Valuation of the rice sector in the Quang Dien district, Vietnam

A case study of the rice sector in three communes in the Quang Dien district Thua Thien Hué Province, Vietnam

M.Sc. Thesis by Kees van Duijvendijk

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Irrigation and Water Engineering Group

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Master thesis Irrigation and Water Engineering submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

Kees van Duijvendijk

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Supervisor:

Dr. Ir. Gerardo E. van Halsema
Irrigation and Water Engineering Group
Centre for Water and Climate
Wageningen University
The Netherlands
www.iwe.wur.nl

Preface

This thesis is the completion of a Master study in International Land- and Water Management at Wageningen University. The thesis is titled 'Valuation of the rice sector in the Quang Dien district - a case study of the rice sector in Thua Thien Hué Province, Vietnam'. The research is focused on the rice sector in a lagoon bordering district in one of the poorer regions in Vietnam. People in this area depend for the main part of their income on either agriculture or aquaculture. Both sectors face increasing difficulties due to the growth of population, the expansion of upstream urban areas (domestic waste) and the problem with the property regime in the lagoon. This latter is the cause that aquaculture has been expanding in an unrestricted manner since the 1990s. Not only this sector has caused pollution and a lack of water circulation, also the agricultural sector has intensified which is causing an increased nutrient and chemical load in the water which is flowing into the lagoon. This polluted water from agriculture and the upstream urban areas is causing, to the opinion of the people in the aquaculture sector, diseases to the commonly cultivated tiger shrimps.

This research is focused on the rice sector and the current input and output of this sector. Farmers in three different communes use different amounts of inputs, varieties and have different outputs. The difference in yield is not only based on the inputs, varieties and the soil types, but also on the water availability and the state of the irrigation system. Since dams are currently being constructed and the irrigation infrastructure is being improved, the water inflow during the problematic dry season (high concentration of pollution) will be improved. This extra flow of freshwater will be used for irrigation and to maintain a good quality of water (higher circulation) in the lagoon. This will help to keep the ecosystem healthy, which also has as an effect that aquaculture. When practiced in a sustainable manner such as polyculture, aquaculture will have higher benefits. An increased water inflow alone will not be sufficient to have a higher intensity of rice and higher yields of aquaculture, but these sectors also have to be changed to be more sustainable. For agriculture, this means that the varieties and inputs (cropping systems) have to be adjusted to the agro-ecological; for aquaculture this means that different crops have to be cultivated during different times of the year and preferably in a system of polyculture.

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Summary

The Tam Giang - Cau Hai lagoon is the largest of its kind in South East Asia and covers an area of 22,000 ha. The lagoon is located in the area with the highest rainfall in Vietnam; there are two main seasons, a dry and a wet season. Seasonal problems to the productivity of rice can thus change from flooding, to drought and salinity intrusion. The water quality in the lagoon is very different over the seasons, due to the mixing of the water from the main rivers in the area, with water from the sea in the lagoon. Over the last two decades, aquaculture extension inside the lagoon and an increased urban use of water has caused less water to flow into the lagoon. The uncontrolled extension of aquaculture ponds has also caused a lack of water circulation, which is especially a big problem for ponds with concrete dikes. This has caused a deterioration of the water quality inside the lagoon, which has negative consequences for the aquaculture sector. The decreased inflow of freshwater is also causing the brackish water inside the lagoon to move more land inwards, what is causing salinity intrusion in lagoon bordering communes. To improve the inflow of freshwater there are three new dams being created in the river basin. This should help to stabilize and restore the ecosystem and gives extra opportunities for irrigation. A salinity intrusion barrier has also been created and the sea-outlet will be enlarged to further increase the circulation of water.

Most people in the lagoon bordering communes depend for the main part of their income on agriculture and aquaculture. The high food price and the failure of many aquaculture and agriculture crops nowadays place many farmers under difficulties and they will remain to live below the poverty line. To improve the livelihood of farmers, new water infrastructure will be created and the effect of these new dams and flood protection on the rice sector in different communes will be assessed in this thesis.
Three communes have been studied and five main factors have been taken into account which could influence the productivity of rice: variety, soil type, state of the irrigation system, input of chemicals and input of nutrients. Differences in these factors cause different yields, but are also related to each other. Certain varieties of rice are only suitable for certain soils and the soil type is impossible to change. GIS maps have been made of the above factors in the different areas together with the main limitations.

An analysis of the rice sector has been made in which all variables have been taken into account and the three different communes have been studied to see the main differences. Since the yield seems to depend most on the varieties, cropping systems have been distinguished, based on the varieties, soil type and area location. The different cropping systems show clear different output and thus income. The income which is derived from the cropping systems varies from US$ -135 to US$ 374 per hectare per year. The influence of three variables (irrigation state, input of nutrients and input of chemicals) has been studied and only for the state of the irrigation system a clear effect on the yield could be found.
Water mosaics have been made in which the different cropping systems were located. The possible transfer of value within and between the different cropping systems has been analyzed. It can be expected that, when the water related problems will be solved, there will only be two main cropping systems left which are only related to the agro-ecological zone and not to the availability of water.
The benefits in the Quang Dien district of an improved irrigation system and flood protection is estimated to be around one million US dollar per year. The yields for the different varieties are taken to below maximum in the calculation, since other limitations will still occur in the different areas.

The benefits for the aquaculture sector in the Tam Giang- Cau Hai lagoon have been studied by the Hué College of Economics (HCE). From this research it has become clear that polyculture is the most beneficial aquaculture model from both an ecological as an economical perspective. When taking into account the benefits for the aquaculture sector, the total yearly benefits of the new water infrastructure will be over 1.4 million US dollar per year in the three study communes plus the township of Sia.

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List of Abbreviations

ADB	Asian Development Bank
APC	Agricultural Production Cooperative
CAR	Cost and Return
CPC	Commune People's Committee
DARD	Department of Agriculture and Rural Development
DOFI	Department of Fisheries
DPC	Districts People Committee
EAF	Ecosystem Approach to Fisheries
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
FU	Farmer Union
GIS	Geo Information Systems
GPS	Global Positioning System
GSO	General Statistics Office
HCE	Hué College of Economics
HRPMB	Huong River Projects Management Board
HYV	High Yielding Variety
ICCO	Interchurch Organization for Development Co-Operation
ICZM	Integrated Coastal Zone Management
IMOLA	Integrated Management of Lagoon Activities
IPM	Integrated Pest Management
IUCN	International Union for the Conservation of Nature
JICA	Japanese International Cooperation Agency
LICCP	Livelihood Improvement in Central Coastal Provinces
LYV	Low Yielding Varieties
LWR	Law on Water Resources
MARD	Ministry of Agriculture and Rural Development
MOLISA	Ministry of Labor, Invalids and Social Affairs
MONRE	Ministry of Natural Resources and Environment
NGO	Non Governmental Organization
OECD	Organization for Economic Co-operation and Development
OM	Organic matter
PPC	Provincial People's Committee
PRA	Participatory Rural Appraisal
PRIMEX	Pacific Rim Innovation and Management Exponents
QA	Quang An (commune)
QD	Quang Dien (district)

QL	Quang Loi (commune)
QP	Quang Phuoc (commune)
SA	Summer – Autumn (season)
Sao	Vietnamese Land Unit, equal to 0,05 hectares
TEV	Total Economic Value
TGCH	Tam Giang – Cau Hai Lagoon
TTH	Thue Thien Hué Province
UN	United Nations
UNCED	United Nations Conference on the Environment and Development
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific Cultural Organization
VBARD	Vietnamese Bank of Agriculture and Rural Development
VEPA	Vietnam Environmental Protection Agency
VND	VietNam Dong, currency unit, US$ 1 = 16.000 VND (2008)
VNICZM	Vietnam - Netherlands Integrated Coastal Zone Management
WHO	World Health Organization
WS	Winter – Spring (season)
WUR	Wageningen University and Research Centre

Chapter 1: Introduction

1.1 Introduction to the area

The Tam Giang - Cau Hai lagoon in the central part of Vietnam is the largest in South East Asia and covers an area of 22,000 ha. The lagoon is located in the central province of Thua Thien Hué. The most important river basin which discharges into this lagoon is the Huong River basin. Since the rainfall in this part of Vietnam is the highest of the country (2,900-3,600 mm annually in the basin, see *table* 2), floodings occur on a regular basis. The biggest flooding in the Thua Thien Province occurred in 1999, in which 373 people died and more than 3000 hectare of crops were flooded (UNDP in UNESCO-IHE, 2007). The total economic loss during this flooding was estimated by the UNDP to be US$ 163 million.

The reason for this high impact of flooding in this area is the uneven distribution of rainfall (70-80% of the annual rainfall falls between September and December (UNESCO-IHE, 2007)) and the steep gradient in the Huong River basin. Deforestation in the uplands in the past decades has worsened the problem and now erosion and large scale flooding are occurring in a larger area during the wet season. In the dry season, which starts in May, the amount of water in the Huong River is diminishing to an extent that the salt water from the lagoon is travelling up river and is threatening not only agricultural land, but also the domestic water intake of the city of Hué (IUCN, 2008). The areas around the lagoon depend for their income mainly on agriculture (especially rice) and aquaculture (mainly shrimps). Both sectors are facing increasing difficulties due to the uneven distribution of water over the year and the pollution in and around the lagoon that is caused by an increasing use of chemicals by the agriculture sector, lack of water circulation caused by aquaculture and domestic and industrial waste.

The mixing of the water from the main rivers in the Huong River basin with water from the sea is thus causing a different quality of the water in the Tam Giang- Cau Hai lagoon during the different seasons and in different years. The intensity of the mixing of the fresh water from the rivers and the salt water from the sea is determined by the volume of the lagoon relative to the amount of fresh water inflow and the exchange of the lagoon with the sea. Since the Tam Giang- Cau Hai lagoon is very large compared to the relatively small river discharge and mixing with the sea, the residence time of water in the lagoon is quite high. This means the physical parameters and the chemical quality in the lagoon is exhibiting typical estuarine gradients (MONRE/VEPA, 2004). This gradient means that the concentrations of pollution are highest near the river mouths and especially during the dry season, when the inflow of freshwater is not sufficient to clean the river. During the wet season, the waste which has been accumulated near the river mouths will be distributed over the entire lagoon and washed away to the sea. The construction of the numerous small scale complexes in the lagoon, such as the aquaculture ponds, fish traps, salt water barriers, dams and drains are limiting the water circulation, especially in the shallow areas of the lagoon, which leads to a deteriorating water quality and to prolonged flooding (MONRE/VEPA, 2004). The high concentrations of pollution, which are accumulating in the dry season, cannot be sufficiently mixed over the whole lagoon area, which means many of the water quality standards are exceeded over a large area of the lagoon.

According to research, done by UNESCO in 2004, the total Nitrogen in the lagoon is exceeding the reference standard value in 35% of the lagoon area (US standard) in the dry season, whereas this is 0% in the wet season. This has been calculated for the present situation of the lagoon without dams. The amount of Phosphorous is also exceeding the standard value (US) in 30% of the area in the dry season (0% in wet season). Formalin exceeds the minimum toxic value for aquatic life (1 μg/l) in 39% of the area in the dry season.

The Tam Giang- Cau Hai Lagoon is a long combination of connected lagoon basins orientated in a line parallel to the shore. From Northwest to Southeast the various basins are Tam Giang, Thanh Lam (Sam, An Truyen), Ha Trung, Thuy Tu and Cau Hai lagoons. The lagoon can be divided into four morphological components: a water body, tidal inlets, a subsystem of barriers and dunes, and inland lagoon banks. A characteristic feature of the coastal lagoon of Thua Thien Hué is the intensive mixing of fresh water and sea water. This leads to a dynamic and highly productive brackish water zone. The lagoon salinity is caused by the different dry and wet season conditions, such as a flooding or drought (ADB, 2006).

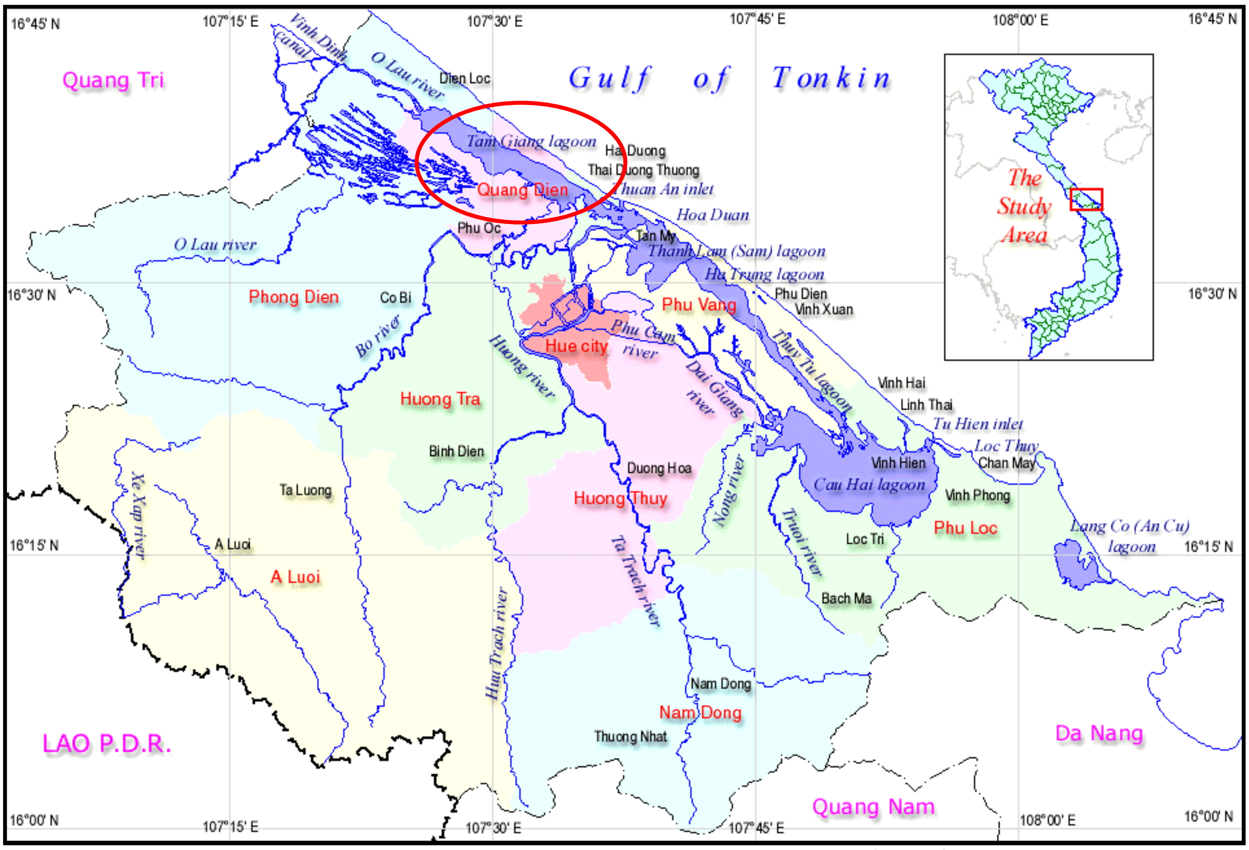


Figure 1: Administrative map of Thua Thien Hué province (MARD)

The area this study will focus on is the Quang Dien district, in the catchment of the Bo River (*see figure* 3). Although the Bo River is one of the main rivers and hardly has contact with the Huong River, the Bo River is still part of the Huong River catchment in which the Huong River Project Management Board acts. The three communes chosen to conduct a valuation study of different water related activities are Quang An (most upstream, best soil), Quang Phuoc (more downstream, saline soils) and Quang Loi (no river, sandy soils). During participatory rural appraisals held in the three communes, both the yield and price of rice was highest in Quang An, followed by Quang Phuoc and at last Quang Loi.

The rapid development of the aquaculture farming, without proper planning and sufficient technical assistance, in most of the 42 communes along the perimeter of the lagoon has resulted in severe water pollution which is exacerbated by pollutants from upstream activities. The Provincial Government of Hue Province (PPC), its line departments and the Ministries wish to redress the current unsustainable situation in the Huong river system and Tam Giang – Cau Hai lagoon, by adopting an integrated water resources management approach that respects the principles of water for food and ecosystems.

In the Huong River basin, a conventional river management authority approach has been adopted, in which the water resources development investments have been geared towards increasing the water capture, conveyance and control infrastructure. In this case (IUCN, 2005):

- Commissioning of three additional dams and reservoirs within Huong river basin to increase the dry season releases in order to restore dry season rice cultivation;
- Building of the salt intrusion barrier in the mouth of the Huong river to protect the domestic water supply to Hue city;
- Enlargement of the see-outlet of Tam Giang – Cau Hai lagoon to increase the water circulation and refreshment rate of the lagoon as well as to diminish or reverse the hydraulic gradients at its fresh-salt water interface.

The construction of Huong Dien Dam and reservoir is expected to bring considerable relief to Quang Dien district when the dam is commissioned in August 2008. With the regulation of the salt intrusion into the Huong River with Thao Long barrage and the dry season releases from Huong Dien Dam (as well as two other large dams), Quang Dien is expected to receive an additional dry-season water flow through the Bo River. Hue city is currently using the entire dry season base flow of the Huong River of 15 m^3 for its city water supply, which means less water is left for the different coastal districts during the dry season. With the new water regime, which is expected to come about when the dams will be finished, the Quang Dien district will be able to meet the water requirements of its two most prominent water use and livelihood sectors: rice production and aquaculture (IUCN, 2005). The improved inflow of fresh water is not only needed for these sectors, but also to stabilize and possibly restore the ecosystem in the Tam Giang- Cau Hai lagoon.

In the present situation (2004), the life of species naturally occurring in the lagoon is affected. Overfishing and transition of natural habitats into aquaculture areas have caused reduction of fish stocks, changes in species composition of crustacean and reduction of bird counts. Phytoplankton concentrations increase due to increased availability of nutrients. Practically only pre-adult fish are caught now in the lagoon open water fisheries. Important habitats of the lagoon such as submerged vegetation, mudflats and mangrove have been drastically reduced in area. This has caused loss of feeding and spawning grounds for many species. Water quality in low-land rivers in the dry season is worsening, affecting habitats of fresh water species. Other new water infrastructures, which have been implemented (dams, salinity barriers) have also changed the water circulation, which in its case has affected the migration routes of species (MONRE/VEPA, 2004).

The hydrological regime of the lagoon is impacted by the inflow from three main rivers (Huong River, O Lau River and Truoi River). The Bo River is a tributary of the Huong River and is thus part of the Huong River Basin. The impact of the inflow to the lagoon hydrology is hardly assessed to date and rather difficult to predict, due to newly constructed dams upstream and the salt water barriers which are built near the mouths of the rivers to prevent saline intrusion in the dry season and to ensure fresh water supply for domestic activities and agriculture. The hydrology is difficult to assess because it is difficult to predict the flow at the inlets due to dynamic changes in their width, and complicated impacts of construction works (dams, reservoirs and weirs) built upstream and at the mouths of the rivers (Huong, Bo, O Lau and Truoi) (ADB, 2007). The area of study in this thesis will be the Quang Dien district, which gets its inflow of freshwater from the Bo River. This river is not flowing through a big city, like the Huong River, so is less polluted by urban waste. The main causes of pollution in this area are dead animals, nutrients and chemicals from agriculture and domestic waste from the villages. The cause and the effect of the problems in this area can thus be seen more clearly than in the bigger rivers. Farmers also perceive salinity as a form of pollution, which is very severe. A dam will also be constructed in the Bo River, to generate hydro power, but also to have a better inflow of freshwater during the dry season.

The trends in the past have led to a situation in which water quantity (and quality) is not sufficient for good agricultural production and water quality (and a narrowing consumption market) is limiting the shrimp production. Besides these problems with production, the quality of the lagoon is also deteriorated to a very bad state. The trends thus have to be changed towards the future, so that the state of the lagoon can be restored and water quality and quantity inflow can have rice production and aquaculture coexist with more stable yields. Measures to restore the degraded state of the current aquatic ecology of the Tam Giang – Cau Hai lagoon may affect some beneficiaries. Especially in the short-run it may have a negative impact on shrimp farmers as this implies a reduction in the current occupation of the lagoon with fish ponds and "hatching nets", which may reduce the benefits of aquaculture from the lagoon. In the long-run it may have a positive impact on shrimp farmers as a better water quality in the future will increase the level of shrimp production. The increase in dry season rice production will on the other hand avoid salt water intrusion from the lagoon into the agricultural fields alongside the lagoon. This means that some sectors will be more affected than others under a particular restoration measure. It is therefore important to start with composing a list of water quality and water quantity criteria of aquaculture, irrigated rice production, Hue city water supply and the ecosystem to study the interdependencies of the above sectors. The tourism potential of Thua Thien Hue is quite big, since it has some unique cultural features (UNESCO world heritage sites), an impressive natural landscape and a large coastal zone. The Tam Giang – Cau Hai lagoon is of international and regional importance and plays a large role in the strategic socioeconomic development of the Province, particularly for the agriculture and fisheries sectors (PRIMEX, 2006).

The current activities in and around the lagoon do not leave much room for agricultural expansion, since all the land is already used in most communes. Only a few downstream areas have still land left uncultivated for some part of the year. The main reason for uncultivated land is the low soil fertility and the lack of water. Increased output will only be possible by applying a combination of better farming practices and better rice varieties and water infrastructure. The problem with the high yielding varieties is that they are not suitable for all the soils in the area. The output of agriculture is currently very different over the areas, which seem to have similar soil characteristics. Not only the varieties, but also the irrigation access, the input of nutrients and chemicals and the occurrence of diseases are limiting the productivity of rice in the area (*Chapter 4*). The room for agricultural intensification is thus still quite big, which means the limited amount of land will still be sufficient to keep the people, depending on rice as their main income generating source, above the poverty limit (*3.4*).

The expectation is that in the future the aquaculture activities will be expanded even more and the agriculture will remain as it is. This will mean that the nutrient loads which are being discharged into the lagoon will increasingly come from the aquaculture sector. Whereas it used to be 80-85% from agriculture, this is expected to be only 30-40% in some years, whereas aquaculture is expected to account for 60-70% of nutrient loads in the lagoon (figure 2).

