Thap Province

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	800,211	1	800,211	8,159	,016[a]
	Residual	1078,866	11	98,079		
	Total	1879,077	12			

a. Predictors: (Constant), Maximum flood peak (m)

b. Dependent Variable: Damage costs (million USD current prices)

Source: author's elaboration with data obtained from Dong Thap People's Committee

In Table 10, the coefficients show that there is a positive relation between the flood peak levels and the damage costs of floods. According to the values, if the maximum flood peak would increase in 1 decimeter, then the damage costs of floods in the Dong Thap province would increase in 1479 million USD (14785 * 0.1). In this regression model it can be observed that the significant values of the last column are both smaller than 0.05. Therefore, the results shows a genuine effect because ß is significantly different from zero, which means that flood peak levels has indeed incidence on the damage costs of floods in Dong Thap.

Table 10. Coefficients- Regression for impact of flood peak levels in the total damage costs in Dong Thap Province

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-55,235	22,441		-2,461	,032
	Maximum flood peak (m)	14,785	5,176	,653	2,856	,016

a. Dependent Variable: Damage costs (million USD current prices)

Source: author's elaboration with data obtained from Dong Thap People's Committee

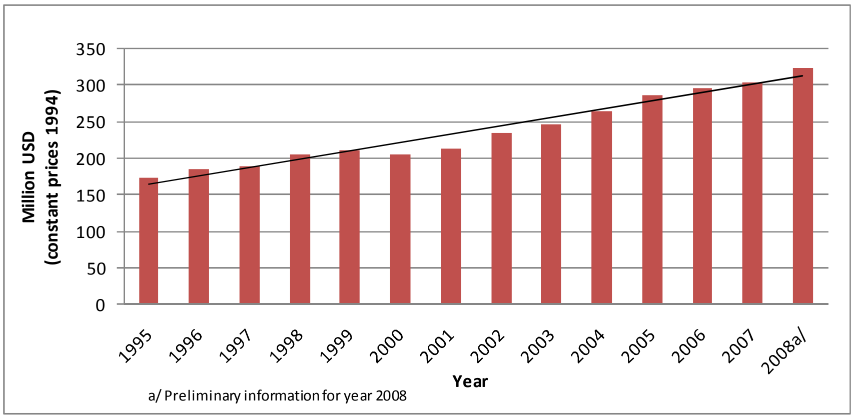
There is no consistent information throughout the years regarding the economic costs of floods for Dong Thap per each of the sectors. In some cases, the information is not available, and for others, it is not reported. For example, reports of damage to infrastructure are generally estimated only when external funds are requested for reconstruction (MRC 2006, p.22). Therefore, for the purpose of this study a particular focus will be done exclusively on the agricultural sector, by analyzing, in an indirect way, the effect of floods in different agricultural activities in the province during the past 15 years.

Impacts of floods in agricultural production

With its overall increasing agricultural production, Dong Thap is a main contributor to national development as well as to the improvement of people's livelihoods (Provincial Steering Committee 1998, p.1). As previously mentioned in sub-section B, agriculture is the main economic sector of the Dong Thap province. Consequently, the trends in agricultural output, mainly for paddy, as well as for the aquatic production of the region, are mentioned here in order to determine if there is a relation between the flooded years and total production levels.

Figure 10 shows the output value of the agricultural sector in Dong Thap. Year 2000 is the only year of the period where a negative growth rate value is observed (-3.0%). All other years show a positive growth rate over 3%, with the exception of 1997, 1999 and 2007 (2.6%, 2.5% and 2.8% respectively).

Figure 10. Total output value of agriculture in Dong Thap province, period 1995-2008