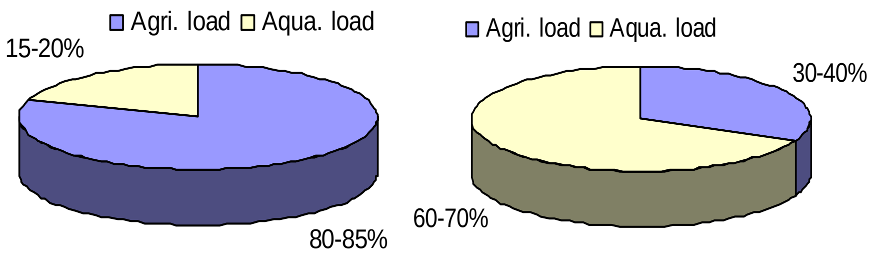


Figure 2 Contribution of agriculture and aquaculture sources to the nutrient load in the lagoon in 2001 (left) and as expected in the future (right). (source: ICZM in ADB, 2007)

A water management plan has been prepared for the Huong River has identified a number of investment opportunities for major infrastructure development, including Ta Trach Dam on Ta Trach River, Binh Dien Dam on Huu Trach River and Huong Dien Dam on Bo River (table 1). Highest priorities were given to the construction of Ta Trach Dam and Binh Dien Dam. These two proposed dams form a major part of a comprehensive management plan under development for the river basin. In addition to flood control and the prevention of saline intrusion, the dams are envisioned to provide water for the irrigation of 34,782 ha of land, to supplement the domestic and industrial water supply, to improve the lagoon environment and the environmental landscape, and to provide power generation (IUCN, 2005).

Table 1: Dams which are currently being constructed (source: Institute of Water Resources Planning in IUCN, 2005)

	Ta Trach Dam	Binh Dien Dam	Huong Dien Dam
Location	Ta Trach River	Huu Trach River	Bo River
Functions	Flood control and hydropower	Flood control, power and water supply	Flood control, power and water supply
Normal water height	45 m	85 m	58 m
Reservoir storage	610×10^6 m3	423.7×10^6 m3	820.7×10^6 m3
Flood control volume	392.6×10^6 m3	$70\text{-}180 \times 10^6$ m3	$200\text{-}400 \times 10^6$ m3
Current status	2006	Under construction	Under construction

These reservoirs can thus be used for multiple purposes. During a flood event, runoff from rainfall can be stored in these reservoirs, after which it can be released in a safe manner due to a reservoir operation strategy which reduces the major flood peaks. Other purposes of the dam are hydroelectric power generation, irrigation and to provide a permanent inflow of fresh water to prevent salt intrusion in the coastal areas in the dry season. Many salinity barriers have been constructed in the area, which do not only have positive impacts but also have as a negative impact that many bird species have left the area due to changed habitats (VEPA-VNICZM, 2004). An initial EIA for Ta Trach Dam was completed in 2002 with a generally positive conclusion, confirming that the dam would help to mitigate the impact of floods in the immediate future and would supply water for industrial, domestic, and agricultural use. In May, 2005, the Vietnamese government, through its Ministry of Industry, issued an approval document that officially allowed the construction of the upstream dams, including Ta Trach Dam, Binh Dien Dam and Huong Dien Dam. The first dams have already been finished and the Huong Dien Dam is expected to be in operation in the end of 2008.
New roads and dams are built continuously in the area to improve access to remote areas and to provide protection against flooding or salinity intrusion. If not properly planned the new infrastructure can aggravate flooding levels and extend the flooding period and slow down the draining of floods. At the same time, water quality can be affected due to reduced circulation. On the regional level, construction of roads in floodplains of the Huong River, such as the road leading to the new bridge over the Thuy Tu lagoon, or the salinity barrier-dyke at O Lau river mouth, could cause impacts during times of extreme flooding. Dam construction on the Huong River will multiply by 7 the total storage capacity of the present Hue dams and will limit peak discharges to 2,000 m^3/s. The dams should be operated to release minimum flows necessary for intermittent flushing of the system as required by the lagoon environment and the coastal sediment balance and health of the inlets (MONRE/VEPA, 2004).

Thua Thien Hue is one of provinces in Vietnam that annually has the highest number of storms. According to the statistic data over the last 30 years, the number of storms that affected this region is about 27% of the total number of storms that affected the whole of Vietnam. The storms usually arrive with high intensity rainfall. The average annual rainfall in the province is about 3,200mm, but it is very uneven through the year. It concentrates in the months from August to December and especially in October and November (UNESCO-IHE, 2007). The total amount of rainfall in four months from September to December is the major amount of the annual rainfall (70 – 80 %). Especially, October and November are two months that have highest rainfall in year.

1.2 Problem statement and research questions

Whereas the population and the price of rice are rapidly growing in the study area, the output of rice is not keeping up with this growth. The current allocation of agricultural land is giving the farmers in the study area around 1 sao (500m^2) per person. This allocation will be revised soon, so that the farmers will receive even less land to cultivate. This means the farmers have to improve the yields of rice and especially the income which they can generate from the cultivation of rice, since the price of inputs is very high (50-60% of the output). If the yield will not increase, the farmers will remain very poor according to the different poverty indicators (3.4). The income which is generated from rice can be improved in two ways. The first is by increasing the output, by using new varieties and better use of inputs, such as water and chemicals. The second is by decreasing the costs of inputs, this can be done by lowering the inputs of pesticides and herbicides and by lowering the labor costs, which have to be paid by farmers to their agricultural services cooperative. In the dry season, from January to August, the flows of freshwater in the rivers are reduced to the minimum and saline intrusion becomes a common phenomenon in areas around the lagoon. The salinity can cause problems to the cultivation of rice, but is also unfavorable for many aquatic species which are being cultivated in the area. The summer rice crops (which starts in May), which previously where commonly cultivated, is currently hardly planted in some communes, due to its dependency on rainwater caused by the lack of irrigation. The area used for agriculture has decreased in the period 2000-2005, without a growth of productivity (*see annex* 3).

The **main research question** is:

- *What are the possible increases or transfers of value, after the construction of new water infrastructure (dams, irrigation structure, flood protection), in the different zones (water mosaics) in the Quang Dien district, Thua Thien Hué Province, Vietnam.*

Another main problem in the area is that the lagoon environment is polluted by chemical substances which are being released from the agricultural production, the daily garbage from the community, chemical agents wasted from industrial factories and the waste which is being released by the shrimp farming in the area. The lack of inflow of freshwater causes an intrusion of not only saline, but also polluted water, which further lowers the productivity of the main income activities in this district. The quality of the lagoon is not only deteriorating due to the fast growth of the aquaculture in the area, but also due to the lack of space for the water in the lagoon to circulate and thus to refresh. The opening from the lagoon towards the sea is currently too small and instable for sufficient water circulation and has to be increased and stabilized in the future so that the quality of the water in the lagoon can be refreshed at a higher rate. Not only the output from agriculture, but also from aquaculture (which has in many places replaced the cultivation of rice) has dropped from two crops per season before 2005, to only 1 main crop per season in 2005. This is caused by the environmental pollution in the area, which is one of the main causes of the increasing occurrence of shrimp deceases in the area (IMOLA, 2006a).

The **sub-questions** for the **agriculture** sector are:

- *How are the current yields in different areas and cropping system influenced by variables, such as the state of irrigation, input of nutrient and input of chemicals?*
- *What is the income which is generated from cultivating rice in the different areas and cropping systems and how can this be improved in the future?*

Other **sub-questions**, regarding the **socio-economic** situation and the **aquaculture** sector are:

- *What is the current socio-economic situation in the study area and how will this be changed by an improvement in the main income generating activities (agriculture and aquaculture)?*
- *What are the input and output of the different aquaculture models and what are the implications of these models on the farmer's income and on the ecological situation?*

Chapter 2: Theoretical framework and methodology

2.1 Water valuation

Water is a natural, social and economic good. A good quantity and quality of water provides ecosystems (forests, floodplains and coastal areas) with the ability to generate economic services, but also helps to avert water-related disasters (IUCN, 2004). Integrated water resource management (IWRM) has been promoted since the Conference on the Environment and Development, which was held in 1992 in Rio the Janeiro (UNCED, 1992). Water allocation has social, cultural, political and economic impacts, which means that assessing different allocation options also means assessing all these different impacts. The values which are considered in these studies should reflect the people's assessment of the contributions to human welfare, caused by the different alternatives. In this approach, it is not only the economic efficiency which is important in the valuation of the alternatives but also other social and ecological objectives can be important (Agudelo, 2001). The availability of good quantity and quality of water is not only important for ecosystems, but also to humans. Water is also a social good, since the availability of clean and affordable water improves individual as well as social well-being. This means a better quality of water is not only helping an individual, but all people who share the same water source. The negative effect of water as a social good is, that is also has private good characteristics, meaning that if one individual uses more water of a certain water source, other people sharing the same source have less water to use (Gleick et al, 2002).

The traditional way to assess the value of water is to calculate the total economic value (TEV); this involves the full range of characteristics of water sources as integrated systems (IUCN, 2004). These are resource stocks, flows of environmental service and the attributes of the entire ecosystem. All the different, present and future, goods and services which an ecosystem provides related to water, whether they are marketed or not, have to be taken into account in this approach (IUCN, 2004). Since this approach will only give an indication of the many aggregated monetary values which water provides and not an indication where improvement can give the highest extra benefits, a new approach will be used in this thesis. A more valuable insight into the value of different water using sectors can be obtained by creating *water value mosaics* (WUR, 2008 *draft*). These mosaics can be used to compare the value and variations of the water using sectors. In this thesis certain water value mosaics will be created in the Quang Dien district. Each mosaic should have the same main characteristics (soil type, irrigation system), making is suitable for one clear optimal water use. In this way the present value can be compared with the optimal value, giving an indication of the benefits of the creation of water infrastructure (irrigation, flood protection). Mosaics of water valuation can thus provide more valuable insights for IWRM strategies, compared to the traditional TEV-method, in two distinct ways:

- The differences in relative value between the (various) water users within one sector, which can be created by the water mosaics, can give an indication of which measures can be taken to increase the economic value of water. The potential future benefits per mosaic, without limitations related to water, can be compared with the current use of water. When creating different water mosaics for an area, the remaining potential to increase the productivity (and economic value) of water can be identified. In this way the economical benefits, when allocating water differently (distribution, irrigation and flood protection) can be assessed.

- The valuation of certain development scenarios can give potential transfers of economic (water) value from one sector to another. This means not only users within one sector, such as agriculture, but also different sectors can be compared in value. These extra benefits which can be created in another sector should be compensated for the 'losers' in this scenario. Water mosaics can provide guidance in the question which additional measures are needed to compensate the value devaluation in the new development scenario (WUR, 2008 *draft*).

2.1.1 Economic valuation

During the decision making process it is important to consider water as an economic good; it facilitates the making of choices between sets of alternative water allocation options. Whereas many people see water pricing as the policy tool to use in water management, water valuation does not necessarily value the different uses in strict monetary terms. This makes water valuation better suitable to choose between different alternatives in a more efficient, equitable en sustainable way (Falkenmark and Rockström, 2004). Water has many aspects, many of which can be seen as economic. Whether the water demand of a certain sector is as important as the water which is directly used by people for the production and consumption activities, is a question on which economists have the stance: If someone cares about it, it counts (Griffin, 2006). Water has been considered as an economic good since the Dublin conference on Water and the Environment in 1992. An economic good is (Gleick et al. 2002) a good or service that has value to more than one person. This includes nearly all goods, including social good. A good that is not 'economic' is either without value or has value to no one but its owner.

The simplest, most straightforward and commonly-used method for valuing any good or service is to look at its market price: how much it costs to buy, or what it is worth to sell. In a well-operating and competitive market these prices are determined by the relative demand for and supply of the good or service in question, reflect its true scarcity, and equate to its marginal value. Even when ecosystem goods and services do not themselves have a market price, other marketed products often rely on them as basic inputs (production function). For example, downstream hydropower and irrigation depend on upper catchment protection services, fisheries depend on clean water supplies, and many sources of industrial production utilize natural products as raw materials. In these cases it is possible to assess the value of ecosystem goods and services by looking at their contribution to other sources of production, and to assess the effects of a change in the quality or quantity of ecosystem goods and services on these broader outputs and profits.

2.1.2 Social valuation

Water also has a social value; water as a social good means that it is a good that has significant "spillovers" benefits or costs. An improvement in water quality for one individual means better water quality for all individuals who share that water-supply system (Gleick et al. 2002). Access to clean water is fundamental to survival and critical for reducing the prevalence of many water-related diseases (UN, 1997). Ensuring that the public receives an adequate supply of social goods requires some level of governmental action, since purely private markets often do not find it profitable to provide social goods. Because water is important to the process of economic development, essential for life and health, and has cultural or religious significance, it has often been provided at subsidized prices or for free in many situations. In theory, this makes water available to even the poorest segments of society. This is politically popular but brings with it a financial burden because society must pay for the subsidy. It can also encourage wasteful use of water, and the perverse result that many of the poor do not have access to clean water at reasonable prices because those who have access use more water than they need. In this thesis, four social features which are related to the availability of freshwater are studied: (1) food security, (2) access to drinking-water, (3) water conflicts, (4) job provision. In this thesis, especially the first social feature (food security) will be important, since most rice is used for home consumption and not much is currently going to the market.

2.1.3 Ecological valuation

Functions of the ecosystem, outside the economical and social functions mentioned above, are the regulating services, such as the regulation of hydrological flows (buffer runoff, soil water infiltration, groundwater recharge, maintenance of base flows), the natural hazard mitigation (e.g. flood prevention, peak flow reduction, landslide reduction) and the control of surface and groundwater quality (IUCN, 2006). The environmental changes which are caused by the change in base flow, which are caused by the construction of dams, can have serious consequence for the ecosystem value and have also to be taken into account in water valuation.

2.1.4 Efficient Water Allocation

The efficient allocation of water has historically been seen as economic efficient use of water, which can be the productivity of water (crop per drop) or the benefits of a project. In previous decision making, this concept has been widely used when the project goals of projects were to maximize the returns from for example irrigation (FAO, 2004). Efficient water allocation was thus based on the maximization of the financial costs and benefits and did not take into account the non-financial aspects of water. From an economical point of view, an improvement is reached when it meets the Kaldor-Hicks criterion; this is a situation in which a change is desirable when the people who will benefit can hypothetically compensate the people who will lose from it (FAO, 2004). This potential Pareto improvement is at the base of most cost-benefit analyses in which the economic efficiency of different alternatives are compared.

Reasons for Inefficient Water Allocation

There are two reasons why the allocation of water is often happening in an inefficient way; (a) through the failure of markets, and (b) by institutional failure. The main reason for this inefficient allocation is that most of the services cannot be monetized and both markets and policies are mostly directed towards the monetary quantifiable data (Turner and Jones in FAO, 2004). Another problem is caused by the different definitions of demand; water use is not the same as water consumed and the multiple uses of water caused by the return flows make it hard to break the water down into potentially marketable proportions (FAO, 2004). Market failure is caused by four main problems (FAO 2004):

- The non existence of markets (public goods and externalities)
- The lack of necessary information (attitude towards risk, social discount rate)
- The restricted operation of markets (monopolies)
- The lack of institutional arrangements (absence of property rights)

Externalities are the costs which are borne by the total population, but not by the individual producer of certain goods, these are thus not incorporated in the market prices. Depletion and degradation of natural resources are the most important externalities (Perkins, 2003). Another feature which is hard to grasp by the market is the social time preference of goods. This means that the costs and benefits which are realized in the future have less value than the costs and benefits which are realized immediately.

2.1.5 Property rights

The last problem for the functioning of markets is the absence or the non-enforcement of property rights (see *2.1.4*). There are four main significant types of property that are distinguished by F. von Benda Beckmann (2001):

- **Private property**: property with clear identification of the owner and with a full set of rights which include the transmissibility of the resource; this will lead to the facilitating of the gathering up of resources into the control of the most efficient users.
- **Open Access**: non-property; the resource is open to everyone.
- **Common Property**: a well defined group of individuals have defined rights on a collectively owned property; rules exist to regulate access to this resource.
- **State Property**: a form of property which is often necessary in places where a central agency is needed to control otherwise unlimited access and withdrawal of a resource.

From a market point of view, anything other than private property is causing inefficient resource allocation. The other property regimes lack the legal security, freedom of transfer and also full specificity that is important to accomplish economic growth (F. von Benda-Beckmann et al. 2004). Many of these market failures can be solved by government intervention, which can regulate access to common resources and impose taxes which better reflect the external costs. Governments tend to subsidize the production of certain commodities which degrade natural resources; the policy instruments which are used such as taxes, subsidies and exchange rates, create distortions in the market prices, which make it rational for individuals to use the natural resources in a manner that is suboptimal (OECD in FAO, 2004).

2.2 Valuation of the different sectors

2.2.1 Valuation of the lagoon ecosystem

The flow of freshwater into the Tam Giang – Cau Hai lagoon is not only needed to provide water for irrigation and aquaculture, but also to restore and stabilize the aquatic ecosystem. A stable aquatic ecosystem, with well regulated capture fishery will provide economical benefits for both the fisher folks as for potential tourism in the future. The real economic value of the lagoon ecosystem is related to capture fishery and tourism (ecological, beach and resort), but tourism does not take place at this moment. From an ecological perspective, the biodiversity in the lagoon has a very high value. Since tourism is not providing any benefits at this moment, capture fishery and biodiversity are the only values which will be taken into account at this point. The problem with biodiversity is that hardly any studies on it have been done in the past or are being done now. The only information which is available is anecdotal and suggests that the biodiversity has declined over the last decades and will probably decline even further in the future (ADB, 2007). Local people report a reduction in the diversity and number of both fish and bird species in the lagoon. While there is still a diversity of phyto-plankton and zooplankton species in the lagoon, the species composition and abundance is greatly altered by water pollution. The lagoon's ecological integrity and health are greatly reduced. Important areas of sea-grass appear to have declined and only two small pockets totaling 10 hectares of mangrove forests remain and even these are degraded (ADB, 2007).

Figure 3: Domestic waste at the borders of the lagoon

For this study, the value of the lagoon ecosystem will get a priority value, although the economical value of the ecosystem is not clear at this point due to a lack of research. The water inflow which will be created after the construction of the new dams is needed to stabilize and potentially restore the ecosystem, so it can provide the same services it provides now in a sustainable manner. This means not only the economical value of capture fishery, but also the ecological value of a high biodiversity.

2.2.2 Valuation of the agricultural sector

To assess the productivity of the rice sector, is should first be known how much people depend on it as the main income earning activity. The water demand of rice is also an important factor influencing the productivity. Rice is currently cultivated once a year in some areas of Quang Dien district, whereas two crops per year would be possible if there was sufficient water during the dry season. The water inflow in the wet season is sufficient for one yield, but in the dry season, the inflow cannot be used to produce another yield. As in other uses, water quality also influences the productivity of irrigation water. Salinity is to a greater or lesser extend found in all natural streams; evaporation of water diverted for irrigation leaves salts behind in irrigated soils, and drainage from such soils increases salinity concentrations downstream of irrigation diversions. So the economic benefits and costs (in the form of forgone benefits) are consequential in economic appraisal of salinity control programs, (Young, 2005).

The standard methods of estimating values of irrigation water are deductive, the models may be just a simple farm crop cost and return (CAR) budget of net return for one crop, which assumes a specific input mix and product yield. Methods to measure the social economic benefits in irrigation projects are more controversial, the conceptual methods which are employed do inadequately take into account the opportunity cost of labor and capital resources in calculating net return to water. In many cases the commodity prices are also not properly adjusted to the existing farm subsidy programs, which would give a more realistic social value of the outputs from a national accounting stance (Young, 2005).

One of the transfers of value of water that might be necessary in the future to remain a healthy ecosystem is a shift from aquaculture, which is causing a lack of water circulation in the lagoon, towards a higher intensity of rice production. The double cropping of rice needs irrigation water in the dry season which causes an inflow of freshwater to the lagoon, which prevents the saline intrusion. The economic value of this double cropping of rice and the water demand can be analyzed.

Since flooding is a problem in many parts of the Quang Dien district, the main problem is currently in the wet season. For this reason not only calculations will be done to assess a possible improvement in the dry season, but also to see how the yield of rice can also be improved during the wet season, by preventing floods or improving drainage. In two of the three communes which have been researched, flooding was the main productivity limiting factor, whereas in the third and most downstream commune, the lack of water was the most limiting factor to the opinion of the farmers.

The occurrence of floods and storms is also a problem, which has especially big problems for the rice farmers, but can also do damage to the ecosystem. The topography of the (Bo) river basin, which changes rapidly from the upstream mountain down to the plains of the lagoon system, causes high runoff in the rainy season. The resulting floods (generally from September to November), cause not only erosion of the upland area, but also washes all the pollutants to the lagoon. Some farmers state that after heavy rainfall all the fish in the river die, since the chemicals are washed from the fields to the river. Also human illness after floods appears, due to the deteriorated water quality (ADB, 2007). The floods do not only have a negative effect, but also are a natural way of cleaning the lagoon. Although many pollutants are washed to the lagoon, the increased circulation caused by the floods, also have an effect on the spreading of these pollutants over a larger area and getting more water in from the sea. Erosion also causes an inflow of more fertile lands in some areas of Quang Dien. Domestic waste is another problem which causes a deteriorated water quality and reduced inflow of fresh water into some parts of the lagoon. Whereas the lagoon had been used as a garbage dump by the local villages, also the more upstream villages throw all their waste in the river. In some places the domestic waste and dead animals can be seen flowing in rivers towards the lagoon. Some rivers which were used to irrigate the land only a few years ago are now so polluted by the dumping of waste that they cannot be used anymore. Lagoon clean-up activities are currently being implemented by IMOLA, but many small rivers discharging in the lagoon are still unsuitable for use for water related activities.

Figure 4: Domestic waste has caused this river to be unsuitable for irrigation, whereas only a few years ago it was used for a large area.

2.3 Methodology

2.3.1 Introduction to methodology

The objective of this thesis is to assess the water quality and quantity demands for the (single and double yield) rice production, the different forms of shrimp production and the restoration of the ecological value of the lagoon. The relative value of the different water users (rice, shrimp and nature) will be assessed in the Quang Dien district, and options for increased return per water quantity will be researched. The future distribution of water (after the construction of a new reservoirs in the Bo River), in which the freshwater inflow during the dry season will increase, will be used to (1) restore the natural ecosystem in the lagoon and (2) to increase rice production to double yielding again. The options for aquaculture (type and location) to coexist within this new situation of water distribution system will be assessed. Trade-offs will be evaluated between different water management alternatives, in which not only the economic, but also the social and environmental aspects will be taken into account.

The initial plan to conduct only qualitative interviews among rice and shrimp farmers has been changed into conducting 'semi structured surveys'. The survey results are needed to give a good overview of the inputs and outputs for the cultivation of rice in different agro ecological zones. In these surveys, not only questions which are easily to statistically analyze, but also qualitative questions were embedded, such as organizational and social questions. In this way the rice sector could be analyzed for its economical, but also its social and ecological (inputs) value.

The focus of this research is on the rice sector and the output of different varieties of rice in different parts of Quang Dien. Different varieties need a different input of water, nutrients and chemicals and also have a different output. Some of the varieties are limited by the soil type, which cannot be expected to change in the new situation with dams. Other varieties are limited by salinity and a lack of water and can thus be expected to have a higher yield when the dams will be operating.