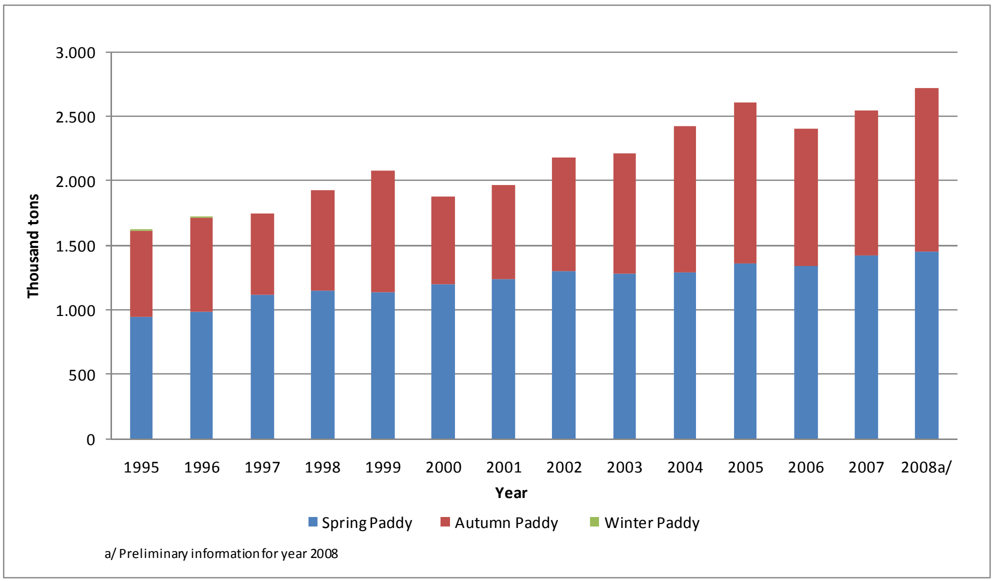


Source: author's elaboration with data from the GSO

i. Rice production

Rice cultivation is the main economic activity in the Plain of Reeds. Dong Thap used to have 3 rice growing cycles per year, but after 1996 there are no registers for paddy production in the winter crop, indicating that nowadays the area is mainly focused on the spring and the autumn crops. However, according to the report on Flood Damages, Benefits and Flood Risk in Focal from the MRC (2009a, p.33), the application of proper flood control measures such as adequate drainage and irrigation procedures could make possible the implementation of a successful triple crop system, resulting in higher revenues for the region (aprox 900 USD/ha).

Figure 11. Total production of paddy by season crop in Dong Thap province, period 1995-2008

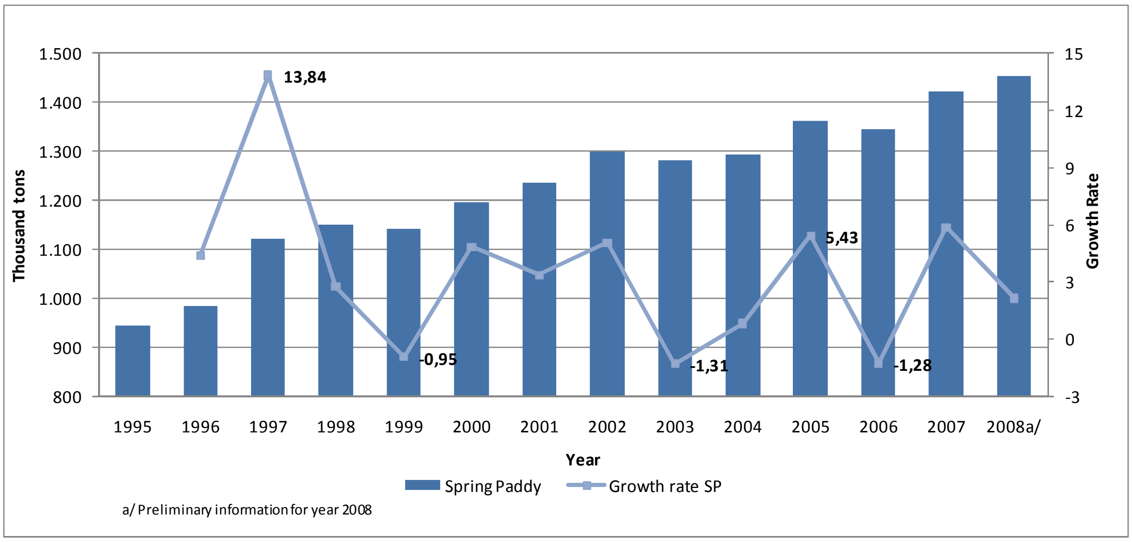


Source: author's elaboration with data from the GSO

For the period being studied, the total production of paddy in Dong Thap represents on average between 12-14% of the total rice production of the Mekong Delta. Figure 11 shows seasonal paddy production trends in Dong Thap over the past 15 years.. Throughout the years, the spring paddy has represented the biggest portion of the total paddy output. There is an overall positive growth rate in rice production along this period with the exception of years 2000 (-9.6%) and 2006 (-7.7%). As established earlier, year 2000 experienced one of the biggest damages caused by floods in Vietnam. This was reflected in the agriculture output of Dong Thap, as well as in the Mekong Delta in general, and it can explain the negative value in the growth rate of paddy production for that year.

On the other hand, year 2006 represents a special case. Water levels registered in Tan Chau for this year were marginally below average. However, these maximum levels occurred two weeks later than normal. Even if the total economic damage in the delta was not severe, the delay in flood peaks had a negative impact for the agriculture sector. High tides combined with incoming flood flows from upstream generated a long period of inundations (MRC 2007, p.33). Hence, the loss of crops due to inundation could explain the decline in paddy production in Dong Thap for year 2006. Loss of paddy crops and damaged land represent good indicators for measuring the impacts of floods; unfortunately, these data for Dong Thap is incomplete for the years considered in this study.