Three communes in the Quang Dien district have been chosen to analyze (see chapter Study Area), which have different soil characteristics and different access to irrigation canals, roads and the market. 120 survey have been conducted, 40 per commune. The main classification has been in high and low areas, since these have very different problems. Except for this, also soil suitability has been taken into account, since high areas can range from very suitable for agriculture to impossible to cultivate. The 40 survey per commune have been distributed in 5 villages per commune, which means 8 household surveys per village. The number of households per village differs a lot, from only 40 households in some villages in Quang Loi, to a village of over 4000 people (around 800 households) in Quang An.

Table 2: Amount of surveys and sampling strategy per commune

Commune	PRA	Survey	Sampling strategy
Quang An	1	> 40	2 villages in high areas, 2 in low areas and on in the middle.
Quang Phuoc	1	>40	2 villages in high areas, 2 in low areas and some survey in the area in between.
Quang Loi	1	40	Since all villages are on the same road along the lagoon, per village 4 farmers with high and 4 with low areas were selected.

2.3.2 Survey type and questions

The survey has tested in one commune before the final version has been made. The survey begins with some general questions, such as how much of their income depends on rice, how many crops they have per year and where they get the water from for irrigation. Other general (social) questions were about how much they used for home consumption, how large their household was and whether they had access to safe drinking water. After the general questions, questions are asked about the exact location of their farm (maps have been used, no GPS) and soil type in this area. This has given a good indication of the different soil types in the study area.

The most important part of this survey has been the input-output of the different rice varieties. Farmers had to indicate which varieties they cultivated during which months and how much inputs they used (quantitative and economic). The yield and the price of their rice was also surveyed. The input-output data gives a good indication on how farmers adapt in different (high/low, water/no water, poor/good soils) areas. The farmers were also asked how much money they estimate to make per land unit (sao) per season.

When the main social and economic question were finished, the questions became aimed towards the farmers own opinion about the main problems in the area. A large number of yes/no questions were asked about topics such as soil suitability for agriculture, is flooding a problem, is salinity a problem, are their conflicts with other sectors, do they use IPM and more. These questions could be compared with the earlier information of the survey to see how the farmers think about the possibilities for rice cultivation.

2.3.3 How to analyze the surveys

Since the data of the survey has been in many different forms (spatial, social and economic), the data also had to be analyzed in different ways. For the social information a sheet has been made to compare the different topics in different areas (Annex 1). The social data has been used both as background information (chapter 3) and as in depth information for the analysis of the rice sector (chapter 4). This information gives the main problems which can be attached to the economic data.

The economic data, which can be derived from the input-output model of rice, has been the basis of the analysis of the economic value of the rice sector. Excel has been used to compare the different inputs and outputs per area and to see how the final economic value has been for different varieties and areas. This economic analysis is used for the results which can be seen in chapter 4. The differences in input and output have been studied per commune and per cropping system and the effect of different variables (state of the irrigation system, input of nutrients and chemicals) have been studied both for the three communes and the five cropping system.

The spatial data has been analyzed using ArcGIS. The location of the farms has been indicated by the farmers together with the yield, variety, limitations and access to irrigation in this area. Maps have been made with the soil types, state of the irrigation, nutrient input and chemical input (*Annex 13-16*). For each season (winter-spring and summer-autumn) also maps have been made for the variety, yield indication and main limitations (*Annex 17-22*). The spatial and the economic data can be combined to create water mosaics to calculate the potential benefits in the Quang Dien district.

2.3.4 Creation of water mosaics

The economic data from the agricultural sector (*this thesis*) and from the aquaculture (*HCE*) can be combined to see which system has the highest economical benefits and how the different systems influence the environment. Different cropping systems (*4.5*) and aquaculture systems (*5.1.2*) are studied for their inputs and outputs and the income which they can generate for the local people.

To create the water mosaics, the economic data and the data from the GIS maps has to be combined to see where which cropping system is being practiced. The cropping systems are based on three factors: soil type, varieties and high/low area. The variables which are studied to see how they influence the yield in the different cropping systems are the state of the irrigation system and the inputs of chemicals and nutrients. In this way the current yield and value in the cropping system can be estimated and the possible future value can be calculated. The benefits of the new water infrastructure can be calculated by looking at the difference between the current and future benefits from rice in the area.
In some cropping systems the yield can only be maximized for the current varieties (limited by soil), but in other areas the varieties are limited by a lack of water or salinity and the varieties can thus be changed to the higher yielding varieties. Flooding is also limiting the cultivation of certain varieties in the low areas and how this influences the yield will also be studied in detail. An idea of how the water mosaics will look is given in figure

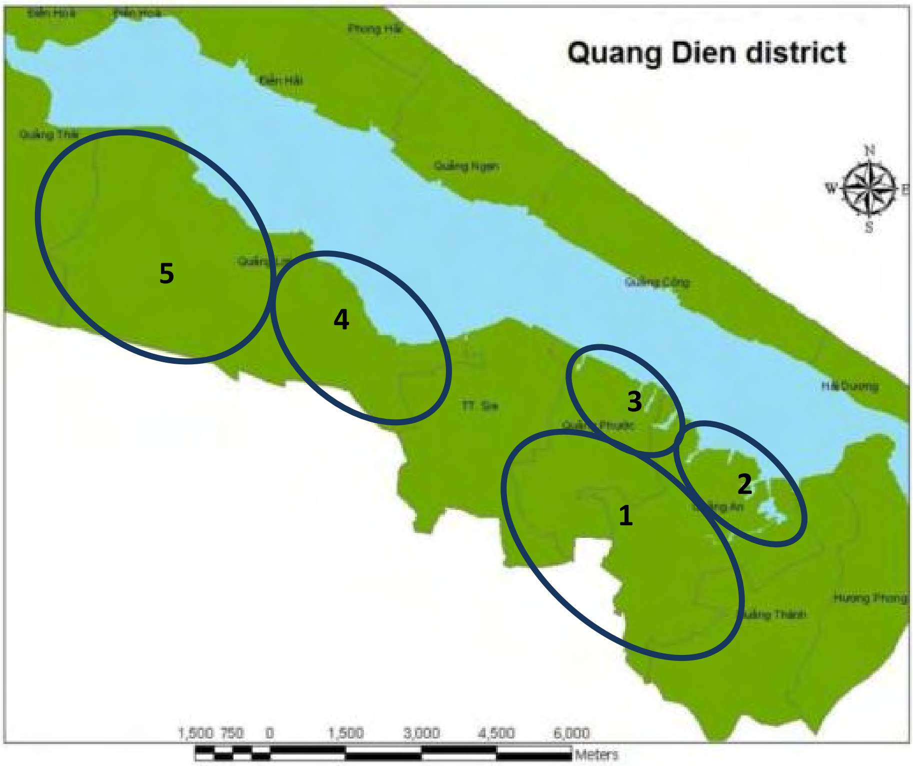


Figure 5: Water mosaics in the Quang Dien district

For the aquaculture systems, the data from the Hué College of Economics will be used to see how the different systems cause different income from the farmers. Since spatial data is not available of the location of these ponds, the whole lagoon area is expected to be a zone with similar characteristics. Low and high tide ponds can be distinguished based on the location in the lagoon or on the landside around the lagoon. High tide ponds conflict with the cultivation of rice in the low areas, although not many high tide ponds can currently be found in the studied commune.

Chapter 3: Analysis of the area

3.1 Climatic and hydrological situation

The rainfall is also relatively high in the dry season months of May and June. This means that there can be two peaks distinguished in the annual rainfall graph of the Huong River basin. The large peak is in the months of October and November and a small peak can be found in May and June. The average annual rainfall tends to increase from the North to the South and from the West to the East. The highest rainfall (>3,400 mm/year) occurs in Nam Dong and A Luoi valleys where there is the source of Huong river. In the Huong river delta, rainfall is lower (average annual rainfall is around 2,700mm to 2,800mm). The rainfall in Huong and Bo river basin has different distribution over the years. The rainfall station which is located closest to Quang Dien district is Phu Oc.

Table 3: Rainfall data from Thua Thien Province (UNESCO-IHE, 2007)

Months	Nam Dong (mm)	A Luoi (mm)	Co Bi (mm)	Binh Dien (mm)	Phu Oc (mm)	Hue (mm)	
January	99.5	66.6	171.9	90.2	93.8	100.0	
February	87.3	43.6	52.2	50.2	72.9	58.7	
March	47.8	64.3	30.1	23.6	49.7	39.6	
April	100.8	152.6	57.1	62.6	75.7	52.8	
May	222.3	231.6	158.5	135.3	134.2	118.5	dry season peak
June	213.1	203.2	193.0	176.1	86.6	116.5	
July	170.4	163.6	71.9	81.1	86.3	75.6	
August	189.5	187.9	121.7	141.3	131.6	120.5	
September	476.9	421.7	499.7	417.2	375.5	394.9	wet season peak
October	999.2	922.9	883.5	840.6	795.9	768.8	
November	755.5	743.7	822.6	733.2	611.6	657.6	
December	296.7	282.7	395.1	391.9	320.9	314.4	
Annual	**3644.0**	**3486.2**	**3455.4**	**3139.0**	**2875.7**	**2818.0**	

The normal inlet widths at Thuan An is around 350m and the depth is up to 11m. A minimum channel depth is maintained at Thuan An by dredging (reportedly up to 40,000m3/year) at 3.5 meter to accommodate the largest ships (MONRE/VEPA, 2004). The movements of the coast are much more severe near the inlets of the lagoon compared to areas which are located several kilometers from the lagoon inlets. The coastline near the inlet has to constantly adjust to the amount of discharge which comes from the lagoon. This means that the inlet is smaller and shallower during the dry periods, since the discharge from the lagoon is low in this period. During the wet season, in which the floods occur, the inlets are much more wide and deep. During the most serious floods (1999), the location of the inlets has completely changed. The movement of the Thuan An channel is currently estimated to be around 15m/year in a northward direction. Other evidence suggests that the movement of the inlet is cyclical and that is might be reversing on a cycle of around 30 years (MONRE/VEPA, 2004).

3.2 Socio-economic situation

Vietnam has experienced a rapid economic growth over the last decade. The Vietnamese economy has shifted, over the last 20 years, from operating within a central planning to a market-led and state-regulated mode of production. This process towards a market-led economy is commonly described as a transition towards capitalism. (Akram-Lodhi, 2005). The last few years have seen a rapid deterioration of the quality of surface water, air, marine and forest resources; they have also put biodiversity under threat. If current trend continue, the sustainability of economic growth could be at risk, with the poor and vulnerable suffering the most (World Bank, Vietnam Development Report 2007). The People's Committee of Thua Thien Hue Province in central Vietnam regards the integrated management of the Huong River Basin as a critical issue. The Huong River Projects Management Project (HRPMB) is designed to support the implementation of Vietnam's Law on Water Resources (LWR). The proposed strategy establishes links between national efforts in building institutional capacity to implement the law and demonstration activities at selected river basins to test the theory on the ground.

The physical impacts of the socio-economic development activities and the inappropriate management of the river basin are currently considered to be the most critical issues for the sustainable development of natural resources in the river basin. The conflicts among stakeholders have worsened since 1990, when the area under shrimp cultivation along the Tam Giang- Cau Hai lagoon started to grow in an unrestricted way in respond to the growing demand for cultivated shrimps in Vietnam and the rest of the world (IUCN, 2005). The infrastructure in the lagoon can have either positive of negative impacts to the different stakeholders (agriculture/aquaculture), which is causing some conflicts around the lagoon.

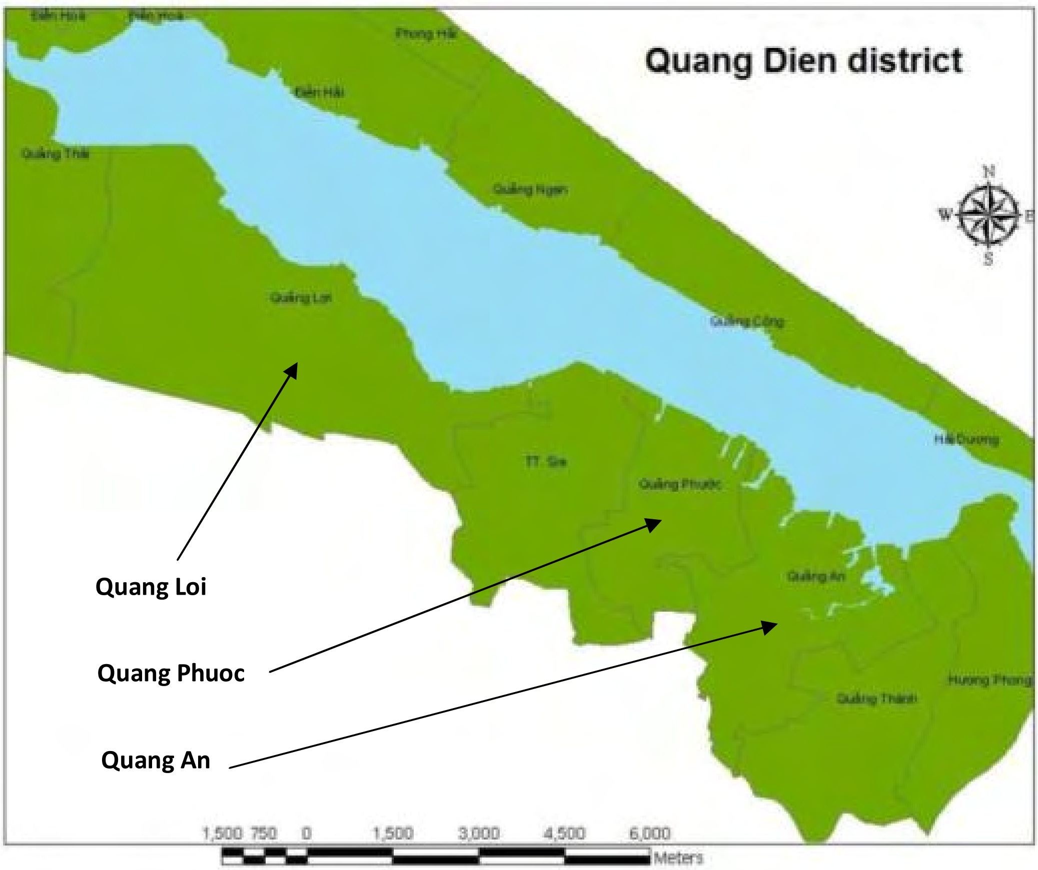


Figure 6: Quang Dien district, distributed in different communes

The three communes which will be studied can be seen in *figure 6* (Quang Loi, Quang Phuoc and Quang An). The economic importance of different sectors as well as the most important agricultural features (population density, agricultural land) of the different communes is given in the tables below.

Table 4: Value of different sectors in Quang Dien

Unit of calculation: million VND (the price of 1994) (DPC yearbook, 2006)

	2003	**2004**	**2005**	**2006**
TOTAL	**426.987**	**450.677**	**465.016**	**529.700**
According to economic field				
1. Agriculture	214.320	214.974	201.130	224.593
2. Forestry	4.000	4.100	4.100	2.554
3. Fishery	67.096	66.452	70.593	66.594
4. Industry-small scale industry	17.945	21.736	24.027	32.093
5. Basic construction	42.780	50.447	57.675	67.007
6. Services	80.846	92.968	107.491	136.859

The economic growth in Quang Dien district is mainly caused by a growth in small scale industry, basic construction and services. The output of the agricultural sectors (including forestry and fishery) has not been changing a lot over the last 5 years, from 285.416 MVND (US$ 17.838.500) in 2003 to 293.740 MVND (US$ 18.358.750) in 2006. The room for a growth in the agricultural sector is limited by the availability of land and the higher frequency of the occurrence of shrimp diseases and rice-failures. The total amount of land per commune in Quang Dien is shown in *table 5* below.

Table 5: Land area in 2006 classified according to soiltype, town and commune (DPC yearbook, 2007)

	Total (unit: ha)	Including		
		Agriculture land	Forestry land	Unusued land
Quang Dien	16.307,7	6239,53	1388,54	1346,56
Sia town	1.189,0	514,95	-	17,41
Quang Ngan commune	1.110,0	192,95	186,65	122,13
Quang Cong commune	1.260,0	284,28	201,90	90,15
Quang Thai commune	1.836,0	658,78	331,30	291,77
Quang Loi commune	**3.238,0**	**712,43**	**479,80**	**390,36**
Quang Phuoc commune	**1.048,0**	**680,86**	**-**	**9,71**
Quang Vinh commune	1.976,0	830,72	188,89	392,02
Quang Phu commune	1.190,0	602,97	-	17,45
Quang Tho commune	957,7	475,17	-	14,17
Quang An commune	**1.421,0**	**640,33**	**-**	**1,14**
Quang Thanh commune	1.082,0	646,09	-	0,25

The table above show that the three communes that will be studied (Quang An, Quang Phuoc and Quang Loi) have comparable amounts of agricultural land. The main difference from the table above is the very high amount of unused land in Quang Loi (the highest in Quang Dien). In the other communes, almost all land is being used for agriculture of forestry purposes. Table 6 shows the average population density in all of the communes of Quang Dien district.

Table 6: Average population density and agricultural land per capita (DPC yearbook, 2007)

	Area (Ha)	Average population (people)	Population density (people/km^2)	Agricultural land per capita (m2)
Total	**16.307,7**	**92.572**	**568**	**674**
- Sia Town	1.189,0	10.340	870	498
- Quang Ngan commune	1.110,0	6.879	620	280
- Quang Cong commune	1.260,0	6.529	518	435
- Quang Thai commune	1.836,0	5.129	279	1284
- **Quang Loi commune**	**3.238,0**	**7.298**	**225**	**976**
- **Quang Phuoc commune**	**1.048,0**	**7.491**	**715**	**909**
- Quang Vinh commune	1.976,0	10.359	524	802
- Quang Phu commune	1.190,0	11.320	951	533
- Quang Tho commune	957,7	7.452	778	638
- **Quang An commune**	**1.421,0**	**9.325**	**656**	**687**
- Quang Thanh commune	1.082,0	10.450	966	618

As mentioned above, three communes will be chosen for this valuation study. The three communes all have different characteristics when it comes to population, soil types and current water use. When focusing on these three different zones, the different transfers of value can be studied for this area. The area which is studied shows similar characteristics as most of the landside of the lagoon, which means the results can be extrapolated to other locations. Agro-ecological zones will be created in the three study communes, in such a way, that all soil types and availability of water can be covered. This means that not only zones will be created from the lagoon to more inland areas, but also zones on different locations along the lagoon. Some of these areas already have access to good irrigation infrastructure and in other places the inflow of water during the dry season is currently very low. The optimal yield per rice variety and soil type can be studied, as well as the benefits of having a good access to irrigation infrastructure. This means the optimal yield can be estimated for all of the zones and the benefits from the dam upstream of the Bo River, which is currently being constructed and will be finished in August 2008, for the production of rice can be calculated for the Quang Dien district

Land in Vietnam is allocated to all farmers in an area. In 1994, the farmers in Quang Dien were allocated with around 1 sao of land (500m2) for every household member. In 2004 the parcels of land were redistributed, without allocating more land to the people born after 1994. This means that relatively young households, with children under 14 have limited land and thus have to either lend land or have off farm activities. Land cannot be bought, so large farms do not really exist in the Quang Dien district. Richer people often have other forms of income, whereas farmers who cultivate a lot of land often seem to have problems, meaning they do not sufficient land themselves and have to pay a lot of money for cultivating someone else's land. Technical change seems to come through training from either government agencies or ngo's and seem to reach the places with better access to the market first, meaning the already well-of communes are being benefited even more, whereas the places with bad market access do not get sufficient training to increase their productive efficiency.

3.3 Comparison of the three study communes

3.3.1 Quang An

Quang An is the most southern commune of Quang Dien district. It is located close to Hué city and has a good supply of water, since the Bo River discharges into the lagoon in this commune. The total area size of Quang An is 1.421 hectares and the population in Quang An is around 9.325 people. This means the population density is only 656 per km^2. The amount of land which is classified as 'agricultural land' is only 640 hectares, which means that per capita only 687 m^2 is available. This is just enough to provide sufficient land per capita, but with an expected population increase of 9.1% (DPC, 2007), the pressure on land will be very high in the future. This means that both the productivity of rice has to be increased and other sources of income have to be created. The main problem in both seasons (wet and dry) is currently flooding (*see Annex 21&22*). There are only three varieties of rice which are being cultivated during both seasons (*Annex 17&18*) and the soil is suitable for agricultural production according to 88% of the interviewed farmers. Due to the low distance from Quang An to Hué, it is relatively easy to work in the city. Still, according to the farmers, only 40% of their income currently comes from off-farm activities, which is mainly pig husbandry.

3.3.2 Quang Phuoc

Quang Phuoc is a commune which is bordering Quang An in the north. The commune is located more in the north than Quang An, which means it is located further from Hué and the location where the Bo River discharges into to lagoon. Still, the lack of water is hardly limiting the agricultural production and the problem is largely the same as in Quang Phuoc, meaning flooding is the main problem in the wet season. In the dry season, problems with salinity and lack of water are higher than in Quang An. The soil types in Quang Phuoc are lighter than in Quang An, meaning that less clay and more sand seems to be available in the soil. This difference in production limiting factors causes Quang Phuoc to cultivate different varieties of rice during the dry season (see Annex 18). During the wet season, the varieties are generally the same as in Quang An. The total area of Quang Phuoc is around 1.048 ha and the population is around 7.491, which means that the average population density is around 715 people per square kilometer. The agricultural land in Quang Phuoc is around 680 ha of the 1048 hectare. This means that the agricultural land per capita is 909m^2. Although agricultural land per capita is relatively high, the productivity of rice has to be increased, especially in the low areas in the wet season. The percentage of income which comes from off-farm activities in Quang Phuoc is only 33% (*survey*).

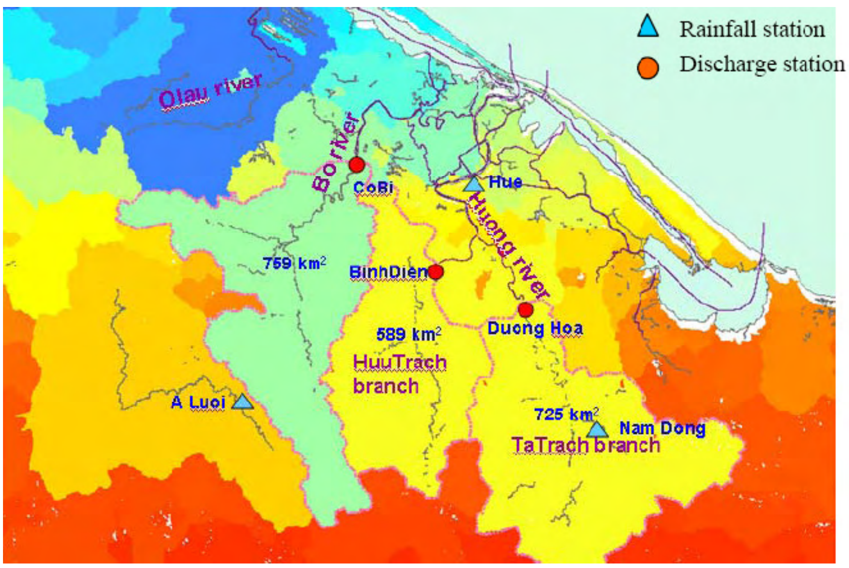


Figure 7: Catchments of the Huong and Bo River (source: Nguyen, 2007)

3.3.3 Quang Loi

Quang Loi is the most northern commune of Quang Dien at the land-inward side of the lagoon. The commune is located north of Quang Phuoc, although Sia town is located in between the both communes. Since Sia town in not depending on agriculture as much as the other communes, it has not been taken into account in this thesis. Quang Loi is located far from the main rivers in the area as well as far from Hué City. The commune depends on reservoirs which have been created in the high areas of the commune. These high areas are unsuitable for agricultural production due to the unfertile soils.

Sand is the main soil type in the high areas. Other problems in Quang Loi are the lack of access to a good irrigation system, bad access to the market and also drinking water is pumped up by wells, whereas the other two study communes have access to piped drinking water, which comes from either Hué or Sia town. The water from wells is of bad quality and has to be treated before use. The total area of Quang Loi is 3.238 ha, of which only 712 ha is classified as agricultural land. 390 ha of land are currently un-used and 480 ha of land are used for forests. Both these numbers are with the highest in the district. The population in Quang Loi is around 7.298, which means the average population density is only around 225 people/km^2. The agricultural land which is available per capita is 976 m^2, which makes it the highest of the three study communes. Whereas the availability of agricultural land seems to be high, only 50% of the farmers in Quang Loi think their land is suitable for agricultural productivity (*survey*). The main problem in this area is the lack of water, but also salinity and diseases are main problems (*see Annex 21&22*). The soils are hard to cultivate, which means the varieties which are used are different than the ones which are being cultivated in Quang An and Quang Phuoc. In most places of this commune there is no rice cultivated during the dry season, due to lack of water. Quang Loi has, except for the limited agricultural production, also a problem with aquaculture. In 2003, decision no. 3677/QD-UB was approved by the PPC of Thua Thien Province, which meant that Quang Loi was places in the sensible zone, whereas Quang Phuoc and Quang An where places in the normal zone. For Quang Loi, this means that only middle term-fishing permits (5 years) will be issued and that shrimp farming extension permits will not be issues anymore.

3.3.4 Differences between the communes

In table 7, the main differences are given for the three study communes. The population density is the lowest in Quang Loi and the agricultural land per capita is the lowest in Quang An. The soil in Quang An is much more suitable for agricultural production than in Quang Loi. The percentage of off-farm income is the highest in Quang Loi, where the most land is left unused. Quang Phuoc has a lot of suitable land and agricultural land per capita; the percentage of income from off-farm activities is low.

Table 7: Main differences between the three study communes

	Quang An	**Quang Phuoc**	**Quang Loi**
Area size (ha) *(DPC yearbook, 2006)*	1.421	1.048	3.238
Population density (people/km^2) *(DPC yearbook, 2006)*	656	715	225
Agricultural land (m^2) / capita *(DPC yearbook, 2006)*	687	909	976
Population growth (%) *(DPC yearbook, 2006)*	10,3	10,7	10,1
Percentage of income from off-farm activities *(survey)*	40	33	50
Soil quality (% suitable land) *(survey)*	88	73	51
Water availability *(survey)*	Too high	Sufficient	Too low

3.4 Land allocation and poverty lines

In 1994 farmers in Quang Dien were allocated with agricultural land. For every member of the household, one sao (500m^2) was allocated. Redbooks were given, which are valid for 20 years (2014). Land has been redistributed in 2004, but at this time no new land has been allocated to the children born after 1994, which means that many large households do not have enough land for self-sufficiency production of rice. This is a reason for many households to lend land; either from people in the area who work in other sectors or are too old to work their own fields (buying is impossible), for which a high fee has to be paid. The fee of land can easily be up to one third of the output, which means that nothing is left for the farmers, since they also have to pay for the inputs and the cooperative costs. In 2014 land will be distributed again, since the current will Redbooks expire in that year. At that time, all families will probably be allocated with one sao for every member of their household.
Since population in Quang Dien is growing, on average, by 11% per year (DPC yearbook, 2007), the amount of agricultural land which will be left in a few years, will probably not even be enough to give this one sao per person again. Another problem is that not all of the agricultural land is suitable for good agricultural production. Land in Quang An and Quang Phuoc is of good quality according to the farmers, but the agricultural land in Quang Loi is sandy in most places and has a low soil fertility, making is unsuitable for a high agricultural productivity (*see table 7*). If the population will keep growing at this rate (>10%/year), the agricultural sector in Quang Dien can probably not provide enough food for the own population (around one sao is needed per person). This means a shift has to be made to other ways of living and rice has to be imported from other areas, unless the productivity will also make a sharp increase in the coming years.

There are two different poverty indicators currently used in Vietnam; one by the GSO (General Statistics Office) and a second by MOLISA (Ministry of Labour, Invalids and Sicial Affairs). GSO uses a method which is internationally comparable for living standards surveys. The so-called **poverty rate** is the percentage of the population that cannot afford a 'consumption basket' which includes food and non-food items, with food spending being large enough to secure 2,100 calories per day for each family member. The so-called **food poverty** is the fraction of the population that is too poor to afford the food part of the consumption basket, even if they did not purchase any non-food items. The cost of this consumption basket is referred to as the Poverty Line. In 2004, this was equivalent to VND 175,000 and VND 160.000 per capita per month for Poor and Food-Poor respectively. The exchange rate in 2004 is around 16.000 Vietnam Dong= US$ 1, which means the food poor have less than US$10 per person per month. Adjustments are made for differences in regional and rural and urban prices. MOLISA uses another methodology which is based on household income and a Vietnamese definition of poverty. In the 1990s MOLISA defined the national poverty line as the income equivalent needed to buy fifteen (**15**), twenty (**20**), and twenty-five (**25**) kilograms of rice per person per month for the mountainous, rural and urban areas respectively. In 2005, MOLISA increased the poverty line from VND 150,000 to VND 260,000 per month for urban areas and from VND 100,000 to VND 200,000 for rural areas, which includes mountainous and remote areas. Households earning less than VND 120,000 per month are classified as Very Poor (PRIMEX, 2006).

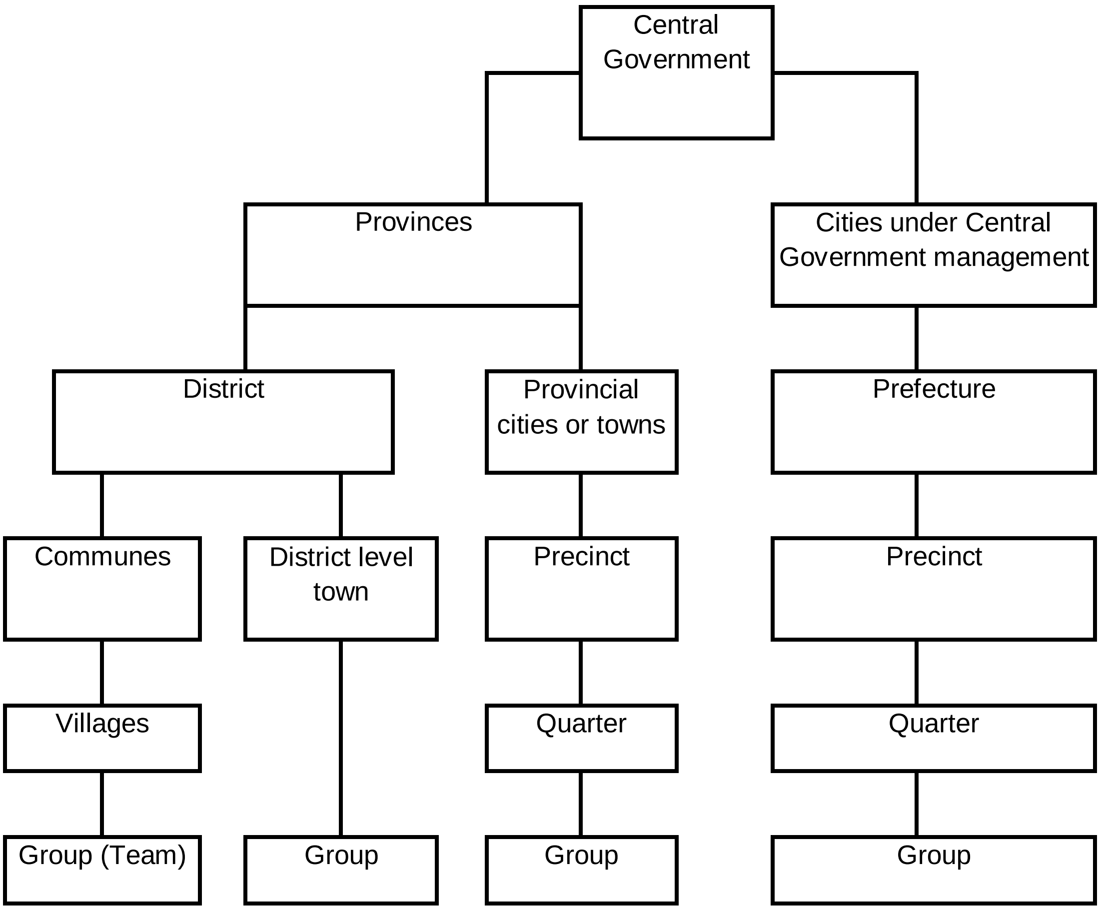
In practice this poverty line by MOLISA (25 kilograms per person per month) means the following: *Every household is allocated with one sao of land per person, which should be able to produce around 300 kilograms of rice per season. 12 times the needed 25 kilograms is 300 kilograms per year; so one sao can produce enough for one person. The problem with this is that the inputs per sao amount to around 50-60% of the total output. This means double the amount (600) kilograms per year is needed to keep the people above the poverty line. This means not only the yield should be on average 300kg, but also that every field should be able to have a double cropping of rice every year, something which is currently impossible.*

3.5 Administrative structure

3.5.1 National administrative structure

In the management of the Huong River Basin, many different stakeholders act. The Huong River Projects Management Board (HRPMB), is assigned to act as the platform for managers. Managers are the directing organizations which coordinate the policy towards their own needs. These mangers are in this case the different ministries which have an interest in water related affairs; since the interest of the provincial line departments can vary a lot (e.g. Agriculture and Fisheries conflict with Natural Resources and the environment, an organization such as the HRPMB is needed. Other stakeholders are the water users (municipal, industry, fishery, aquaculture and agriculture). The shift in water management has led to decentralization of the water management, from national to more local level. Water management is now a participatory activity, in which the water user organizations and the managers are in close contact.

Table 8: Levels of governance in Vietnam



3.5.2 Legal framework for agriculture

Outside the decision making institutions (MARD/DARD) and the communes, several other organizations work on the implementation of the agricultural policies. The farmer's associations and the agriculture service cooperative are the most important organizations. Their task is described below.

The farmers' associations (FA) were established in 1930 as a socio-political organization of farm workers throughout the country mass organization of Vietnamese peasants. The association has a comprehensive structure from the central level through province, district, and commune down to the smallest hamlet, with the lowest level represented by groups of farmers under a group leader.
The functions of FA's are: (I) mobilization and training of farmer-members to promote ownership rights, learning activities, and skills/competence enhancement in all aspects; (II) representing the farmer class to take part at meetings to develop Party and State policies; and (III) looking after and protecting legitimate rights and interests of Vietnamese farmers (ABD-LICCP, 2006).
The responsibilities of FA's are: (I) organization of training and dissemination of information on laws, decrees, policies, and guidelines of the Party and Government, along with documents of Central Fas, to members and farmers; (II) implementation of, or playing key roles in, activities or movements of socioeconomic development programs, national target programs of hunger elimination and poverty reduction, and measures to promote rural infrastructure and family culture; (III) participation in State management and social management, helping implement and monitor commune-level democratic regulations, policies, and laws, and proposing and participating in development of policies relating to farmers, agricultural, and rural areas; (IV) cooperation with national and international organizations to improve farmers' living conditions and rural development; and (V) together with other mass organizations, mobilizing farmers in efforts to improve household and community economies and implement policies concerning ethnic groups and religion (ADB-LICCP, 2006).

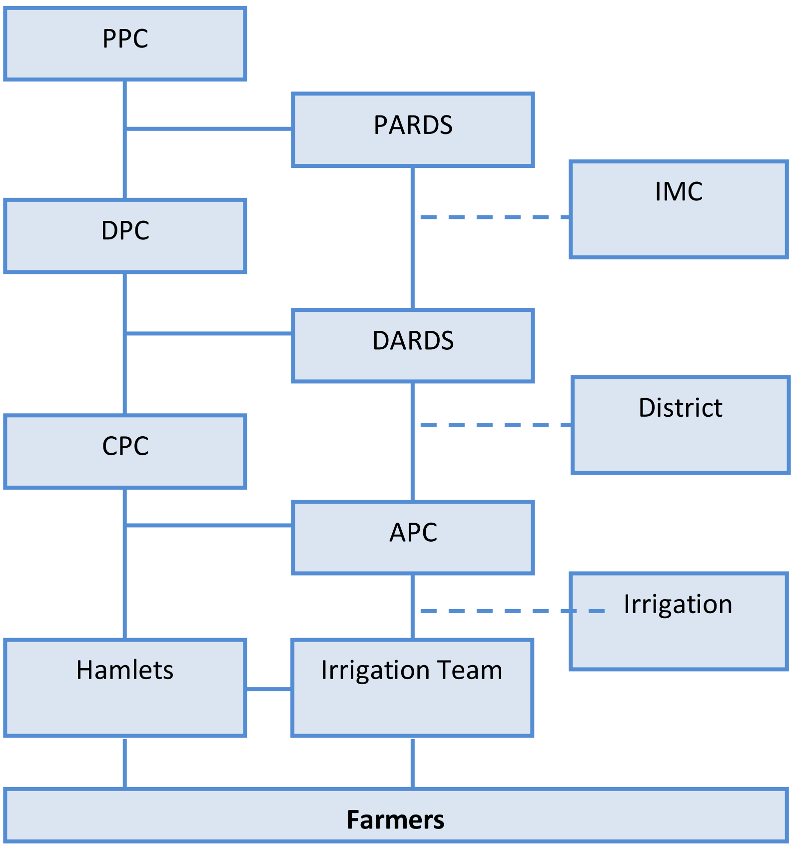
The irrigation water supply and management system is mainly controlled by Agricultural Water Management Companies and the Agricultural Service Cooperatives at the communal and village levels. Annually, these cooperatives represent local farmers in the signing of contracts with the companies for the supply of irrigation water. They then collect fees from the farmers, who avail of the water supply service, based on the irrigated farm area (ADB-LICCP, 2006). The rural electricity management system is controlled by the Electric Power Supply Companies in cooperation with the Agricultural Service Cooperatives at the communal and village levels. Annually, these cooperatives represent local farmers in the signing of contracts with the companies for the supply of electrical power. They then collect fees from the farmers, based on the amount of electric power used.

Agricultural Service Cooperatives at communal and village levels also provide this service, particularly in the distribution of seeds of agricultural crops (i.e., rice, corn, peanut, beans, vegetables, etc.) and pesticides. Local farmers can therefore purchase input materials for agricultural production according to their choice, either directly from the companies and their agencies operating within their vicinity or indirectly through the agricultural service cooperatives. The advantage of purchasing production materials from service cooperatives is the assurance of good quality products and better service. Other tasks of cooperatives are providing training and lending money to farmers.
Many different form of organization exist of which the farmers can be member. People under 30 are member of the Youth Union, male farmers are member of the Farmer Union, women are member of the Women Union, former soldiers are member of the Former Soldier Union en the old people are member of the Elder Union. Hardly anybody in Quang Dien is not member of one of these organizations. For this research only the organizations which have an effect on rice cultivation are of interest, which means the Farmer Union (FU). The FU does not manage the water in any way (official task), but provides seed (higher price than province), gives training and can give loans.

3.5.3 Irrigation management structure

Table 8: Administrative units for irrigation service

Administrative levels	Technical Agencies	Irrigation Management	Main Responsibilities



Represents the State and supervises the IMC

Assists the Provincial People Committee (PPC) in supervision of the IMC

IMC Manages system's O&M

DPC Supervises the District Station's operations

Assists the DPC in the supervision of the District Station's operations

Signs water contract with Agricultural Production Cooperatives or CPC's

CPC or APC enters into a contract with the District Station for the delivery of water to the farmers

Sub-station delivers irrigation water to the Irrigation Team set up by the commune authorities

Protects and maintains commune's irrigation facilities and distributes water to the farmers

Water users receive irrigation water from the Irrigation Team and pay irrigation fees to Heads of Hamlets.

The different water sources which are used for crop irrigation in the coastal communes consist of the following three: (1) provincial irrigation systems managed and operated by the provincial companies; (2) natural lakes managed by communal authorities and the agricultural production cooperatives; and (3) underground water sources operated in some communes using tube wells (PRIMEX, 2004). All rice farmers are automatically member of a cooperative (one per village). These cooperatives (Irrigation Team in above table) provide irrigation water turns to the farmers, which are divided into several teams per village. Irrigation can be done by (concrete/earthen) canal, irrigation boat or from a manmade reservoir. Conflicts do not often seem to arise between farmers, since they get water when they pay for it (which is really expensive when it is scarce). The most mentioned problem with the irrigation organization is that it is often not operating fast enough, which means that even in periods with sufficient water the irrigation turns are sometimes not given on the right time.

Chapter 4: Analysis of the rice sector

4.1 Introduction

The value of the rice sector in Quang Dien will be analyzed in the different communes and for the different cropping systems. How the different factors influence the overall yield will first be explained. The factors that will be studied are high vs. low areas, irrigation state, rice varieties, nutrients and chemicals. Different factors give a fluctuating yield throughout the area, what is partly caused by the fact that diverse soil types and other factors limit the cultivation of certain rice varieties.

After the influence of the different variables will be explained for the entire district, an analysis will be made for the three study communes. These communes will be divided into high and low areas and the income which is generated in these different areas will be analyzed. Since the differences between the study communes is partly caused by an interrelation of the several variables (soil type, high/low and varieties), the analysis will be made more explicit for different cropping systems. Cropping systems are created by making a combination of soil types, area types (high/low) and rice varieties which can be expected to be linked together. The creation of cropping systems gives a better indication of the local effect of the main variables of irrigation state, nutrients and chemicals.

4.2. Classification and influence of the different factors

4.2.1 High vs. low areas

Rice farmers in Quang Dien have different production limiting factors especially related to the zone in which they are located. Money for inputs has not been a production limiting factor, neither is the size of the farm. Around 25% of the area suffers from yearly flooding over a longer period, but a much larger part also suffers from a drainage problem during periods of heavy rainfall, which can also occur during the dry season. The problem with drainage is highest in areas which are located near the lagoon. Whereas being located near the lagoon means a flood risk in the communes of Quang An and Quang Phuoc; being a farmer in the lowlands of Quang Loi means having a lack of water during the dry season. Many farmers mention their farm as being located in a low area and some farmers refer to their land as being located too low. High areas also have certain production limiting factors; in Quang An and Quang Loi, the cover of alluvium is sometimes too big and in Quang Loi, the soil-type in the highlands is sand, which makes is for a large part unsuitable for rice (only for peanuts and sweet potato). In this thesis, the farms will be classified in low and high area farms. Low area farms have flooding (WS) and lack of water (SA) as a main problem (in many cases accompanied by salinity, lack of water during the dry season and problem with water quality). High areas can escape the yearly flooding, which occur mainly in the wet season, but often have less fertile soils. Difference in yields between these areas can be seen in the table below; especially the difference during the WS season is big. Not only the yield, but also the inputs and price of rice differ a lot between the high / low areas.

Table 9: Yield for 2007, divided in low and high areas per commune

Area			WS yield (000kg/ha)	SA yield (000kg/ha)
Quang Dien	high	*n=59*	5,34	**5,06** ↑
	low	*n=63*	**5,40** ↑	5,00
Quang An	high	*n=20*	6,04	5,34
	low	*n=21*	**6,44** ↑	**5,56** ↑
Quang Phuoc	high	*n=17*	**5,98** ↑	**5,02** ↑
	low	*n=25*	5,36	4,66
Quang Loi	high	*n=22*	**4,20** ↑	**3,70** ↑
	low	*n=17*	4,14	3,50

Whereas it was initially expected that the output in high areas would be a lot higher than in the low areas, this does not seem to be the case. The output in Quang An is even higher in the low areas and the difference is not significant when looking at the district as a whole. A difference between the areas becomes clearer after extracting the costs of inputs, both basic and for community services, the profit in high areas is always higher when extracting the inputs. It was expected that the high areas would be located more upstream and thus have a better access to water during the season. Especially in the dry season this would be the case. Even in the summer-autumn season, the difference is very small (in the whole district, the difference is only 60 kilograms per hectare). The reason for this is caused by the fact that the difference between high and low areas is not as large per commune as it is between the different communes. All areas in Quang Loi for example can be said to be located 'low', since it is more downstream than the other communes. The lack of water is the most limiting factor in Quang Loi, whereas in the problem in the other two communes differ. The channels cannot handle the peak flows during periods of high intensity rainfall. A lack of water also occurs in the other two communes, but is not a very serious problem and is mainly caused by a lack of a good irrigation service. The soils in the different areas are also not so easy to compare over the areas. The lowland areas often show the same characteristics (salty wet clay with sand), the areas which are located high can be very good (clay with alluvium cover) or very bad (sandy soils). The high areas in Quang An and Quang Phuoc are very suitable for rice cultivation, whereas most of the highland area of Quang Loi is not cultivated due to the infertile soils which are located here.

There are four main types of soils in Quang Dien: alluvial soils, saline soils, acid sulphate soil and coastal sandy soil. The two most common types are alluvial soils (fluvisoils), and coastal sandy soils (ADB, 2007). Whereas high and low areas can be spatially distributed throughout the whole commune, the soil types have more clear locations in the area. Near the coast, farmers often classify their soils as clay with sand (coastal sandy soils) en more inland and near tributaries of the Bo River, the soils are often fluvisoils. There are two main types of coastal sandy soils, which have in common the low organic matter (OM) content. There are many different kinds of fluvisoils in Quang Dien, which all have a low pH, but have a higher OM content than the coastal sandy soils. The most common type of fluvisoils in Quang Dien is dystric fluvisoils. A classification in soil-types will be used to compare the different communes, when a classification in high-and low areas has shown not be sufficient to explain the large differences.