Figure 12. Total production of spring paddy in Dong Thap province, period 1995-2008

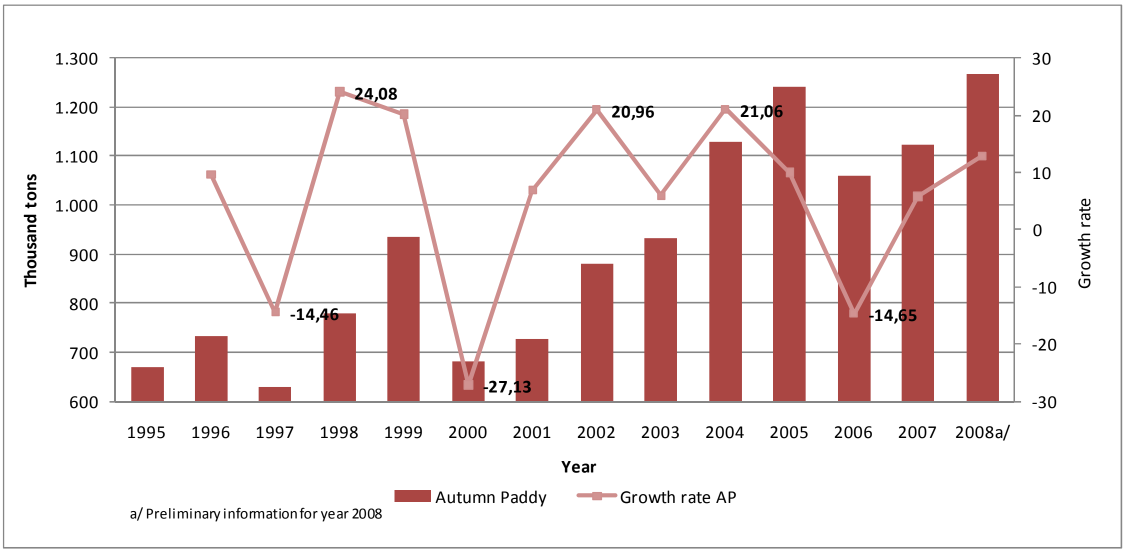


Source: author's elaboration with data from the GSO

When analyzing the variations of the spring and autumn paddy crops separately, it is observed that the growth rate variations for the autumn paddy tend be more volatile when compared to the ones from the spring paddy crop (Figure 12 and 13). Coincidentally, the autumn paddy crop takes place during the wet season; it is planted from March-April and is harvested from July to mid of August; whereas the spring paddy crop is planted between November-December and harvested between February-March, during the dry season.

Figure 13. Total production of autumn paddy

in Dong Thap province, period 1995-2008



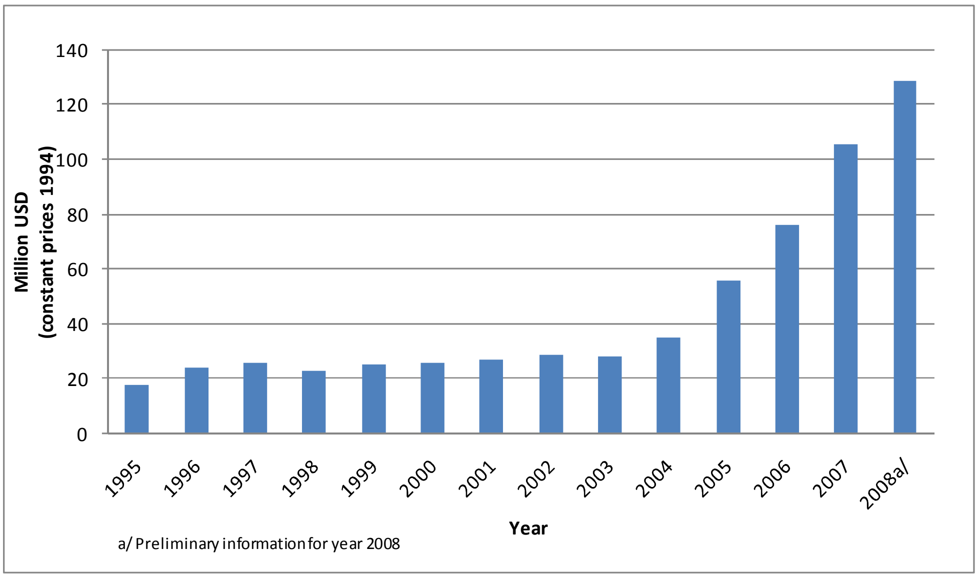
Source: author's elaboration with data from the GSO