4.2.2 Access to the irrigation system

Irrigation in Quang Dien district is mainly done by water from the Bo River. The way in which this is done is very diverse over the area. Whereas the farmers in the high areas of the two upstream communes (Quang An & Quang Phuoc) have in most cases access to a concrete irrigation system, the farmers in the lower areas and in the most downstream commune (Quang Loi) have many problems with their water supply. Farmers in Quang An have to use either clay irrigation canals or get irrigation by a pump-boat (*figure* 9), farmers in Quang Phuoc have an irrigation system which is concrete, but in bad state and the farmers in Quang Loi have to use self-made reservoirs to irrigate their land during the dry season. These reservoirs are used by a large number of households, but do not provide sufficient water, which means either the water becomes very expensive or conflicts arise over the water turns.

Figure 9: Boat used for irrigation in areas where pumps or irrigation canals are not available

The main responsibility over the irrigation system lies with the DARD, who manages the main irrigation infrastructure in the Quang Dien district. Managing the irrigation system is thus a task of DARD, who in their turn makes yearly contracts with agricultural service cooperatives. These cooperatives provide water for the farmers who pay for the water service. The amount of water that has to be paid depends on the cooperative and the size of the area. A fee has to be paid per sao, per season. The volume of water that is actually used is thus not important, only the size of the area. In many places the fee for the different seasons is the same, although irrigation is often not needed in the wet season. In areas where the water supply is not provided for by the district, such as in Quang Loi, the fee for water is different. The reservoirs in Quang Loi are created by villages and not by the district. The amount of water which has to be paid to cooperatives in these areas is much higher, due to the limited supply of water during the dry season. This means that the fee in the dry season is easily double the amount that has to be paid in the wet season. This causes the fact that only a small amount of farmers use the irrigation system during the dry season.

One of the objectives of this thesis will be to assess the added value of having a concrete irrigation system throughout the whole area, which would provide sufficient water during both seasons. Lack of water is not the only problem, which means the current wet season yields cannot be extrapolated to the dry season. Some of the main problems in the area are the high temperature, coldness, salinity, floods, diseases, insects and mice. These problems are often not the highest production lowering factors (mice, diseases and insects) or can be overcome by having a good cropping schedule (floods). Salinity can also be reduced by having a sufficient inflow of freshwater throughout the year. The main two problems which cannot be prevented, except by introducing new rice varieties, are the high and low temperatures which are increasingly being experienced in the area.

4.2.3 Rice varieties

Before the 1970s, when high yielding varieties (HYVs) were introduced, all cultivars were of local origin. Thus a high level of rice diversity has been maintained because farmers use a diverse set of varieties as a strategy to cope with land heterogeneity and adverse conditions. In recent years, with access to technologically advanced seed, the use of improved varieties with higher yields has needed intensive farming, which has gradually reduced the area committed to local rice varieties, which have low productivity and economic returns (Jarvis et al, 2005).

In Vietnam the frequent occurrence of floods and typhoons may affect rice diversity because they cause the loss of seeds and varieties and also destroy seed infrastructure. For example, the 1999 catastrophic flood that occurred in Thua Thien Hue caused a strong flood that damaged seeds and caused the loss of varieties of most farmer households in the region. In response to farmers' needs, the government provided new seeds to farmers as a subsidy to enable them to continue rice cropping, but the seeds were not of the varieties preferred by the farmers. The seeds provided were of a modern variety, called 'Khang Nhan'. As a result, no traditional varieties were cultivated. This has contributed significantly to the replacement of rice LYVs (Jarvis et al, 2005).

In Quang Dien, the distribution of rice varieties is very diverse over the different communes. The above mentioned Khang Nhan variety is still very common in Quang Phuoc, whereas it is only cultivated in a few villages of Quang Loi (replaced by C23) and is not cultivated at all in the most upstream commune Quang Phuoc. Traditional varieties can only be found in the lowlands of Quang Phuoc, where irrigation is limited. The LYV Heo has been replaced in most area during the last few years, but is still cultivated in the most flood prone areas, since it is a tall variety compared to most of the modern varieties. Many farmers cultivated still a part of their field with Heo, because they think the taste is better, it can withstand flood and can also protect other varieties from wind.

According to Jarvis et al, (2005), the conditions that have the highest impact on farmers' rice diversity management, is the level of irrigation. In the irrigated fields farmers replace LYVs with HYVs to increase rice productivity (high yield and cropping rate). In the irrigated areas, the percentage of households who planted LYVs was much lower than in the rain-fed lowlands. It was found that the rice diversity is still maintained in rain-fed lowland rice systems, but is not completely lost in the irrigated one (Jarvis et al, 2005). In this research, there has only one rice variety been identified as a LYV, the other varieties are all modern and have replaced LYV during the last decade (after the flood).

The main varieties which are cultivated in the area are 4B, Khang Nhan, TH5, T92, C23 and 13/2. During the winter-spring season 45% of the farmers cultivate 4B (often also cultivate a part of their land with another variety if it is lowland). 29% of the farmers cultivated Khang Nhan in this season, 13% C23, 10% cultivates TH5 and 8% cultivates 13/2. Farmers in areas which are only partly sensitive to flooding, cultivate short season crops on part of the area. As can be seen in the table below, some crops are long-season and other crops are short-season crops. Long season crops take around 1-1,5 month extra before they can be harvested and can thus only be cultivated in areas which can be secure from flooding around 5 months. In the lower areas, even during the WS season, short season varieties are cultivated to escape from the risk of flooding. TH5 and T92 are most commonly used for this (see Annex 17&18).

During the dry season, only short-season varieties can be cultivated, which take 3-3,5 month before they can be harvested. Of the short-day crops, TH5 is with 50%, (100% in Quang An) the most commonly used, followed by Khang Nhan (20%) and T92 (17%, all in Quang Phuoc). Farmers in Quang Loi do not have sufficient water in the dry season and thus often leave their land fallow or cultivate another crop (peanuts or sweet potato), which means that of the total households interviewed, 23% does not cultivate a SA-season rice crop (70% of Quang Loi).

The different main varieties which are cultivated in the Quang Dien district are given in table 10. There are three long season varieties (WS season) and three short season varieties (SA season). In most areas two crops are always cultivated within one year (cropping system). The main cropping systems are (WS-SA): 4B-TH5, TH5-TH5, 4B-T92, KN/C23-KN and KN/C23-fallow (or another crop). These cropping systems are based on different factors, such as soil type and access to water. The maximum yield in the table below is taken to be equal to the highest two yields per variety and can thus differ from the actual agronomic maximum yield which can be achieved under ideal circumstances.

Table 10: Different rice varieties with price, productivity and (dis)advantages

Variety	Long-season (L) / short season (s) variety	Advantages/disadvantages	Quality	Average 2007 productivity (ton/hectare)	Average 2007 price (VND/kg)
4B	**L**	Hard to cut by machine, longest season (1,5 months longer than TH5). Best quality. Good food. Not suitable for sandy soils	**++**	(WS): 6,04 (SA): - Max: 8,00	*3.038* -
C23	**L**	Medium productivity, suitable for salty wet clay & sand soils in QL. Can survive salinity. Good quality	**+**	(WS): 4,28 (SA): - Max: 6,00	*3.000* -
13/2	**L**	High output, low quality (animal feed), suitable for salty wet clay, tall rice. Problem with insects.	**- -**	(WS): 6,48 (SA): - Max: 9,00	*3.045** -
Khangh Nhan (KN)	**S**	One week longer than TH5. Medium productivity (higher than C23), suitable for saline soils	**+**	(WS): 4,64 (SA): 4,46 Max: 6,00	*2.912* *3.131*
T92	**S**	Medium productivity, small rice. Good food. Suitable for low areas which suffer from salinity	**+**	(WS): - (SA): 4,84 Max: 6,00	- *3.012*
TH5	**S**	Low price, shortest season, can escape flooding. Less suitable for saline and sandy soils than T92. High productivity, low quality	**-**	(WS): 5,90 (SA): 5,16 Max: 7,00	*3.050* *2.915*

**13/2 is a rice variety which is often cultivated together with 4B. 13/2 is used as animal feed and 4B for home consumption. Since 13/2 has a high productivity and 4B a high price, the farmers often give the productivity of 13/2 and the price of 4B, which gives a wrong indication of the actual price of 13/2.*

The choice for rice variety is not only based on water availability and soil type, but also by the training which is provided by the local government or ngo's. Whereas all farmers in Quang An seem to have made a rational choice (highest possible output in the different areas), the farmers in the other two communes have much more different varieties in areas with the same characteristics. For example the variety T92 is competing with TH5 in the low areas of Quang Phuoc. In Quang Loi, C23 has only been introduced in the last few years, in an area where normally the traditional, low yielding variety Heo was cultivated. Heo has as an advantage that no chemicals have to be applied according to the farmers, but the maximum yield for this variety is only around 4ton/ha, compared to 6ton/ha for C23.

4.2.4 Nutrients

Nitrogen (N), phosphorus (P) and potassium (K) are applied in different forms and at different times during the rice growing phase. In some areas, the nutrients are applied together (N.P.K) and in other communes, the nutrients are still mainly applied separately. Sub-optimal N- management by farmers is a key constraint to increasing yield. Improved N management causes greater yield responses to fertilizer N application compared to farmer practice, and yield responses to fertilizer phosphorus (P) and potassium (K) application often occur after proper N-management (Witt et al, 2005). In the table below, the current amount of nutrients, which are applied per growing season, are given.

Table 11: Input of nutrients in the different communes

Nutrients *(kilograms/ha)*	N.P.K. *(16-16-8%)*	**WS-season** N *(46% N)*	P (18% P_2O_5)	K *(50% K_2O)**	Total inputs (US$/ha)
Quang An	608	74	88	70	271
Quang Phuoc	296	166	142	138	225
Quang Loi	240	246	264	168	266
		SA-season			
Quang An	622	108	92	102	303
Quang Phuoc	318	180	144	140	247
Quang Loi	270	256	292	160	297

Whereas the amount of nutrients looks different over the areas, it is mainly the way in which it is applied which is different. The amount of N, for example is 608*0.16 + 74*0.46= 122 kg/ha in Quang An and 240*0.16 + 246*0.46= 154 kg/ha in Quang Loi. In Quang An, most farmers use N.P.K. which is already put together in the relative amount of 16-16-8%. In the poorer commune of Quang Loi, farmers use N (urea), P (lan) and K (kaly) as separate nutrients. The difference between the winter-spring and summer-autumn season is not very big, it averages around an extra 23.000 VND/sao, which is around 10% of the summer season input. The difference between high and low areas (see tables per commune) is also net very different, neither have the farmers changed the amount of inputs significantly over the last five years. The amount of input in two very different regions (Quang An and Quang Loi) is almost the same, whereas Quang Phuoc, which has the same soil characteristics as Quang An, uses around 40.000 VND/sao (20%) less.

A solution to this high application of fertilizer, which does currently not seem to be dependent on area or season (and thus the actual need), would be to use a leaf color chart. This is a chart which helps the farmers to decide how much nitrogen fertilizer they should apply, by comparing the color of the rice leaves with colors on the chart. This leaf color chart has been recognized by the MARD as technical progress, and is now popular with farmers in the Mekong River Delta (no farmers in Quang Dien mentioned this chart, so the awareness of this chart is probably very low in this region).

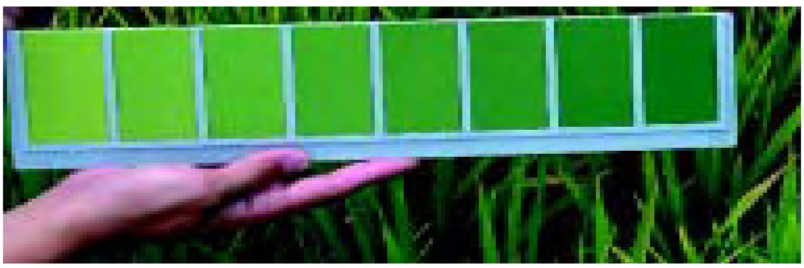


Figure 10: color leaf chart to indicate nutrient application

4.2.5 Pesticides and Herbicides

Pesticides and herbicides are applied to rice during several moments before and during the growing stage of rice. The chemicals are applied in several turns and the amount which is used varies per area. The amount of chemicals which is spent by farmers per sao of rice can be seen in the table below.

Table 12: Input of chemicals in the different communes

Pesticides and herbicides		**WS-season**	**SA-season**
		Pesticides+ Herbicides (US$/ha)	Pesticides+ Herbicides (US$/ha)
Quang An	*High Areas*	130	139
	Low Areas	179	194
Quang Phuoc	*High Areas*	94	96
	Low Areas	110	117
Quang Loi	*High Areas*	103	110
	Low Areas	64	50

In the above table it can be seen that the differences between both seasons is small compared to the differences per area. Herbicides generally take account for only around 20.000 VND-sao and differences are relatively small compared to the differences in the use of pesticides. For this reason the differences in above table will for now be subscribed to the use of pesticides.

In two of the communes (QA&QP), the use of chemicals is a lot higher in the low areas. When removing the 20.000 VND paid for herbicides from these amounts, the use of pesticides is around one third higher in low areas of QA and a 20% higher in the low areas of QP. Pests are, according to farmers, more common in these low areas and for this reason they have to spend large amounts of money on chemicals. In Quang Loi, the amount of chemicals also differs a lot between the high and the low areas, but in this commune the amount of chemicals which is applied in the low areas is much lower. According to the farmers in the low areas, the area is so wet and saline that they have no problem with rice diseases and also insects are rarely seen in this area close to the lagoon. This difference in application of chemicals between the communes is very high and hard to understand, but improvement can probably easily be made by applying better pest management techniques in this area.

Integrated Pest Management

Integrated Pest management (IPM) is a method which has been introduced in the field of land conservation in the 1980s. The initial idea of this method is that pest damage should be managed by the most economical means and with least hazards to people and the environment, on base of the already available practices and with more comprehensive data about the life cycles and interactions of pests (EPA, 2008). IPM is an ecosystem based approach for dealing with pest problems and is very site specific. It is already practices in some areas of Quang Dien with success and in other areas the farmers are unsatisfied and have thus stopped with the IPM practices. Some of the benefits of IPM include (a) a better pest control, (b) a safer and healthier workplace and also very important (c) lower costs because of the reduction of the inputs of pesticides. In the areas with the lowest output of rice (Quang Loi), IPM is practiced in the areas near the lagoon to reduce the amount of inputs and thus keep a higher profit per sao. Some farmers in the high areas in Quang An and Quang Phuoc claim the method does not work in the high areas and that they have already tried to use it in the past.

4.2.6 Soil types

In order to classify the soil types in the area, farmers have been asked to describe their soil with some key characteristics. Soil types which were given were clay, sand, alluvium and every combination of these three soil types. Except for this classification, the farmers also were asked to give other soil limitations, such as salinity and were asked if the soil, overall, was suitable for agricultural production to their opinion. The soil types can be found in Annex 14. In Quang An the soils near the lagoon are clay and more land inwards the clay soils are being mixed with alluvial, which is being transported to the area by the Bo River. 88% of the farmers in Quang An thinks their field is suitable for agriculture. In Quang Phuoc the soils are sandier than in Quang An. The areas near the lagoon are often classified as sand with clay and more land inward the soils are often classified as alluvial. There is thus, according to the farmers, less clay in the soils compared to Quang An. In this commune 73% of the farmers classify their field as suitable for agricultural production. The most northern commune, Quang Loi has no inflow from the Bo River and has thus even less clay and alluvium in the soil. The areas near the lagoon are still quite often clay with sand (the same as in Quang Phuoc), but a only a short distance from the lagoon the soils are pure sand. No agriculture is possible in the high areas of Quang Loi. Only 51% of the farmers think that their soil is suitable for agriculture. The soil types are all suitable for different rice varieties. Some varieties can deal with salinity and sandy soil, although these varieties are often of a lower quality and have a lower productivity than the varieties on the good soils without a problem with salinity. In the figure below, the main classification of soils in the area according to the farmers can be found. The soils are clearly heavier in the upstream areas (QP & QA) compared to QL.

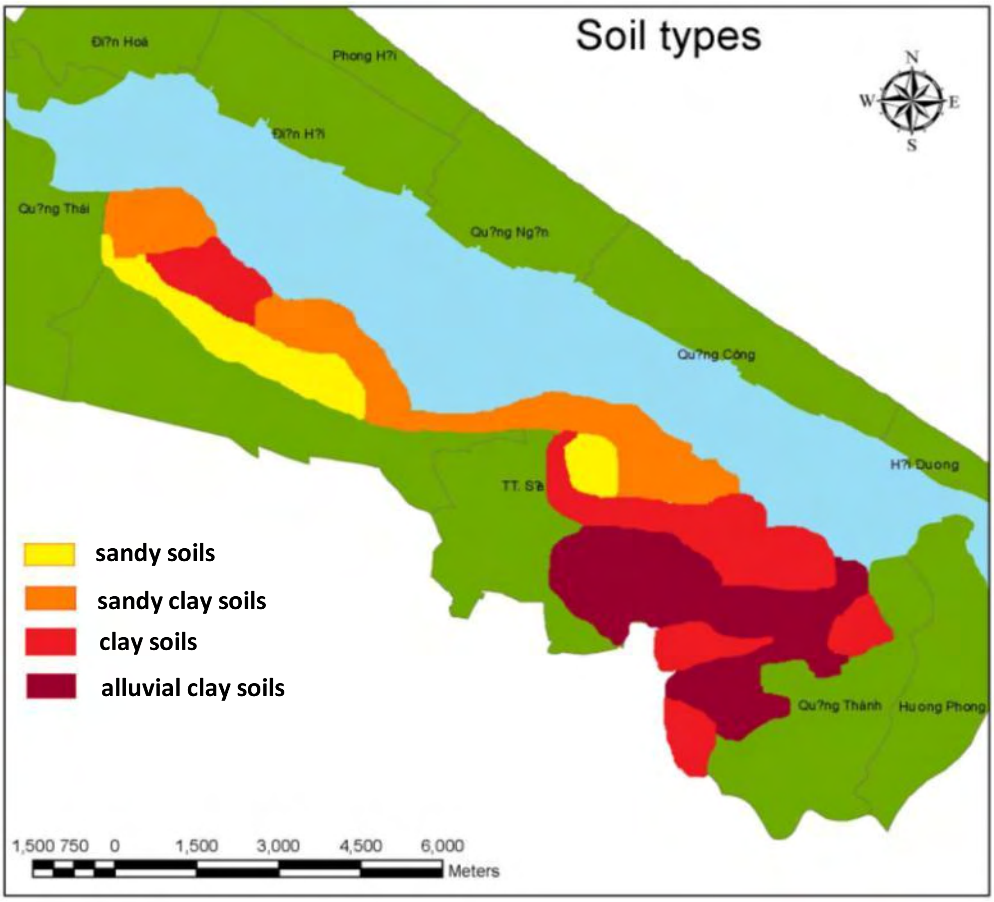


Figure 11: Soil types in Quang Dien, as indicated by the farmers

4.2.7 State of the irrigation system

The main irrigation system in Quang Dien transports the water from (mainly) the Bo River to the different communes. Since the most upstream commune, Quang An, also has to provide for sufficient drainage during peak floods, the water infrastructure in this commune is in relative good state. The more downstream commune of Quang Phuoc also has good water infrastructure. Most areas in Quang Phuoc already have access to concrete irrigation system and in other areas developments are currently underway. Water scarcity is said to be a problem in a few low areas, but this is not a regular problem. The most downstream commune of Quang Loi has only access to the main irrigation system in a few places. The rest of the commune has to use reservoirs. The water infrastructure is in very poor state and is clay in the most places. The water conveyance infrastructure from the reservoirs to the field is very long (reservoirs are in the high areas and agricultural land in the low areas) and often also in very bad state. This means the little water that is available will not be transported to the field in an efficient wat. Developments in this commune seem to focus more in improving the access to the market first, before the irrigation system will also be improved.
The access to an irrigation system has been divided into five categories (no access, earth canal in bad state, earth canal in good state, concrete system in bad state, concrete system in good state). Some farmers had only access to irrigation by boat. Since more farmers fell into this category than in the category of a good clay system, it has been chosen as a separate category.

Table 13: Yield in different areas, related to irrigation access

Irrigation access (n=120)		WS season yield (000kg)	SA season yield (000kg)	% without rice in SA season
1. No irrigation	*n=17*	4,38	4,20	82
2. Clay, bad state	*n=35*	4,48	4,34	69
3. Concrete, bad state	*n=11*	5,94	5,28	0
4. Clay, good state	*n=9*	6,24	5,06	0
5. Concrete, good state	*n=38*	6,08	5,06	0
6. By boat	*n=10*	6,36	5,80	0

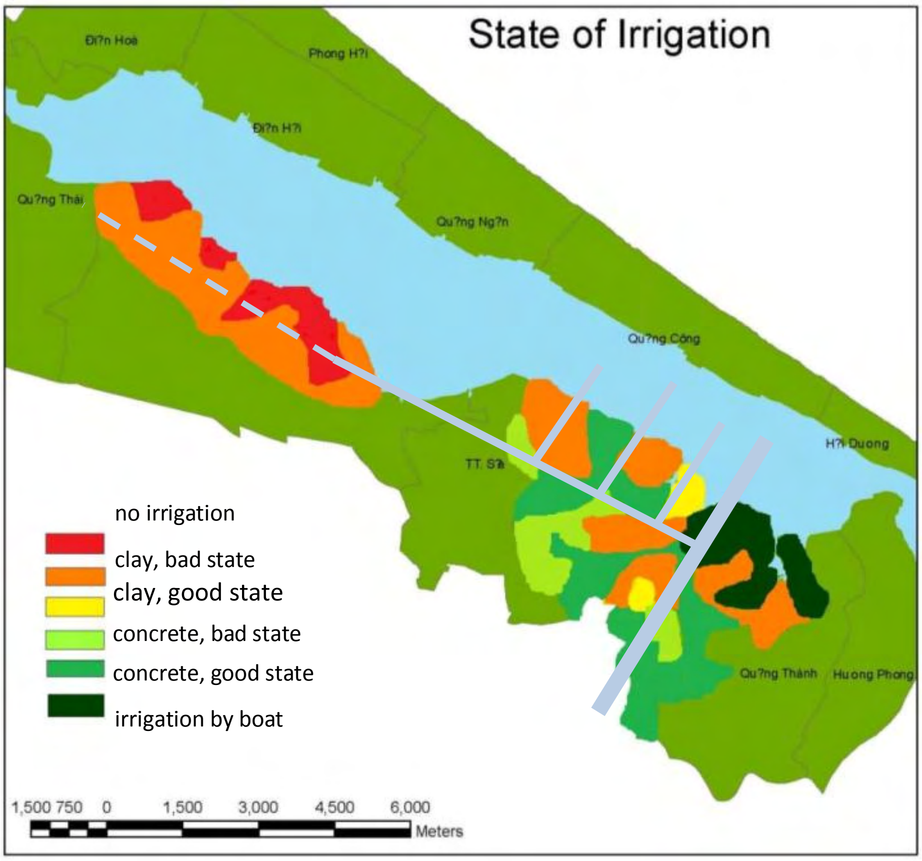
The above table has some limitations, since the categories are not all clear to the farmers. Neighboring farmers sharing the same irrigation system can define it as in good or bad state. Irrigation by boat is only done in Quang An, which already has the best soils, so this category cannot be extrapolated to other areas. The number of farmers which categorize their irrigation system as a good quality clay system is also very small, most of which also live in Quang An, which makes it not a very useful category. A concrete irrigation system is the most common in the high areas of Quang An and Quang Phuoc, whereas the downstream areas of these communes also have some clay systems. A concrete irrigation system only reaches the most upstream part of Quang Loi and the rest of this commune only has access to irrigation from reservoirs or from poor clay canals.