As a result, flood damage to rice crops occurs mainly in the autumn paddy (MRC 2009a, p.10). In 2000 and 2006, negative growth rates were registered in rice production (-27.13% and -14.65% respectively, graph 13). Nowadays, areas severely affected by deep-floods in the Plain of Reeds are protected with dikes that were designed to protect agricultural land from floods starting in August, as a way to ensure the safe harvesting of the autumn crop. However, if the flood comes earlier than August, the crop can suffer severe damages.

ii. Aquaculture and fishery

Aquaculture activity in Dong Thap has taken a positive turn especially over the last 5 years. The area of water surface devoted for aquaculture has increased from 3200 ha in 1995 to 5800 ha in 2008 (GSO, 2008). The output value of fishing has increased drastically over the past years, showing growth rates of over 20%. In 2008, the preliminary figure of output value of fishing was of 128.6 million USD. Figure 14 illustrates the behavior of the output over the period 1995-2008.

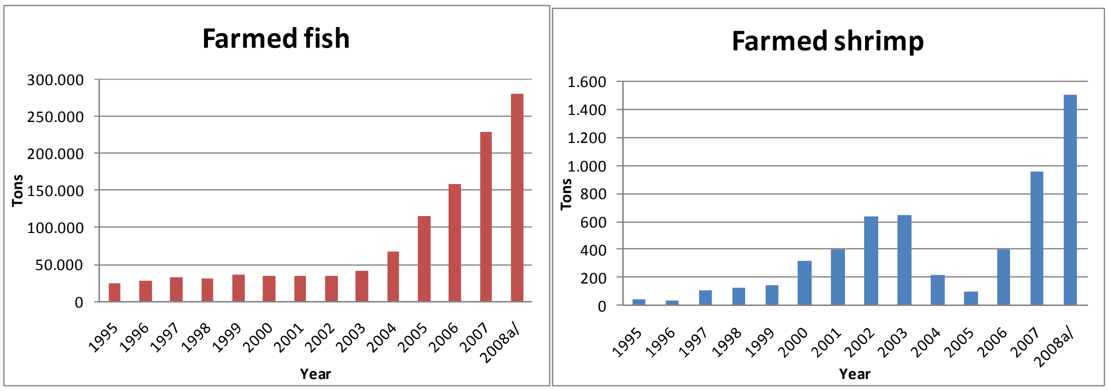
Figure 14. Output value of fishing activity in Dong Thap province, period 1995-2008



Source: author's elaboration with data from the GSO

From the studied period, only 1998 and 2003 show a negative growth. However, growth rates of year 2000 and 2001, two of the main flood years, were very modest in comparison to other years (2.2% and 3.4% respectively).

Figure 15. Total farmed fish and shrimp in Dong Thap province, period 1995-2008



Source: author's elaboration with data from the GSO

With respect to the production of farmed fish and shrimp (Figure 15), the period between 2000-2002 shows a stagnant pattern in the amount of tons of farmed fish. One of the possible causes might be the big amount of fish and shrimp ponds that were destroyed after the floods, in addition to the drifted fish cages. Also, elevated levels of sediments in riverbanks during the flood period can cause clogging of fish gills and decrease penetration of light in water, slowing the photosynthetic process and therefore affecting the growth of aquatic plants (2009a, p.99).

Shrimp farming activity is not as strong in Dong Thap as in other coastal provinces such as Soc Trang, Bac Lieu and Ca Mau, which have the conditions for optimal shrimp farming (brackish water). Nevertheless, the modest shrimp farming industry in the province has shown a notable growth in the past 3 years (Figure 15).

Benefits of floods in Dong Thap

For the report on Flood Damages, Benefits and Flood Risk in Focal Areas elaborated by the MRC, several interviews and focus groups were carried out with household members from the Dong Thap province. According to these farmers, after a period of big floods, the amount of fertilizers and pesticides needed for the spring paddy crop is less than the normal amount that they would use in an average non-flood year, reducing their overall production costs. Moreover, paddy yield is higher by 0.5-1.0 ton/ha (MRC 2009a, p.33). Regarding aquaculture and fishery, families that live in flooded areas in the Plain of Reeds take advantage of their position by capturing fish during the flood period, which could last from 30 to 120 days.

In general, participants in the study categorized floods that allow the normal growth of the autumn rice crop and increase the fish catch as “good floods”. “Bad floods”, on the other hand, were those that started sooner (before August), the ones that lasted longer than normal and/or the ones with higher-than-normal water levels (2009, p.143).