Another limitation is that the state of the irrigation system is not a direct indication of the amount of water in an area. Since no other data of good quality was available about the amount of water, irrigation structure has been taken as the main indicator of water availability; it is the same in different season and different years which gives a good option to compare the effect on output. The concrete systems of a bad state is located near the main irrigation structure in the upstream communes, which might be the cause that more water will be available in the SA season compared to the clay system with a good state. The good clay system has a higher yield in the WS season and a lower yield in the SA season compared to poor concrete system, possibly caused by the different locations of these types.

An interesting difference is between the non irrigated and bad state clay systems (n=52) and the other four categories (n=68). During the wet season, the yield in the first category is 4,46 ton per hectare whereas it is 6,12 ton per hectare for the other four categories. In the dry season the difference is 4,30 ton per hectare against 5,20 ton per hectare in the better irrigated areas. The difference in the low season is currently smaller since many of the farmers in the poorly irrigated areas do not cultivate a rice crop during the SA season (only the richer farmers with good soils). Although the different varieties play an important role in the different yield in the table above, the room for improvement by creating a good irrigation system will probably still be high in Quang Dien district.

Irrigation by boat seems to be giving the highest yields. This is for a large part due to the fact that these irrigation boats are only used in areas where sufficient water is already available (the low areas of Quang An, Annex 13). Since the boats irrigate from the large canals, they cannot be used in areas with salinity intrusion, since this intrusion will be highest in the larger canals which flow into the lagoon.
The soils in these areas are also the most suitable for agricultural production, so that the yield can already be relatively high, compared to the other areas. Irrigation by boat is taking place in the areas where a high concentration of wide drainage canals is located. The wide canals are needed for the movement of the boat to different fields. The price of irrigation by boat is not significant higher than other forms of irrigation in Quang An (it depends on the cooperative/village and not on the type of irrigation).
The lack of wide canals with sufficient water at all times can be expected to be a reason why this form of irrigation does not take place in the other communes. The initial and operation and maintenance costs of irrigation by boat will probably not be a lot higher than the construction of reservoirs, so this will not be a reason why, for example, Quang Loi does not use this form of irrigation. The figure below (*15*) gives an overview of the state of the irrigation in Quang Dien, as indicated by the farmers. The results are extrapolated from the respondents on field level, so they can differ a bit in size and area from the original results. A schematic drawing of the irrigation infrastructure is also added to the map, which shows where the density of drainage is high and where the good irrigation system currently finishes (Quang Loi).

Figure 12: State of the irrigation together with a schematic drawing of the irrigation infrastructure



4.2.8 Salinity

In Thua Thien Hue, about 2,500 ha of agriculture area around the lagoon suffer from salinity intrusion in the dry season (summer), and 51.5% of farmers have experienced it. There two main reasons for the salinity intrusion: (1). natural flow of sea water inside the lagoon in the dry season; (2). aquaculture ponds built in converted agriculture area. The high salinity is not favorable for shrimp to grow fast. However, high salinity is a suitable condition for the poly-culture of marine fish. Generally ponds located in high-tide areas lack a fresh water supply system to aquaculture (IMOLA, 2006a). The quality of soil for agriculture varies around the lagoon. The soil quality in Quang Dien has been classified as suitable for agricultural production by 71% of the surveyed farmers. This differs a lot amongst the communes. In Quang An, 88% of farmers considered their land as suitable, whereas in Quang Loi, only 51% of the farmers consider their land to be suitable for agricultural production. The problem with salinity has smaller changes over the different communes. On average, 36% of the farmers experience salinity. This differs only slightly over the communes, in Quang An, 29% experience flooding, in Quang Phuoc this is 42% and in Quang Loi, 38% of the farmers experience salinity. Almost all of the farmers who experience salinity also see this as a productivity limiting factor (*see annex 1*). Salinity is considered as the fourth biggest productivity limiting factor in the studied communes (after flooding, diseases and lack of water).

4.3 Water valuation in different areas

4.3.1 Quang An Commune

Quang An is the most upstream commune of the three researched communes and is located closest to Hué. During the PRA held in Quang An, both the yields and price of rice was highest in this commune. According to **commune data**, the area under rice farming was around 460 hectares in 2007, with an average output of 12.3 tons/ha for the two cropping seasons (6.15 tons/ha per season), which means a total production of 5.6 million kilograms. The price which is attached to this amount of output is 19662 MVND (1.2 million US$), meaning a price for rice of 3.500 VND (0.22 US$)/kilograms. This report is more positive than the actual output and price (see table below), but the area under cultivation will be probably close to the actual size. More than 9000 people live in Quang An, which means just over one sao is available per person for the cultivation of rice (DPC-yearbook, 2007).

Agriculture

In table 14, the average wet and dry season yields of 2007 can be found, including the different inputs (basic and for the commune) and the price of rice. The total average yield was 584 kilo per sao (11,7 tons/ha/year) and the average price was only 2.930 VND (0,18 US$) /kg, caused by the cultivation of the low valued TH5 crop during the SA season. This data differs quite a lot from the commune data, as mentioned above. The yearly yield in this research is 0.5 tons/ha lower and the price is 0.04 US$ lower per kilogram of rice. Per hectare this means a difference of US$ 565 per year.

Table 14: WS and SA in- and output of rice in Quang An

Quang An	WS- season	SA- season*	Yearly
Output:			
Yield (kg/ha)	6.244	5.444	11.688
Price (US$/kg)	0,188	0,178	0,183
Total	*1.174*	*968*	*2.141*
Input (basic):			
Nutrients	271	303	575
Herbicides	23	23	46
Pesticides	132	144	276
Seed	38	39	77
Input (labor+commune):			
Harvesting	132	132	265
Water	60	59	119
Land preparation	81	80	161
Seperating	24	24	48
Transportation	15	15	31
Profit:			
Basic	*709*	*459*	*1.168*
Including labor costs	*397*	*149*	***545***

High vs. low areas

As can be seen in table 15, the yield in the low areas of Quang An is somehow higher than that in the high areas, especially in the winter-spring season. The table below shows the difference in inputs.

Table 15: In- an output of rice in high and low areas of Quang An

Quang An		Output	Input					Profit
	Yield (ton/ha) + Main variety		Nutrients (N.P.K.)	Herbicide + Pesticide	Seed	Water	Other commune costs	
		(US$/ha)	*(US$/ha)*	*(US$/ha)*	*(US$/ha)*	*(US$/ha)*	*(US$/ha)*	*(US$/ha)*
High Areas (WS)	6,04 **4B**	1130	298	130	34	51	222	395
Low Areas (WS)	6,44 **4B/TH5**	1215	284	179	42	68	260	382
High Areas (SA)	5,34 **TH5**	948	324	139	35	52	222	177
Low Areas (SA)	5,56 **TH5**	987	283	194	43	66	290	111

Although the output in the low areas is higher during both seasons, the costs in the low areas are also a lot higher. Whereas only little more nutrients are used in the high areas, the farmers in low areas use more seed, herbicides and pesticides. The costs for labor and water are also higher in the low areas. Especially the commune costs (land making and cutting) are high, due to the wet soils, which cause the use of machines to be difficult and labor has to be used for some activities, such as harvesting. The costs which have to be paid to the cooperative are money for land making, water and separating. These costs are either paid in money or in kilograms of rice. For separating, the average charge is around 7 kg per sao (per season) in this area (26 US$/ha). For water, as can be seen above, the amount which has to be paid depends per area. In the high areas around 14 kg per sao has to be paid (US$ 52/ha), whereas low areas pay around 68 US$/ha, which is 18 kilo's rice. The reason for this difference is unclear, but could well be based on the location from the main irrigation infrastructure and thus extra costs of system maintenance in the areas which are located downstream.

Land preparation is the most expensive of the commune costs and averages US$ 75/ha in the area, which means 20 kilograms of rice per sao. Costs which the farmer has to make and which are not provided for by the commune are cutting (harvesting), looking out for the rice and transportation. The costs for cutting depend on the area. Cutting machines are available, but they can only be used on dry areas. This means that in the low areas or during periods of rainfall, labor has to be used. The difference is from around US$ 25 for a machine to US$ 150 per hectare for labor. When using a machine, the rice also has to be collected, but this takes less time and can be done by the farmer. Some varieties of rice (4B) are also not really suitable to cut by machine, so these are often also harvested by hand on the high areas. The costs for transportation depend on the area and distance to the field. Some farmers transport by boat and have to rent a boat (US$ 6/day). The most difficult costs to assess is the cost of the own labor provided for by the farmers. Farmers estimate to spend **five** days per **sao** to look after the rice, but the cost for one day of work has been said to be US$ 3 in Quang An, whereas farmers in Quang Loi took less than US$ **2** per day for their own costs. When extracting this own labor (US$ 200/hectare ***(5*20*2)***) from the profit, there would be a loss during the SA season in Quang An.

Social aspects

The farmers in Quang An use, on average, 78% for home consumption. This means this amount is not going to the market, but is used as food for the family and for the animals. 56% of the farmers uses 100% of the rice for home consumption and some of these even have to buy additional rice during some times of the year. Some farmers included selling rice for inputs for the next year under home-consumption, which means that more than 22% of rice goes to the market. Other activities outside cultivating rice in Quang An amount for 40% of the household income, especially growing pigs (75% of respondents) is an important source of income outside rice cultivation. Other activities are fishing, aquaculture, laborer, teacher or bonsai growing.

Around 93% of the interviewed farmers in Quang An are member of one of the organizations in the area, most of the Farmer Union. Water is managed by teams, which are created by the cooperatives in the area (one cooperative per village). Half of the people do not see pollution as a problem for the cultivation of rice. Most of the other farmers see it as a problem (most often mentioned salinity intrusion) for the cultivation of rice, especially during the dry season. The biggest productivity limiting factors in this area are flood, coldness and wind during the WS season and salinity, flood and mice during the SA season. The biggest overall problem is the high price of inputs.

4.3.2 Quang Phuoc Commune

Quang Phuoc is the commune bordering Quang An, downstream of the Bo River, but the rest of the characteristics are the same. Farmers in this area make a clearer distinguish between the high and low areas. 25% of this area is located too low meaning these areas are fully flooded during some time of the year. This has an influence on both the WS and SA yields, since flooding can occur in both seasons, rice varieties have been adjusted in the low areas, to better cope with the flooding (T92). According to the 2006 statistics of the CPC, the total area cultivated was 360 hectares, with an output of 12 tons per hectare (6 tons/ha per season). This makes a total production 4.300 tons, the price in **2006** was 2.500 VND (0,16 US$) /kg (*this data is older than that of Quang An, so a higher price in 2007 can be expected*). The yearly profit per hectare, according to this statistics, would be US$ 1.875.

Agriculture

The farmers in Quang Phuoc lose money in the dry season, but make this up during the winter-spring season. Around twenty percent of the crop fails (which means they lose 15-20% of output), which is caused by cold wheather, flood, mice, fog and insects during the wet season and by hot weather, mice, lack of water and insects during the dry season. In the past, the output was lower, which was caused by fewer water, bad seed, no crop planning and lack of good fertilizer. In Quang Phuoc, most farmers cultivate two rice crops per year, only 3 of the total of 360 ha of agricultural land is used to cultivate peanuts. The increased production can be seen in the table below. The main reason for the low current yield is the occurrence of diseases, which are happening more often.

In the *table 16*, the results from the household survey in Quang Phuoc can be seen. The data differs a lot from the given commune data from 2006. The yearly yield is 1.6 ton/ha lower and the price is 0,03 US$ lower, which makes the total profit US$ 103 per hectare higher, but when correcting the price to the current level (US$ 0,19), the profit would be US$ 302 lower per hectare per year.

Table 16: WS and SA in- and output of rice in Quang Phuoc

Quang Phuoc	WS- season	SA- season	Yearly
Output:			
Yield (kg/ha)	5.610	4.805	10.414
Price (US$/kg)	0,189	0,190	0,190
Total	*1.064*	*914*	*1.978*
input (basic):			
Nutrients	225	247	471
Herbicides	28	26	54
Pesticides	78	88	166
Seed	43	42	85
input (labor+commune):			
Harvesting	107	109	216
Water	62	62	124
Land preparation	84	86	170
Seperating	26	26	52
Transportation	18	18	37
Profit:			
Basic	*691*	*511*	*1.202*
Including labor costs	*394*	*209*	***603***

Table 17: In- and output in high and low areas of Quang Phuoc

Quang Phuoc		**Output**	**Input**					**Profit**
	Yield (ton/ha) + Main variety		Nutrients (N.P.K.)	Herbicide + Pesticide	Seed	Water	Other commune costs	
		(US$/ha)	*(US$/ha)*	*(US$/ha)*			*(US$/ha)*	*(US$/ha)*
High Areas (WS)	5,98 **4B**	1131	228	94	48	61	205	494
Low Areas (WS)	5,36 **4B/KN**	1025	223	110	39	63	227	364
High Areas (SA)	5,02 **TH5/KN**	955	241	96	51	62	205	300
Low Areas (SA)	4,66 **T92**	901	246	117	36	62	231	208

In the above table can be seen that the yield and final output do not change a lot after the different inputs in the area. Whereas the low areas use a lot more pesticide and herbicide, the seed-price seems to be a lot lower in the low areas. The amount of nutrients in the high and low areas does not differ a lot, whereas the commune costs in the low areas is a lot higher due to the use of labor for cutting.

Cooperative costs

Farmers have to pay a certain amount of kilograms of rice for services such as water provision, land making, rice separating, mice killing, field traffic and in some cases have to pay a fee per sao to the commune. The rent for land that has to be paid to the commune differs from 16 to 100 kg per sao, but renting land is not a very common practice. The fee for water provision differs per area and depends on the price of rice. Farmers have to pay between 13 and 23 kilograms of rice per growing season (US$ 40 - 90 per hectare). For land making the price is higher, and ranges from 19 to 53 kilograms of rice (US$ 60 - 160 per hectare), depending on the use of a machine or buffalos. The price for separating rice is a lot lower, with an average of 7 kilograms, which was around US$ 1.3 in 2007 (US$ 26 per hectare). Other costs are paid either only by a few farmers (mice killing) or are only paid once every few years (field traffic). A fee per sao is paid by farmers in some areas of the commune and can range from 30 to 200 US dollars per hectare per season. The average for costs which are paid to the commune per hectare per growing season is US$ 216, which is around 57 kilograms of rice per sao.

Labor costs

Most farmers in the Quang Phuoc Commune have to hire labor to do the rice cutting for them. A price of US$ 150 per hectare per season is most often given by farmers as the cost for this service. Some farmers use a machine to cut their rice, which only will cost about US$ 30 per sao, but rice has to be transported from the field to their home, which will give extra transportation cost. Still the difference between cutting the rice by machine and by laborer is quite high, but is a choice the farmers make and depends per household. Other labor costs are looking out for the rice, but if done by the farmers themselves. Farmers estimate to use 5 days per sao per season to look after the rice. The use of own labor power is estimated to cost US$ 200 per hectare per season (*US$ 2 per day, five days are needed per sao, twenty sao is equal to one hectare*) for most farmers. Since the same inputs have to be paid to the commune in both seasons, the farmers lose money in the dry season, since the output is often lower than the inputs in case of a yield reduction.

Social aspects

Around 75% of the rice which is cultivated by the farmers in Quang Phuoc is used for home consumption. This amount is thus not going to the market, but is mainly used for the home consumption and sometimes as feed for the animals, which are mainly pigs. Per person, a minimum of 180 kilograms of rice is needed. The percentage of farmers which use all of their rice for home consumption in Quang Phuoc is even 40%, there are even some farmers which have to buy additional rice during some times of the year. Some farmers included selling rice for inputs for the next year under home-consumption, which means that more than 25% of rice goes to the market. Off-farm activities in Quang Phuoc amount to around one third of the total household income; the most important one is growing pigs (87%) is the important source of income outside rice cultivation. Other activities are fishing, aquaculture, laborer, teacher or bonsai growing.

Almost all of the interviewed farmers in Quang Phuoc are member of one of the organizations in the area, most of the Farmer Union. Water is managed by teams, which are created by the cooperatives in the area (one cooperative per village). Around one third of the farmers do not see pollution as a big problem, whereas 45% of the farmers sees is as a very big problem during some parts of the season (most mention both problems). Flood and coldness are the biggest problems in the wet season, followed by mice and insects. During the dry season salinity, the high temperature and mice are the main problems. The overall problems are the high price of inputs and of the agricultural services.

4.3.3 Quang Loi Commune

Quang Loi is the most downstream commune of the studied communes. The Bo River hardly reaches this area (only a small part can be irrigated from the river). The people living in Quang Loi also refer to their commune as 'dead water land' since they fully depend on rainwater and manmade reservoirs.

Figure 13: The largest reservoir in Quang Loi

The area has, especially in the dry season a large problem with the lack of water. This lack of water causes most farmers to either leave their field fallow, or to cultivate other crops, such as sweet potato or peanuts. Only the most southern part has access to the main irrigation canal in the district and the most northern part has access to the largest reservoir, which give these areas the opportunity to have two rice crops per year. The problem with the water from the reservoirs is that the cost is very high since the availability of water is limited. This means that the benefits of the second rice crop, which is always already lower than the WS rice crop, will be very low. Having a season of rice-fallow will probably thus give the same benefits as having two rice crops. There are other limitations for the other two crops. Peanuts give reasonably high benefits, but are a crop that fails very often, so that only once every two years the farmers can expect to have a good yield. Sweet potato has a quite high productivity, but has a very low value. Only farmers that have managed to get a state contract to sell the yield. Only a few farmers managed to get a good (state) price for the sweet potato, so all other farmers have hardly any profit from their crop.

The amount of land per capita is the highest in this commune of the three study communes, but the quality of the land is by far the lowest. A large part of the land is currently un-used, but some of the land that is being used is not of a very good quality as well. Around 50% of the farmers in this commune state that their land is unsuitable for agricultural production. In Quang Phuoc this is 73% and in Quang An even 88%. This bad soil quality means that the varieties which are being cultivated are different than in the other communes, since the varieties should be suitable for sandy areas, which occur les in the other communes. The varieties have a lower maximum output (6ton/ha), compared to 7 or 8 tons per hectare for the varieties which are cultivated in Quang Phuoc and Quang An.

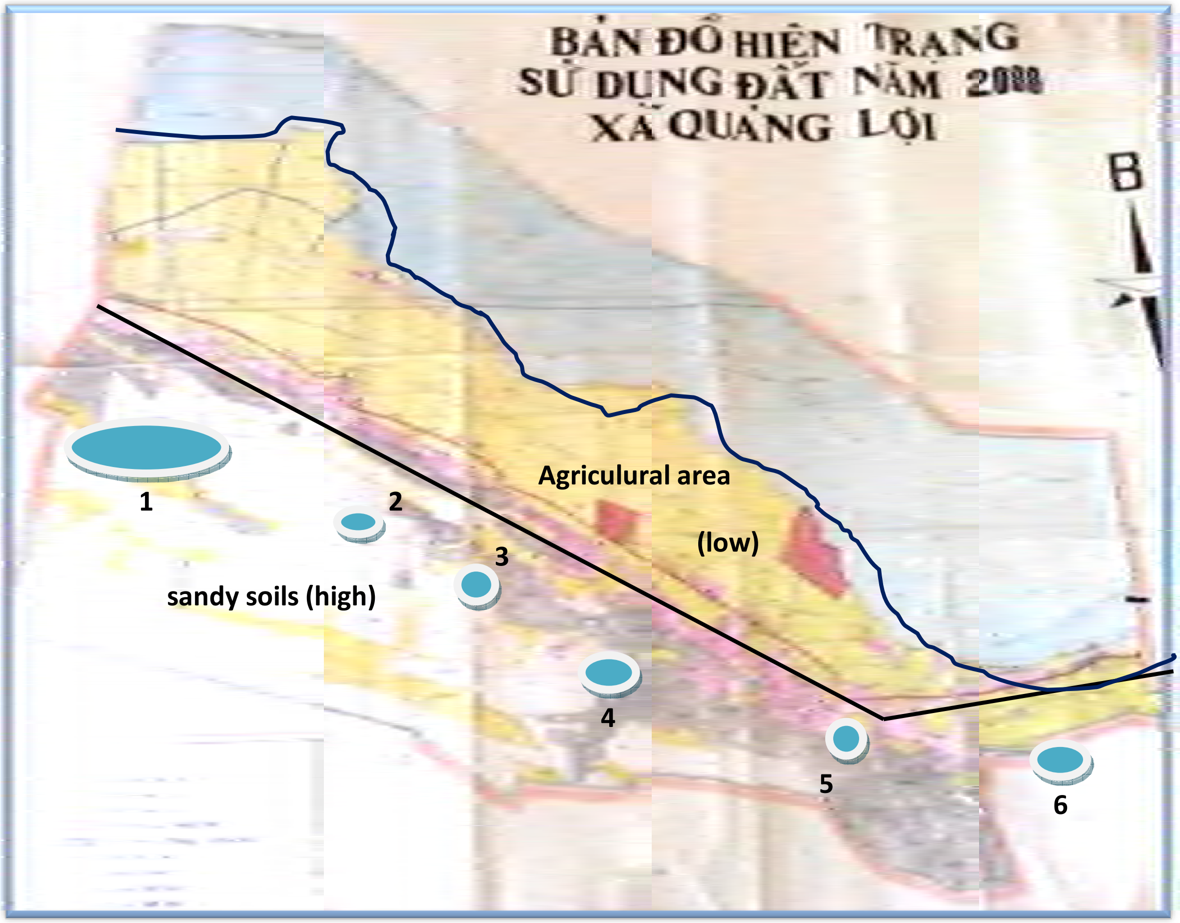


Figure 14: Reservoirs in Quang Loi

Although there seem to be quite many reservoirs, the total reservoir storage is only 77.000 m3 (the Huong Dien in the Bo River will have a storage capacity of 820.000.000m3). The total area in Quang Loi is around 712 hectares and the summer-autumn season for rice is around three months. Per hectare around 108m^3 is available, which is the same as 10.8mm, if it would be used for the entire area. Since this water is only used by few farmers who pay a lot of money, the amount per hectare will be a lot higher than this 11mm and rice can be cultivated. Not only is the storage capacity not sufficient, also the irrigation canals from the reservoirs to field level are in a very bad state and the reservoirs are unevenly distributed. The most northern part of Quang Loi has a 50.000m3 reservoir and rest has only 27.000m3. The most southern of Quang Loi has access to the main irrigation canal and thus can cultivate two crops already, but this is only around 10% of the total area according to farmers.