There are several points that stand out from this chapter. As mentioned in Chapter II, it was evident that the maximum flood peak level cannot be strictly linked to the economic loss of the selected years of study. In addition, as in the rest of the Delta, the strong flood of 2000 had severe impacts on Dong Thap, which resulted in a considerable reduction of rice yield for that year. At the moment, infrastructure has been developed to protect rice production from these events, especially the autumn paddy crop which is the most susceptible to damage by floods. However, variability in the beginning of the flood season still represents a risk for farmers.

Most of the provinces in the Delta have vast natural resources; a factor which explains why most of them have agriculture-oriented economies. Dong Thap is no exception to this abundance in resources; however, its flat, low-land area and geographic position makes it more vulnerable to floods and extended inundations than other provinces. Floods and other natural disasters result in major economic losses, and the consequent volatility of revenues generates instability for the farmers and the province's economy. Therefore, the focus of the provincial government to empower the Industry and Service sectors might not only represent a development alternative through diversification of activities, but also a way of guaranteeing a higher and more stable income for its inhabitants. Also, another particular distinction of Dong Thap with respect to the rest of the provinces of the Delta is its optimal geographic position (bordering area with Cambodia). In line with the growth rates of the Industry and Service sector, this advantage could lead, in the near future, to a shift in the main economic basis: from an agriculture-based economy to an industry/service-oriented one.

IV. Current initiatives for flood management in the Mekong Delta

According to the most recent study by the MRC (2009a, p.152), Vietnam has a well organized system of flood warning, preparedness, emergency response and recovery that is coordinated through the various governmental levels. Information on flood warnings and status is disseminated through television, and budget plans are prepared beforehand to be implemented in case of emergency.

A) "Living with Floods" strategy

The Vietnamese government, aware of the recurrent floods in the Mekong Delta, and after the catastrophic flood that took place in 2000, decided to implement a strategy called "Living with Floods". This strategy is based on a full realization of the non-preventive nature of floods, and also from the positive and negative impacts on livelihoods (Tinh & Hang 2003). The strategy also promotes the involvement of communities in disaster planning at a local level (district, communes) by preparing discussions and field work conducted by local representatives.

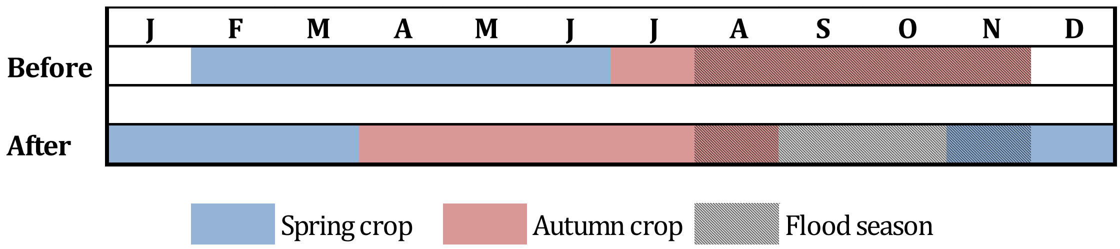
According to Weichselsgartner (2005), most governmental programs on flood management tend to have a top-down angle. However, this new cooperative mechanism shows that mitigation measures are implemented through a bottom-up approach. The top-down approach is also one of the main criticisms that NGOs in Vietnam point out to the multilateral international organizations that perform research studies in the area. The latter ones tend to have a narrow vision on infrastructure development, neglecting the basic needs and specific problems of the people by only focusing on broader levels of action (White 2002, Fox 2003 cited in Nikula 2008).

There are different ways in which flood damage loss can be reduced:

> *'Options include (i) flood prevention by structural measures (e.g., dikes, embankments, reservoirs); (ii) flood prevention by non-structural measures (e.g., hazard zoning, land use regulation); (iii) flood preparedness (early warning and alert systems, awareness raising campaigns); and (iv) flood response by emergency assistance and disaster relief.'*(Weichselgartner 2005, p.8)

Also, they should be divided between short, medium, and long-term measures depending on people´s needs and the context of the situation.
Raising awareness of how to cope with floods is one of the main targets of this strategy. Some of the positive results of the diffusion of information are the rise in floor levels in flood-prone houses, the building of embankments to protect crops, the provision of swimming lessons for kids in some communities, and the creation of daycare facilities for children to stay while their parents work, to avoid the risk of death during floods.
One of the main changes to reduce the damage in the agricultural sector was the shifting of the cropping calendar, as is shown in Figure 16. Initially, the spring crop was planted in February and harvested in June, whereas the autumn crop was planted in July and harvested in November. There were some places in which the farmers also grew a third crop during some months. This was causing severe damage to the autumn crop, which was in the middle of the flood season (August to November), coinciding with the growing season of rice.

Figure 16. Shifting of the cropping calendar in Vietnam



Source: author’s elaboration with data obtained from Tinh & Hang 2003

As a solution, the Government banned the third crop and suggested a shift in the cropping calendar. That is why the spring crop is now planted in November and harvested in March and the autumn crop is sown in April and harvested in August. Also, nowadays it is possible to cultivate floating rice in some areas during the flood season.
In the past years, several structures have been constructed in Vietnam for transport, salinity protection, land reclamation and urbanization, and storm protection. Among these, roads and dikes against floods are crucial to prevent of massive damage (Hoa et al 2007).

B) Constraints to flood management

Local communities and the Government also have to deal with some constraints when applying flood damage prevention measures. For instance, Tinh & Hang (2003, p.4) mention that the quality of some residential areas constructed after the 2000 flood was poor, resulting in deterioration and damage after the 2002 flood. Also, loans assigned for the construction of flood-proof infrastructures benefited mainly the middle-class in the delta, and not the poorest people who are the ones that needed them the most.

Another inconvenience in flood management of the delta is the fact that in the case of a transboundary river basin, such as the Mekong River, information of flood frequency and water discharge is needed from upstream countries in order to develop adequate policies on flood control throughout the basin. The fact that China and Myanmar are not part of the Mekong River Commission makes it more difficult to obtain the information on water behavior upstream. Moreover, the environmental and economic impact of China's huge investment in dam construction over the rest of the downstream countries is still uncertain, given that data regarding these projects is inaccessible in most cases.

Miscommunication is another problem when referring to information regarding floods. As mentioned before, with the case of the People's Steering Committee and the CCFSC, sometimes different governmental entities have dissimilar data with respect to one same topic, misleading the results of research. Also, many international organizations develop projects and studies in Vietnam, however, the lack of coordination among them leads to repetitive investigations, inconsistent information, and in many cases the results of these studies do not even reach the Government for further use in future planning.

Finally, a very important issue to consider is the expected impact of climate change in Vietnam. In particular, the Mekong Delta is one of the most vulnerable areas of the country because of its susceptibility to inundations (MRC 2009b, p.16). The current development of new studies on how to deal with such incidences should be encouraged in order for authorities to be fully informed when analyzing the best options to adapt to forthcoming climate variations. More information on this topic can be found under the Appendix I.

To synthesize, there are still elements that need to be considered for future planning in terms of flood control. It is fair to recognize that the strategy of "Living with Floods" has managed to act under a more local approach to eventually expand to broader levels. Nonetheless, further research should be developed to target the most vulnerable groups in a way that when aid is provided, they have a priority in receiving it. Also, the quality of this aid should be guaranteed, not only acting as a temporary patch to cover damage in the short term.

It is important to enhance the development and maintenance of infrastructure for crop and house protection during flood periods, but the government and aid organizations should reinforce the monitoring of the impact of such implementations to make sure that their long term effect is indeed in line with the main idea of improving flood management and control, and consequently, improving livelihoods. For instance, without the proper assessment, creation of embankments and river deviations could lead to floods in new areas, or relocation of households to prevent risk of floods could lead to poverty increment if residents do not receive the proper aid to develop alternative sources of income in their new location.

Furthermore, expected effects from climate change in the agriculture of the Delta should be taken into account when developing future policies and implications related to flood management and coping. Considering that damage costs due to natural disasters are expected to increase soon, authorities should come up with alternatives that will work as income sources in order to deal with such changes on time.

V. Conclusions and Recommendations

From the study of floods in the Mekong Delta over the past 15 years, it can be concluded that the agricultural sector in the region tends to suffer severely from losses during flood years. In recent years there have not been critical floods in the Mekong Delta such as the ones that took place in the period between 2000-2002, therefore the damage costs related to floods have been relatively lower than before. Nevertheless, a massive flood could occur at any moment and the inhabitants of the Mekong Delta should be prepared to face it without dealing with such high damage costs. Also, although the high peak water levels tend to be related to high economic losses, different hydrological and situational variables intervene in the total damage costs of each flood. An explanation for the differences in damage costs under similar flood years could be the lack of preparation for them when not dealing with adequate coping measures and quality infrastructure. As a result, this could have increased the overall damage of the floods in some years.

However, floods do not only bring economic loss and damage. People in the delta also perceive the positive benefits that annual floods bring to their livelihoods. Soil enrichment, decrease in agricultural production costs, and optimal conditions for aquaculture activity are some of the benefits that people in the Delta can enjoy as a consequence of floods. Nevertheless, when trying to present such benefits in quantitative terms, there is still a constraint that makes it difficult for researchers to develop accurate cost-benefit analyses. This could give space to the emergence of policies for flood control that underestimate the positive effects of the natural phenomenon.