Table 18: Name and storage capacity of different reservoirs (PRA data)

1	Dong Bao	50.000m^3
2	Tram Nay	1000m^3
3	Mieu Ba	5000m^3
4	Thuy Co	500 m^3
5	Vung Phuong	500m^3
6	Dong Giang	10.000m^3

Agriculture

Economical aspects

Table 19: WS and SA in- and output of rice in Quang Loi

Quang Loi	WS- season	SA- season*	Yearly
Output:			
Yield (kg/ha)	4.174	4.062	8.236
Price (US$/kg)	0,181	0,193	0,187
Total	*760*	*788*	*1.548*
Input (basic):			
Nutrients	266	297	563
Herbicides	15	21	36
Pesticides	71	104	175
Seed	35	37	72
Input (labor+commune):			
Harvesting	84	58	142
Water	33	87	120
Land preparation	84	82	167
Seperating	22	23	45
Transportation	33	39	72
Profit:			
Basic	*374*	*328*	*702*
Including labor costs	*118*	*39*	***157***

In the above calculation (table 19), the value of the SA season is given for the few farmers that have a SA-season crop. This means the fields which are left fallow or where other crops are being cultivated are not being taken into account. The yield in both areas is only around 4 tons/ha, which make it a lot lower than in the other two communes. The price is, even though it is located far from the market, still around the same as in the other two communes. The main problem in this commune is the high inputs which are needed to be able to get a reasonable profit. The price of chemicals is not very high, but the input of nutrients is around the same as in Quang An, where they have around 50% higher output. The profit in the WS season is already very low (US$ 118 compared to around US$ 400 for the other two communes), but the problem in the SA season is even bigger. The output is not much lower than in the WS season, but the price of inputs, especially of water, is a lot higher. The basic profit (only taking into account nutrients, chemicals and seed), is not much lower than in the other season. The difference between both seasons is even the lowest of all three study communes when looking at the basic profit. When taking into account the costs which have to be paid to the cooperative, the profit which is left is only US$39, compared to around US$ 200 in the other communes. Whereas it seems there would still be a profit (not taking into account the own labor), this is unevenly distributed over the high and low areas. When looking at table 20, it becomes clear that some areas have a reasonable profit and some areas lose money during the SA season.

High vs. low areas

Table 20: In- and output in high and low areas of Quang Loi

Quang Loi		Output	Input					Profit
	Yield (ton/ha) + Main variety		Nutrients (N.P.K.)	Herbicide + Pesticide	Seed	Water	Other commune costs	
		(US$/ha)	*(US$/ha)*	*(US$/ha)*			*(US$/ha)*	*(US$/ha)*
High Areas (WS)	4,20 **C23/KN**	755	264	103	35	25	158	171
Low Areas (WS)	4,14 **C23/KN**	767	268	64	36	43	246	110
High Areas (SA)*1	3,70 **KN**	736	289	110	33	80	129	95
Low Areas (SA)*2	3,50 **KN**	666	215	50	42	93	355	-89

**1. The amount of people surveyed who cultivate during the SA season in high areas is only n=11.*
**2 .The amount of people surveyed who cultivate during the SA season in low areas is only n=2*

Quang An commune is located on a long strip alongside the lagoon and all areas which are suitable for agriculture can be said to be located in low areas. The high areas in most places have sandy soils which are unsuitable for agriculture. The choice of varieties seems to be based more on training than on the actual soil conditions. The output in Quang An is a lot lower than in the other two communes, whereas the difference between the both season doesn't seem to differ a lot. The big problem is the lack of water in the dry season, which causes most of the fields to be left fallow (around 70%). Also some of the farmers which do cultivate their fields with rice cultivate only a part of their land with rice. Other options farmers have during the dry season are peanuts and sweet potato. Whereas the peanuts give a reasonable good profit (very insecure yield), the sweet potato have a very low value. Some farmers could make a deal with the government to get a state-supported price for their sweet potato, but this number of farmers was limited. Most farmers cultivate other crops only due to the lack of water.

Cooperative costs

The cooperative costs are very different in Quang Loi between both seasons. Getting water during the dry season is in most places very expensive, which means only the already rich farmers can afford to get water for a second rice crop. The difference in the above table is around 40.000 VND between both seasons. Another big difference are the land making, cutting and separating costs, which are especially high during the SA season in the low areas. Due to the low number of people who cultivate during this season, conclusions from this high value cannot be made. The farmers in the low area almost all have to use labor for cutting, resulting in a big difference between high and low areas.

Labor costs

When taking the five days of labor into account, which farmers have to provide for themselves, the profit in the high areas during the wet season will even disappear and the farmers will lose money. Farmers in Quang Loi cultivate rice almost only for home consumption, since they lose money by doing it. Lack of water and unfertile soils are the main reasons for the low productivity, but many other constraints can be found in this area, such as the bad market access.

Social aspects

Farming in Quang Loi is, at this moment, not beneficial for the farmers. Other possibilities in this area, such as aquaculture or fisheries, are also restricted by law. The lack of inflow of freshwater and the already high area under aquaculture has led this area to be listed as a sensitive fishing zone, which makes it hard for people to start fishing or aquaculture in this area. Off-farm employment in Quang Loi is mainly done in the form of pig husbandry, peanuts growing and handicrafts. Making handicrafts is not a high valued form of income, and the bad roads and access to the market do not make this a very good option in this area.

The farmers in this area use more than 90% of their rice for home consumption. For 80% of the farmers all rice is used for home consumption, many of which have to sell extra rice during some time of the season. The current high price of rice is thus quite a big problem in this commune. Around 90% of the farmers in this area are member of one kind of organization. Water management in this area is done in a different way compared to the other two communes. Since there is hardly an irrigation canal running through the area and most water for irrigation comes from 5 big reservoirs, which are created by groups of households, water is managed on a smaller scale. People get their irrigation turns when they pay water. Whereas some farmers claim this use of a limited resource had led to some conflict, most farmers say that only when you pay (a high amount), you get water and this thus does not lead to a lot of conflict, since only some farmers can afford to get water.

Possibilities

Since Quang Loi is the poorest commune and is disadvantaged in many ways (downstream, bad irrigation system, bad roads, bad market access, poor soils and bad fishing grounds), the room for improvement in this area is the highest. Currently, the lack of freshwater causes not only most farmers to leave their fields either fallow or cultivate low valued crops, but also causes this commune to be placed in the category of sensible zone for fishing and aquaculture. This means only short term fishing permits are granted and that there is not room for new shrimp farming extension. High rainfall in this area is not causing an inflow of fertile soils, like in Quang An and Quang Phuoc, but is causing erosion on the sandy soils, which means the infertile soils are moving to the more fertile soils near the lagoon. Whereas currently 50% of income is generated from off-farm income, the current high price of rice, the occurrence of animal diseases and the unfavorable location for off-farm activities make the need for improvement in the agricultural sector very high.

Figure 15: Irrigation canal at the beginning of Quang Loi

4.4 Conclusions of the GIS maps

4.4.1 Introduction

The results of this survey have been put into GIS maps. This means that a spatial distribution has been made of the farms that have been surveyed, together with their main characteristics. Not only soil type and state if the irrigation system, but also the varieties, yields, input of chemical and nutrients and main limitations during both seasons, can be analyzed in their spatial distribution. Since the maps of soil types and state of the irrigation system already have been shown, the focus here will be on the effect of the different varieties, inputs and limitations on the yield of rice during both seasons. The GIS maps can also be found in *Annex 13-22*.

4.4.2 WS season

Most farmers in Quang Dien cultivate rice in the winter-spring season. The yield shows strong variations in this season, from 2-9 tons per hectare, depending on variety, soil type, inputs and limitations. The lowest yields occur in areas where natural disasters or diseases damage the already low yielding varieties. High yields occur in areas where favorable conditions cause the farmers to be able to cultivate high yielding varieties. Although the difference in yields seems big, most farmers have a yield between 4 and 6 tons per hectare. Higher yields are possible, but the quality of the higher yielding variety is in most cases a lot worse than the more general varieties (4B, Khang Nhan, TH5).

Since the winter-spring season is the wet season, the main limitations are both the floodings and the coldness during the winter months. Irrigation only has a limited impact in this season (*see Annex 23-27*). The other limitations, which were mentioned for the WS season, are diseases, lack of water and even salinity. The last two limitations only occur in Quang Loi, were water is even the most limiting factor in the wet season. The farmers fully depend on rainfall and cannot deal with periods without rain in the last two months (March-April) of the winter spring season.

The main varieties which are cultivated in the WS season are often long season varieties (around five months). The most commonly cultivated long-season varieties are 4B and C23. Since many farmers do not expect to have 5 months with favorable weather in this season (due to the above mentioned limitations), they adapt by cultivating short-season varieties, which only need 3,5 months. Farmers often use TH5 in the low areas, which are prone to flooding and use Khang Nhan in other areas, since this variety can adapt more quickly to the local conditions such as saline soils.

The main inputs of nutrients (N.P.K.) and chemicals (herbicides and pesticides) have been put into GIS maps in the same way the yields have been analyzed. This means the darker (red) dots indicate higher inputs. When comparing the GIS maps of nutrients and chemicals for the WS-season (*Annex 16&19*), no links can be found, meaning the amount of nutrients does not directly influence the yield. The amount of nutrient inputs seems to be related more to the soil type and does not change in areas with low yields. The links between amount of chemicals (*Annex 15*) and the yield (*Annex 19*) is clearer. Farmers in areas with high yields use high inputs of chemicals and farmers in areas with low yields use fewer chemicals. This is probably caused by the adaptation of farmers to their lower yields by using less chemicals and thus keeping a higher profit. Methods of lower inputs of chemicals are quite common (*see 4.2.5: IPM*).

The figure 16 and indication of the yield can be seen for the winter-spring season. The main limitations in the different areas and the varieties are also indicated. The main limitations show a lot of overlap with the cultivated varieties. C23 is cultivated where diseases are the main limitation, Khang Nhan where lack of water (probably also salinity) is the main limitation and TH5 is cultivated where floodings occur in the dry season. Yields clearly become higher from the north of Quang Loi to the low part of Quang An. A main reason for this is the productivity of the rice varieties. Whereat C23 and Khang Nhan can be expected to have a maximum yield of only 6 tons/ha, TH5 and 4B can have much higher yields with yields of relatively 7 and 8 tons/ha. The main limitations in the areas with low yields are also more severe than in areas with high yields. Farmers can more easily adapt to coldness and flooding (by adapting the cropping schedule) than to a lack of water. A lack of water and the different diseases will decrease the yields more than the floodings and coldness.

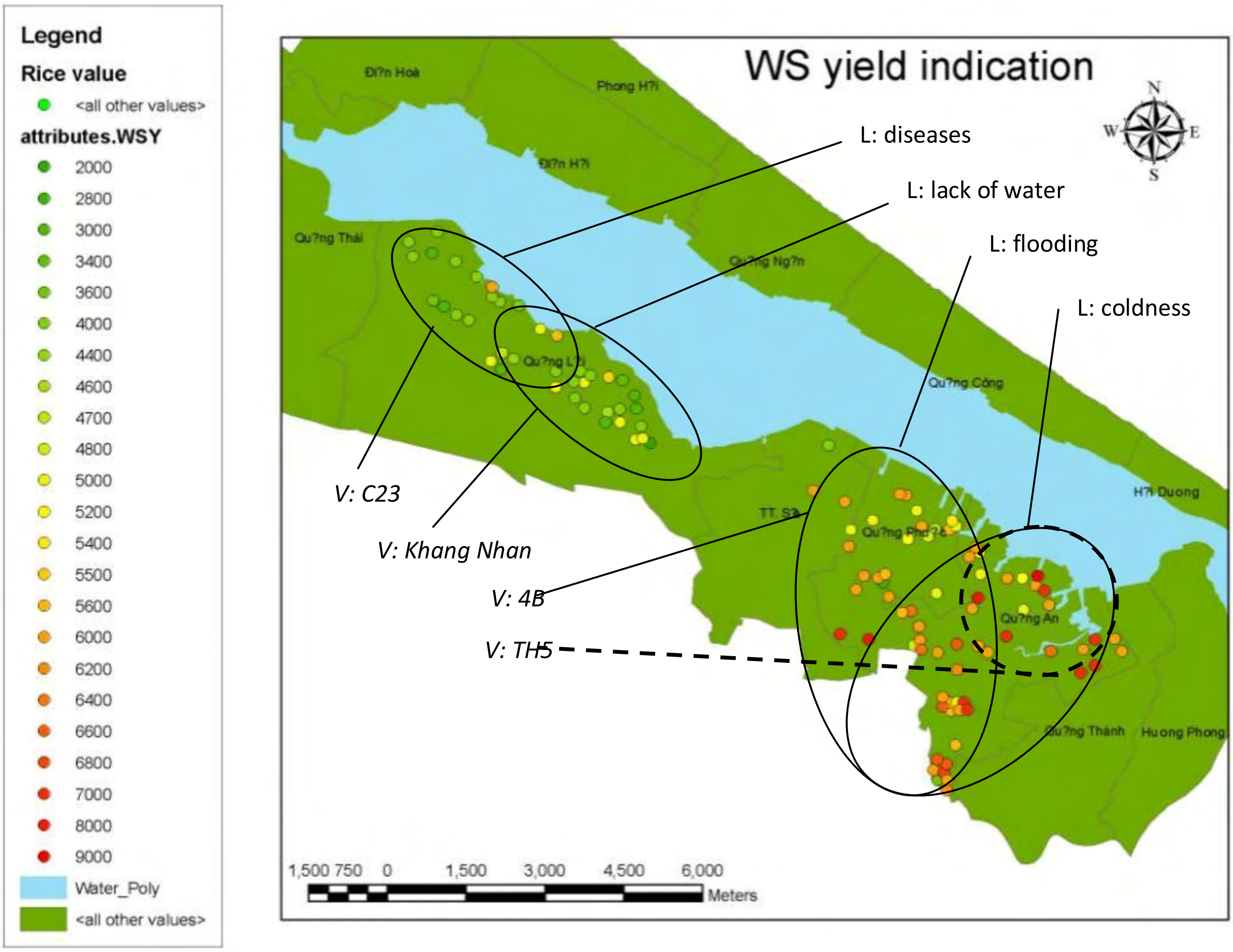


Figure 16: WS yield indication with the main limitations and cultivated varieties

The relative importance of the different variables to the yield of rice is hard to assess, since most of the factors depend on each other. The different main limitations cause the farmers to adapt by changing the variety and the input of chemicals. It is clear that the state of the irrigation system is important, but the different varieties, soil types and main limitations also cause large differences in yield. In 4.5 the correlation between the different variables and the yields will be given for different cropping systems.

4.4.3 SA-season

Farmers in Quang Dien do not always cultivate rice in the summer autumn season. The reason for this is in some cases that the output is often too low and the inputs too expensive to make is profitable. Since most farmers cultivate rice for home consumption, profit is not very important and most farmers will cultivate rice when this will be possible. The difference in yield in this season is smaller than in the WS season, due to the lower differences in maximum yield of the short season varieties (max. 6-7 tons/ha). The limitations in the summer-autumn season are a lack of water (Quang Loi), flooding (Quang An), hot temperatures and salinity (Quang Phuoc). Whereas this season is very different from the winter-spring season, the main limitations in many areas are the same. Flooding is, according to the farmers, still the main problem in this season in the most upstream area whereas a lack of water is still the main problem in the most downstream areas. Whereas flooding is a big problem according to the farmers, the expected difference in yield between high and low areas in Quang An and Quang Phuoc is not clear.

The adaptation to these limitations is not only done by changing the varieties of rice, but also by changing to different crops (or no crops). Whereas the yields in Quang An and Quang Phuoc still seem relatively good, the yields in Quang Loi are often very low, when rice is being cultivated. Farmers have a lack of water do to their dependency on rainfall, which causes them to either leave the fields fallow or cultivate sweet potato or peanuts. Both crops have their own limitations, since the price of sweet potato is in most cases very low and peanuts only five a good yields once every two years. The main varieties of rice which are being cultivated seem to fit to the main limitations in this season, just as in the WS- season. In areas with a lack of water, the farmers tend to cultivate drought resistant crops (sweet potato or peanuts) or Khang Nhan, which is a short season variety which can adapt to saline soils and drought in the SA-season.

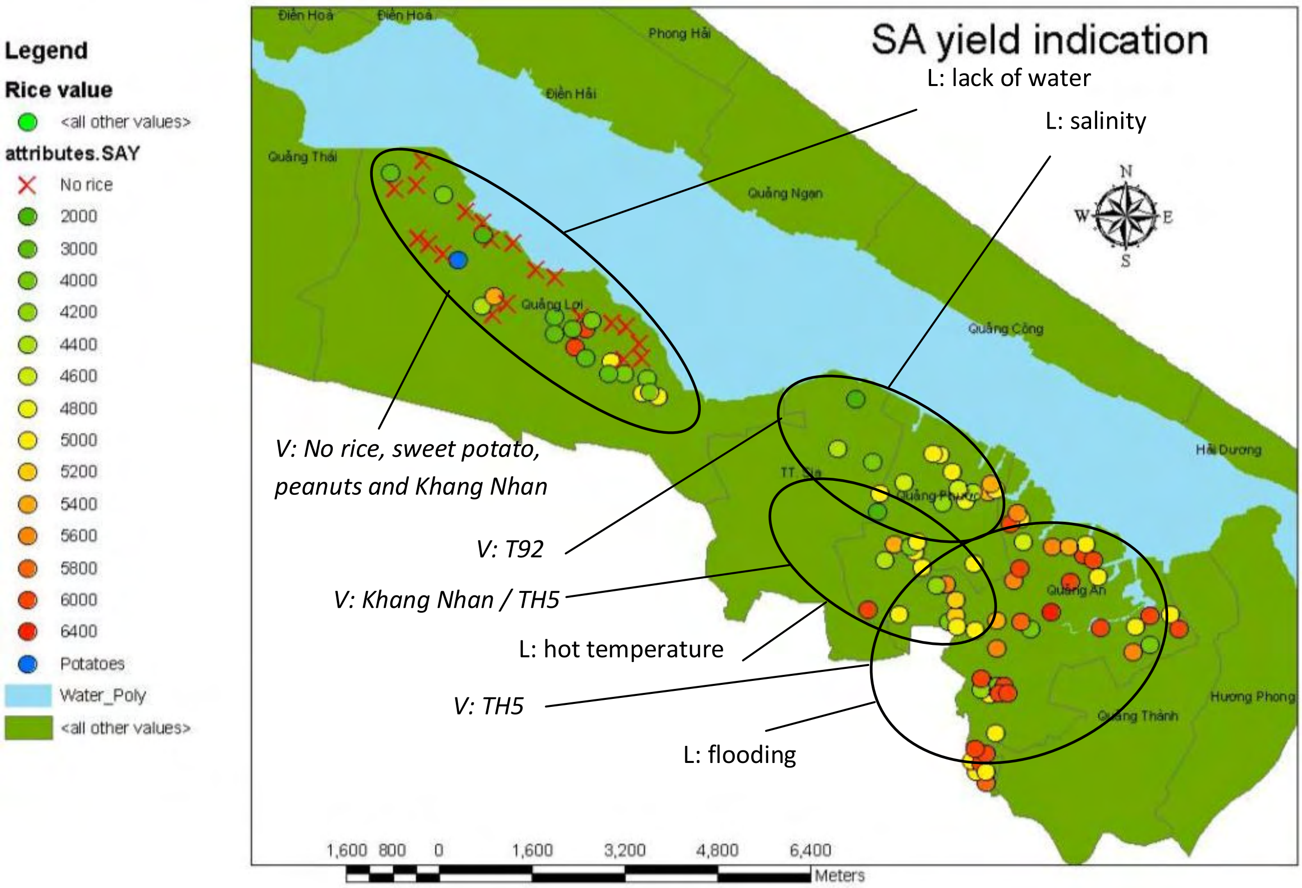


Figure 17: Yield indication with the main varieties and different limitations during the SA – season

In areas where salinity is the main limitation, farmers tend to cultivate T92. This is another short season variety which is of better quality than Khang Nhan. Whereas the productivity is similar, T92 is very good on saline soils and is better food (according to the farmers) than Khang Nhan. A combination of Khang Nhan and TH5 is used in areas where the limitations are very different (hot temperature, flooding, lack of water and diseases. There is no clear limitation in this area and farmers have not made a clear choice for a certain variety as is the case in most other areas. The areas in Quang An, where flooding is the main limitation in the SA-season, use the same variety as in areas where flooding is the main limitation in the WS-season. TH5 is cultivated by all interviewed farmers in this commune.

Not only the varieties and the limitations are the reason for the very different yields in the SA-season, but especially the state of the irrigation system is important in this season. The yields clearly become lower (up to no yield in Quang Loi) in areas further from the main irrigation system. Where water is sufficient, the yields are as high as in the WS-season. In areas with medium water availability, the yields already become a lot lower and in areas with no water, the farmers cannot even cultivate rice. The different relations between yield and limitations, varieties, soil types and state of the irrigation system will be given below in section *4.5*.

4.5 Cropping systems

Different cropping systems will be evaluated to see how the main variables influence the yield when taking into account the differences that are caused by the varieties of rice. As mentioned earlier, the farmers in Quang Dien have adapted to the local limitations, by cultivating different varieties of rice. The highest yielding varieties are only suitable for well irrigated field with good soils. In the WS season, not only the long season varieties (4B, 13/2 and C23) are cultivated, but often also short season varieties which can overcome the yearly flooding in the wet season. When combining the data from table 9 with the information which can be seen in figure 16 and 17, five different cropping systems can be distinguished.