Dong Thap is not an exception to the damage suffered by other provinces in the Delta. The same pattern of major economic loss was also registered for years 1996, 2000, 2001 and 2002. In 2000 the damage costs were of 44.2 million USD and 150 deaths. The output of agriculture had negative growth rates for 2000 and 2006. It was also noticed that growth rates of paddy are more volatile for the autumn crop than for the spring crop, mainly because the autumn crop takes place during the rainy season. Presently, infrastructure such as dikes and canals has been constructed to protect rice harvests during the flood season, especially the autumn paddy. However the uncertainty in the starting time of the flood season continues to represent a risk for farmers’ annual production yields.

In the aquaculture sector, on the other hand, the output value of fishing is positive in all flood years, even if sometimes it represents only modest growth. Dong Thap has a modest shrimp farming activity in comparison to other coastal provinces in the Delta, but still it has shown a considerable increase in total output after 2006.

Although Dong Thap is still highly dependent on agriculture (representing 52% of the economy), the development of the Industry and Service sector promoted by the provincial government has become evident throughout the past years. On one side, Dong Thap's flat condition and geographical position makes it a vulnerable area to floods. On the other hand, this position is the one that allows the development of trade, services and transport facilities, giving it a relative advantage with respect to other provinces. Therefore, it can be expected that the Industry and Service sectors will maintain a steady growth in upcoming years, guaranteeing higher and more stable incomes to the people in the province.

As for the Government's participation in flood management in the delta, the creation of the initiative called "Living with Floods" has been a major step from the local levels of the government to work in cooperation with people from communes and districts at a more personal level under a bottom-up approach. Raising awareness of cropping conditions, infrastructure development to prevent floods and daycare facilities for children are some of the positive aspects of this program. Still, bad quality of construction works unable to resist floods and the lack of monitoring of previous investments to ensure their effectiveness are some of the main problems that prevail.

Several considerations have to be made and/or reinforced for the implementation of initiatives to cope with flood as well as with environmental change. First, the possibility of implementing a third rice crop should be studied in detail. With the proper drainage and infrastructure, high revenues are expected from this activity. However, it is important to consider future climatic conditions to see if it is feasible to invest in such infrastructure in the long run. New technologies are already being tested to create variations of a more resistant paddy that could grow under heat stress conditions, but their quality and nutritional value may not be as satisfactory as expected.

In addition, another alternative to increase benefits from floods could involve carrying out workshops and training programs designed by local governments to instruct fish farmers in the normative and rules of international standards for fish exports. In that way, in flood years were capture fishery is enhanced, they could have the opportunity to allocate their products worldwide. Also, the direct contact with farmers allows the local authority to ensure that farmers are understanding and applying what they learn, and not only handing out learning programs which they might not use, as is known to happen frequently.

Future policies implanted by local authorities should put more effort in the clear dissemination of information about weather conditions and flood forecasts through radio and television. Sanitation programs should be reinforced to minimize the propagation of epidemics and water-borne diseases during flood season. Also, people should be informed about the results of studies related to climate change, in a way that they can adjust their economic activities and decisions in advance to face the upcoming conditions. Moreover, studies and projects cannot continue to be carried out without transparency and proper dissemination. Large amounts of money from international organizations are being invested in the development of research in Vietnam to address climate change, water management and flood control. However, it becomes ineffective information if it remains accessible only for a small group instead of reaching higher authorities or other researchers.

As for structural measures, more infrastructures for water management such as dikes, embankments and flood-proof houses have to be constructed. Dam construction in Vietnam should be performed carefully as well, by carrying out environmental impact studies and not only by quantifying the economic benefits in the short run. In cases of provinces such as Dong Thap, which has a growing industrial and service sector, the improvement of infrastructure and working facilities would empower these sectors of the economy to grown even at a quicker pace.

The importance of addressing flood management correctly in the Mekong Delta relies in the fact that a big part of the country's economic and agricultural activity depends on the productivity of this area. The loss of output value of agriculture and aquaculture not only jeopardizes the Vietnamese exports, but also endangers the country's capacity to secure the required amount of food for its 85 million inhabitants.

Appendix I

Climate Change in the Mekong Delta of Vietnam

The Mekong River basin is undergoing rapid political, economic and social changes. Activities carried out upstream could imply significant consequences for downstream countries. For instance, the clearing of upstream forests has had an impact on the rainfall-runoff relations, resulting in more frequent floods in the past years (Hirsch and Cheong 1996 cited in White 2002). This, together with the impacts of climate change, has been suggested to increase the frequency of extreme events in the future.

A) Vietnam, a vulnerable country

Over the past years many studies have taken place in Vietnam to address the consequences of climate change for the country, with the purpose of determining the policy responses that the country should implement. The International Centre for Environmental Management (ICEM) indicates in a report that they developed for the MRC (2009b) that Vietnam is amongst the countries expected to be most severely affected by climate change. The Mekong and the Red River delta are the most vulnerable areas because of their susceptibility to inundations (MRC 2009b, p.16). The main climate change predictions for the south of Vietnam derived from their study are the following:

- Temperature increase of 1.1°C by 2050, with negative effects on agriculture, extension of drought periods and increase in the incidence of epidemic diseases.
- Seasonal rainfall is predicted to decrease in July and August and increase in September, October and November. The shortage of rain during the dry season will then result in extended droughts.
- Sea level is expected to rise by 33 cm in 2050, with negative impact mostly in coastal provinces such as Ca Mau, Soc Trang, Ben Tre and Kien Giang
- It is anticipated that the number of heavy storms and typhoons to hit the country will increase in intensity and occurrence because of climate change.

The risk that rice production will undergo because of climate change is one of the major concerns of the inhabitants of the Mekong Delta, considering that the most part of the agricultural economy revolves around this crop. Global warming may result in heat stress for rice grown in tropical/subtropical climates (Moya et al. 1998 cited in Wassmann 2004). Also, the productivity of rice systems may be affected by hydrological changes in the area because of the precipitation pattern volatility. Moreover, important cultivation areas could be covered under salt water because of SLR. Besides, ICEM predicts that productivity of ocean products will decrease by one third with reductions in the abundance of fish species with high commercial value and decrease in size of fish species (MRC 2009b, p.21). All these results represent a threat for the export oriented economy of the country and also to its food security. Other indirect effects such as damage in infrastructure, increase in energy consumption for irrigation and drainage, and damage in transportation and tourism are also expected to affect the Vietnamese economy.

B) Responses to climate change

Vietnam ratified the UNFCCC in 1994, and the Kyoto Protocol in 2002.On December 2008, the Vietnamese government approved the National Target Program to Respond to Climate Change (NTP). Its main strategic objective is

> *'to assess climate change's impacts on sectors/areas and regions in specific periods and develop feasible action plan to effective respond to climate change in each short term/long-term periods to ensure sustainable development of Viet Nam, take over opportunities to develop towards a low-carbon economy, and joint international community's effort to mitigate climate change impacts and protect global climatic system.'* (MONRE, 2008)

More specific objectives include the promotion of scientific and technological activities, the enhancement of public awareness, responsibility and participation of citizens and the promotion of international cooperation to obtain external support; all of them in response to climate change. The Program is divide in three phases: i) Start Up (2009-2010), ii) Implementation (2011-2015), and iii) Development (after 2015). The main focus until now has been given to the assessment of climate variability and impacts of climate change on different scenarios and locations. The Ministry of Natural Resources and Environment (MONRE) is the main institution in charge of climate change related activities.

The plan of the Government is to integrate the NTP in other related strategies and policies. For instance, the Program is intended to work together with the "Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector for the period 2008-2020". The latter one was prepared under the MARD mandate, and intends to link the disaster management activities with climate change adaptation activities. The main objective of this plan is

> '*to enhance capability of mitigation and adaptation to climate change (CC) to minimize its adverse impacts and ensure sustainable development of the agriculture and rural development sector in the context of climate change.'* (MARD 2008, p.1)

Hence, both programs have to be used simultaneously to address agriculture development of the country under climatic change.

Together with the different governmental ministries and departments working on climate change, MRC (2009b, p.79) mentions that there are over 200 climate change projects across 9 sectors, involving a very large number of international organizations such as UNEP, CARE, ADB, World Bank, UNDP, and the Government of Australia and the Netherlands, among many others.

Vietnam in the UNFCCC in Copenhagen

According to the United Nations Resident Coordinator in Vietnam, Mr. John Hendra, Vietnam is not considered a top priority country for the agreements in Copenhagen since it has more capacities than other poorer developing countries (UN Press Release, 2010). Because of this, he suggested that Vietnam should prepare to access the short and medium-term financing opportunities that are arising for technical assistance, capacity building and research on climate change responses. Also, he mentioned the importance of developing vulnerability assessments that are more robust in the estimation of climate change adaptations. Furthermore, he highlighted the importance of developing a mechanism on Reducing Emissions from Deforestation and Forest Degradation (REDD), which now is being financed by the UN and Norway. Finally, he mentioned the need of assessing the best opportunities for greenhouse gas emissions mitigation and the possible use of market instruments to ensure a low carbon, environmentally sustainable growth path. Right now the UN supports this initiative and is in negotiation with the governmental authorities and possible donors to work on that area.

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