The first cropping system (table 21) is the most common system and can be expected to have the highest economic benefits. The best long season variety can be combined with the highest yielding short season variety in this cropping system, which gives a yearly yield of 11,4 ton per hectare. The second cropping system has the same soils as the first system but has a flooding problem in the WS season that causes the farmers to be able to only have a short season available for the cultivation of rice. Two times TH5 are cultivated in this system. The third system has reasonably good soils, but a lack of water inflow in the dry season which causes a problem with salinity. Farmers adapt to this by cultivating T92. In the fourth and fifth system, the soils and availability of water is already a lot lower. Farmers cultivate either Khang Nhan or C23 in the wet season, depending on the availability of water. Some farmers (system 4) can cultivate another crop, Khang Nhan, in the dry season.

Table 21: The different cropping systems in Quang Dien with the related average yield

Cropping system	N	WS variety	WS yield	SA variety	SA yield
1	43	4B	**6,2**	TH5	**5,2**
2	18	TH5	**6,1**	TH5	**5,4**
3	20	4B	**5,1**	T92	**4,9**
4	12	KN, C23	**4,7**	KN	**3,9**
5	27	KN, C23	**4,1**	-	**-**

The five main cropping systems that can be distinguished in the Quang Dien district have very different yields that are not only caused by the differences in variety. Whereas the yield from TH5 in the SA season is quite similar for the first and second cropping system, the yield of 4B in the WS season in the first and third cropping system is showing a large difference. How the other variables influence these differences in yield will be examined in *4.6*.
Not only the yield is different, but also the input and output of the different cropping systems. The input, output and profit from the different cropping systems can be seen in table 22. Whereas the first cropping system looks the most favorable from an economic point of view, the actual profit of this system is similar to that of the second cropping system. The cultivation of a short season variety in the long season is thus not significantly limiting the economic value of the rice, although the quality of 4B is still a lot higher according to the farmers. This difference in quality is not clearly expressed in the economic value, but there might still be a social preference for the first system.
The third system is mainly limited by a lack of water and has a quite high SA profit, meaning that T92 is not a limitation. The main limitation is the lack of output in the WS season, since the inputs are similar to that of the first two cropping systems. The yield thus not weight up to the inputs. System four and five both have a loss in the WS season, since the output of the varieties in these areas is not high. The fourth system can cultivate a second variety and can make up for the loss in the SA season. The fifth system is the worst system, limited by the soils and lack of water. The farmers in this area lose money with the cultivation of rice. Some farmers will cultivate another crop in the SA season.

Table 22: Input, output and profit in the different seasons for the main cropping systems

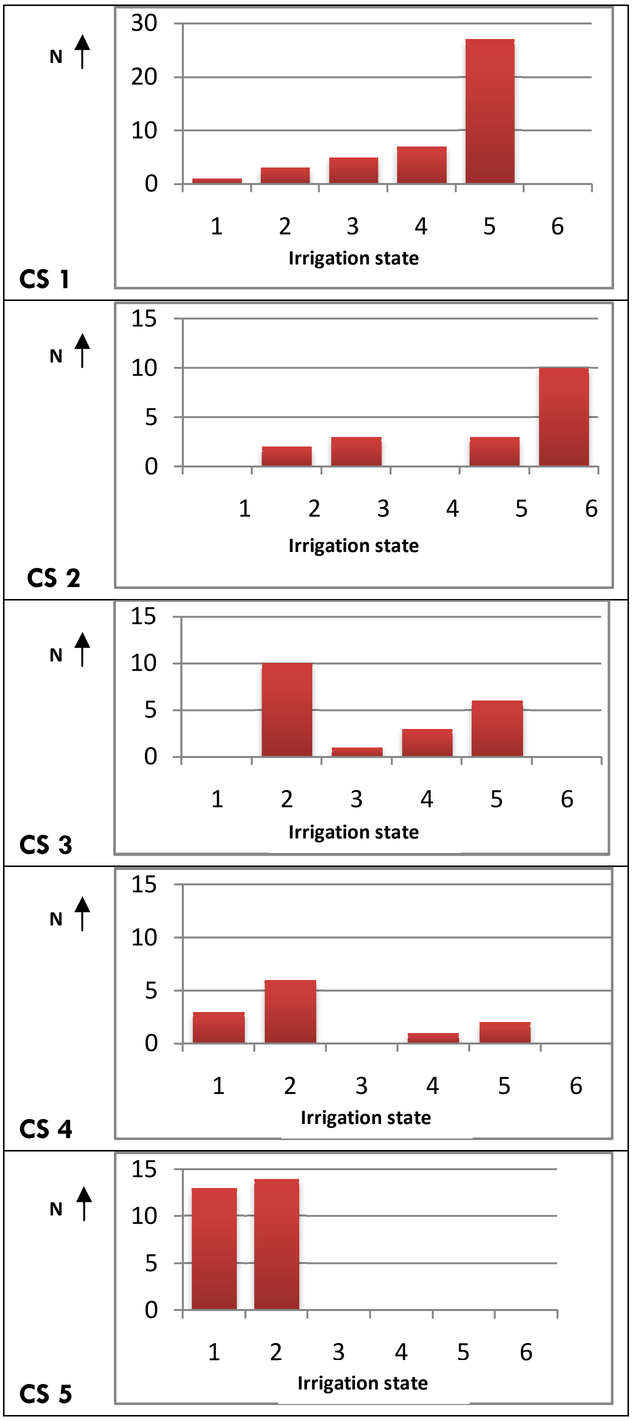
Cropping system	WS output US$/ha	WS input US$/ha	SA output US$/ha	SA input US$/ha	WS profit US$/ha	SA profit US$/ha	**Mixed income** US$/ha
1	1172	979	941	788	193	153	**346**
2	1169	964	1036	867	205	169	**374**
3	941	935	915	707	6	208	**214**
4	881	896	715	698	-15	17	**2**
5	716	852	-	-	-135	-	**-135**

4.6 Influence of the different factors per cropping system

The cropping systems are based on the area type (high/low), the soil type and the cultivated rice varieties. These three factors are related to each other, but are not the only factors which actually influence the output of rice. The variation within the different cropping systems is very high, meaning that there are other variables which can influence the yield. The three variables which can influence the yield within these cropping systems are the state of the irrigation system, the inputs of nutrients and the input of chemicals. In the annexes 23-27, these variables have been divided into different classes to see how they influence the productivity of rice. The main findings from these calculations will be explained in this section.

The first interesting finding is the occurrence of different irrigation states in the cropping systems. In *table 23* the farms in each cropping system are divided over the irrigation states. Irrigation state (IS) 1 means no access to an irrigation system, IS 2 is a poor and clay system, IS 3 is a poor concrete system, IS 4 is a good clay system, IS 5 is a good concrete system and IS 6 is irrigation by boat. It can be seen in the table that the irrigation state in the first two cropping system is much better than in the last three cropping system. System one mainly has a good concrete system, whereas in system two, irrigation by boat is often practiced. This is an area where flooding often occurs. Cropping system 3 has two peaks, for irrigation state 2 (poor, clay) and five (good, concrete). Cropping system 4 and 5 have the peaks at irrigation state 1 and 2, meaning the irrigation system in this area is either poor or lacking.

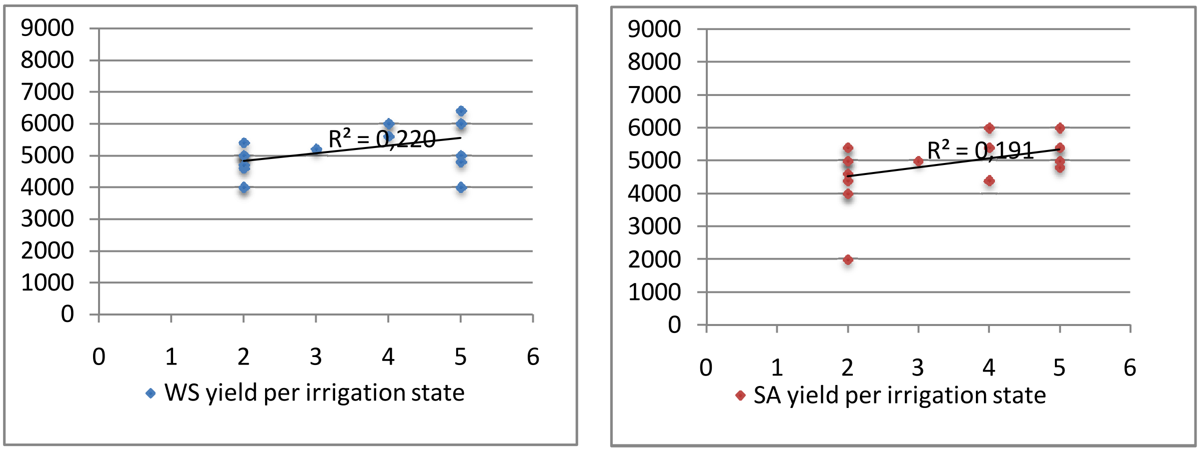
Table 23: Amount of farmers in each irrigation state for the five cropping systems



In the above table can be seen that there are clear peaks for cropping system 1 and 2. The peak for cropping system 1 at a concrete state means that irrigation is not a problem and that the best potential varieties of rice can be cultivated here. The peak at IS 6 for cropping system 2 means irrigation by boat is common in this area. Irrigation by boat can only take place in area where sufficient drainage canals can be found. The occurrence of these drainage canals implies that flooding is a problem in this area. The problem with flooding is the cause that farmers cultivate TH5 in the WS season instead of 4B. Cropping systems 4 and 5 have peaks at low irrigation state, which means that a lack of water is probable in the SA season. This lack of water in the SA season can be seen in the low productivity of Khang Nhan in in the SA season in CS 4 and the non-cultivation of rice in the SA season in CS 5. The main question which arises from the above table is why CS 3 does not change to either CS 1 or 2.

Cropping system 3 has in some places access to a good concrete irrigation system (IS5). Still the varieties which are cultivated in this area are different to the ones in cropping system 2 and 3. The reason for the different varieties is due to the problem with salinity in this area and the lower suitability of the soils (*sandy clay soils - figure 11*). The lower quality of the soils can be seen in table 20; the yield of 4B in cropping system 3 is much lower than in cropping system 1. In the SA season the farmers cultivate T92 due to the salinity. The influence of the irrigation state in cropping system 3 can be seen below (table 24). The difference between IS 2 and IS 5 is around 1ton per hectare per season. The variation of the yield in the different irrigation states is quite high, but a clear trend can be seen.

Table 24: Influence of the irrigation state on the yield in both seasons in cropping system 3



When analyzing annexes 23-27 it can be seen that the trends in yield, which are caused by the different irrigation state, differ between the winter-spring and the summer-autumn season. For the first cropping system no clear trend can be found. Although most farms have good access to a concrete irrigation system, the large fluctuation for this irrigation state causes the trend to diminish. Water is never a big problem in the area where this cropping system can be found, which can explain the small influence of a good irrigation state in both seasons.
In the second cropping system a clearer trend can be seen, mainly caused by the high occurrence of irrigation by boat in this cropping system. This area has flooding as a problem in the WS-season, which makes many farmers cultivate the short season variety TH5 instead of 4B. The amount of large canals in this area is also higher, which enables the farmers to use boats with electric pumps to irrigate their fields. The third cropping system shows similar upwards trends for both seasons (*table 24*).

In the fourth system, clay canals in a bad state can be found again in half of the surveyed farms. Whereas there were clear upward trends in both seasons in cropping system 3, the trend is only clear in the WS season in cropping system 4. The reason for the low trend in the SA season is both the low fluctuation for the cultivated variety (max 6t) and the low number of farms with good irrigation.
Since only two irrigation states can be found in the fifth cropping system (no irrigation and poor clay), there is no clear trend which can be seen in this system. The influence of irrigation on yield within the different cropping systems is lower than the influence of the state of irrigation on yields throughout the whole area. Not only the irrigation state influences the yield in the different cropping systems, but also the input of nutrients and chemicals plays a role. Farmers apply nutrients and chemicals in different monetary amounts. The first class (1) has the lowest input and the last class (1) has the highest input. A trend upward trend would thus be expected for the yield towards the higher categories of input.
The trend of the input of nutrients and chemicals does not show clear trends for any of the five cropping systems. This means that the input of chemicals and nutrients is not directly influencing the yield. The only reasonable influential variable is the state of the irrigation system. A good concrete system or irrigation by boat show, in general, a higher yield than the lower categories. The input of nutrients and chemicals is placed in different monetary values, which does not seem to have an important influence on the yield.

Chapter 5: Analysis of the aquaculture sector

5.1 Introduction to aquaculture

The aquaculture activities in the Tam Giang-Cau Hai lagoon can be divided into capture fisheries and shrimp farming. Since the objective of this thesis is to find possible transfers of values between different water-related activities and the possibility to transfer the area used for capture fisheries is hard, the focus in this thesis will only be on shrimp farming in and around the lagoon. Aquaculture is seen as a key economic activity and a means to escape poverty. The dramatic and not well planned development in recent years has led to many issues, which are hampering the development of the sector. More than 73% of aquaculture farmers are engaged in shrimp farming mainly using improved extensive and semi-intensive system. Fresh, brackish and marine fish are also farmed in cages and net enclosures whilst mollusc culture is in its infancy. Shrimp seed is available within and outside the province although quantity and quality are a concern. Marine fish seed is mainly caught from the wild. Freshwater fish seed is only available far from the lagoon and of low quality. Farmers have limited technical skills and shrimp disease outbreaks occur every year, affecting more than 90% of farmers in the Quang Dien district. Continued crop failures are causing serious debts. The public-private extension service should co-ordinate better to fulfill farmers needs.

5.1.2 Classification

For aquaculture, there are different types of systems and different types of ponds. Three different systems will be explained (semi-intensive, improved extensive and polyculture. The two main types of ponds are based on the geographic location, which can either be submerged or non-submerged.

Low tide shrimp culture area: Submerged area, permanent or temporary, along the lagoon coast where the pond cannot be dried for technical procedures of intensive or extensive shrimp culture. Usually the low tide shrimp culture area is the lagoon water surface beyond the saline prevention dam or beyond the fields on the lagoon coast. According to IMOLA (2006a), this area includes both (a) water surface and (b) special-use water surface and is called inter-tidal area in this report.

High tide shrimp culture area: Non-submerged area on lagoon coast, where the pond can be dried for technical procedures of intensive or extensive shrimp culture. Usually the high tide shrimp culture area is the area on the lagoon coast inside the saline prevention dam, the area on the lagoon dunes, or the coast sand soil area.

Semi-intensive aquaculture*:* Type of aquaculture in which industrial feed is used and which has a high stocking density (10-20 heads/m^2). The costs of this system are very high since the ponds have to be treated very well (*cleaning and pond improvement costs*) and due to the high costs of industrial feed. Diseases are occurring quite frequent in these systems, so the costs for disease prevention are also high.

Improved extensive aquaculture: This model of aquaculture is based on the traditional extensive models, in which natural feed and breed are being used. The improvement compared to the *extensive* system is that additional feed and breed are adopted, which has raised the stocking density from 3-5 heads/m^2 in the past to 5-10 heads/m^2 nowadays. The costs of this system are low compared to the semi-intensive system, but the output is also much lower (*see table 27*).

Since the initial costs of construction of high-tide shrimp ponds is much higher than that of the low-tide ponds, the high-tide ponds are less common in Quang Dien district. High tide shrimp ponds are, when looking at the ecological zones, conflicting with agriculture, whereas low tide ponds cannot be used for agricultural purposes, since they are found inside the lagoon. High tide ponds can only be found in two communes of Quang Dien (Quang Cong and Quang Ngan). In the three study communes, only low tide ponds can be found (DOFI, 2007). Although high tide ponds cannot currently be found in the three study communes (Quang An, Quang Phuoc and Quang Loi), this classification will still be studied for economical value to look whether it can be a possible transfer of value, when the high tide ponds will be used for a sustainable form of aquaculture (poly-culture). The total area of aquaculture in Quang An is 127 hectare, all of this is done in low tide ponds, 81 hectare of this is polluted. In Quang Phuoc, the area under aquaculture is 161 hectare, again only in low tide ponds. In this commune 145 hectare is categorized as polluted. Quang Loi has, with 19 hectare, the least aquaculture (only low-tide). In this commune, 8 hectare is polluted according to DOFI (DOFI, 2007)
To give an indication of the species used in aquaculture, the data from the aquaculture survey, which has been conducted by IMOLA in 2007, will be used. This survey has so far only been conducted in one of the three communes this research will focus on. In Quang Phuoc, a full census survey has been done (413 aquaculture farmers). All these farmers have low tide ponds in which most farmers cultivate tiger shrimps. This is the main cultivated species and the one with the highest economical benefit (main crop). Research by the HCE in 2008 has also focused on this crop; the results of this research will be shown in

Most farmers cultivate more species over one year, of which tiger shrimps are the most important and cultivated in the most favorable season. Other species are crab, rabbit fish and orange spotted shrimp. Of the 413 farms which have been interviewed, 159 do not experience diseases and 53 do not have information about the occurrence of diseases. The rest of the farmers (201) experience various diseases in their ponds. The main diseases which occur are the white spot disease (64), gills black/yellow (63) and the accumulation of seaweed (20), the rest of the diseases are not classified by the farmers. Off the farmers, 306 do not use chemicals or medicine to treat the diseases, 54 farmers use some kind of medicine and the rest did not give data. Treatments for diseases are: lime, chlorine, BKC, Dolomit, Kadulai and Sarponin.

5.1.2 Polyculture

In most aquaculture ponds in Quang Dien, polyculture is already practiced (around 80%). This means the unsustainable stocking rates of tiger shrimps have been lowered to a more sustainable level and fish have been added to the ponds. In this way, the negative ecological effects of the high stocking rate has been lowered, while the economic benefits more or less remain the same due to the value of the newly added fish in the ponds. New technology of better pollution management in brackish water shrimp ponds will constitute to around 9% of annual shrimp farming costs per hectare (SEAFDEC, 2008), but give more security, since the current risk of losing everything due to diseases is very high. Some more effects are described below (SEAFDEC, internet, 2008):

1. Lowered stocking density- this may decrease the harvest volume by 20-30%, but he harvest value could increase by 8-10% due to the bigger size and improved feed conversion. Feeding and nutrient loading is reduced by 20% and the risk of opportunistic diseases is reduced as well.

2. Improvement of pond bottom management- this may increase plowing or tilling cost, add net cage construction to the expense but these costs could be recovered from the sale of the added fish crop. Bacterial profile of sediment is improved, however, as well as water effluent quality.

3. Crop rotation- one shrimp crop may be lost but there is some income from fish culture. Crop rotation improves sediment bacterial profile, reduces incidence of white spot and ultimately allow time for organic waste to break down.

5.2 The ecosystem approach

The ecosystem approach, as described in existing policy documents (e.g. WSSD 2002), contributes to sustainable development, which requires that the needs of future generations are not compromised by the actions of people today. The ecosystem approach is variously defined, but principally puts emphasis on a management regime that maintains the health of the ecosystem alongside appropriate human use of the marine environment, for the benefit of current and future generations (Jennings, 2004). The broad purpose of the ecosystem approach to fisheries (EAF) for example is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services (including, of course, non fisheries benefits) provided by marine ecosystems (FAO 2003).

From ecological, economic and social perspectives, existing management methods have generally failed. Thus, 47% of the world's main stocks or species groups are fully exploited, while 18% are overexploited and 10% are severely depleted or recovering from depletion. Only 25% of stocks are under- or moderately exploited (FAO 2002).
From an ecological perspective, the ecosystem approach recognizes, and aims to remedy, the unwanted impacts of fishing on non-target species, habitats and ecological interactions. The approach recognizes that ecosystems provide goods and services other than fish and may change the burden of proof if existing management is not precautionary (Sainsbury & Sumaila in Jennings, 2004). However, in the broadest directional terms, scientific advice is consistent from both single-species and ecosystem perspectives: significant capacity reductions are needed (Jennings, 2004).

Industry, tourism, agriculture and aquaculture are developing rapidly in Thua Thien Hue province. As a result, waste discharged from these activities into the lagoon environment is increasing. Tam Giang – Cau Hai lagoon receives the waters from the Huong River basin including the main rivers such as Huong River, Bo River, O Lau River and Truoi River. Therefore, all the wastes, liquid and solid, that run-off from the land and into the rivers ultimately flow into the lagoon (ADB, 2007).

There are four main sources of lagoon water pollution:

- Liquid and solid wastes from domestic and municipal activities;
- Industrial wastewaters;
- Effluents from aquaculture activities, especially shrimp culture;
- Run-off and drainage from farmland (agricultural activity).

Whereas en ecosystem approach is needed to understand the full range of problems and to find solutions to maintain a healthy and productive ecosystem (both terrestrial as aquatic), the current management of the lagoon is mainly focused on either the aquatic environment (e.g. IMOLA) or the terrestrial activities and river inflow up to the lagoon level (HRPMB). This means that the problems are not tackled in an integrated way and the ecosystem based approach is only partly implemented.

The main problem in the area in and around the Tam Giang-Cau Hai Lagoon is the failure of aquaculture farming in recent years and the decreasing profit from natural catching. The reason for this is, to the opinion of the aquaculture farmers and fishing folks, the increased and uncontrolled use of pesticide and chemicals by the rice farmers in the upstream area. This means that the reason for their failure is eutrophication of the lagoon water. Eutrophication is *"an accelerated growth of algae on higher forms of plant life caused by the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus and inducing an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned"* (WHO, 2002). Under eutrophic conditions, phytoplankton over-growth (including toxic algae) sometimes causes undesirable "algae bloom" phenomena, gradually leading to degradation of biodiversity and damage to aquatic life and other animals (WHO, 2002). Eutrophication is clearly a concern for the lagoon ecosystem. Eutrophication can increase the risk of oxygen depletion at the bottom of the lagoon which adversely impacts on benthic biota. In addition, toxic algae growth under eutrophic conditions can be a threat to the health of aquatic animals in the lagoon and humans consuming them (ADB, 2007)

The conflict between the agricultural and aquaculture/fishing sector is for a large part based on the 'bottom-up' notion that the pollution from the agricultural sector is causing the eutrophication which is resulting in the loss of productivity and outbreak of diseases, but a clear link cannot be found. Over the last 10 years, the agricultural sector has been using increasingly more inputs, the city of Hué has experienced a rapid growth and also the aquacultural sector itself has been rapidly expanding over the lagoon area. Jackson *et al.* (2001) give a top-down explanation for the degradation of (marine) ecosystems. They state that the increasing eutrophication, which is resulting in increased sedimentation, loss of seagrass, higher frequency and duration of algal and toxic bloom and fish kills, can also be caused by the losses in benthic suspension feeders. This means not only the agricultural sector, but also the fishery and aquaculture sector are causing the problems to the ecosystem.

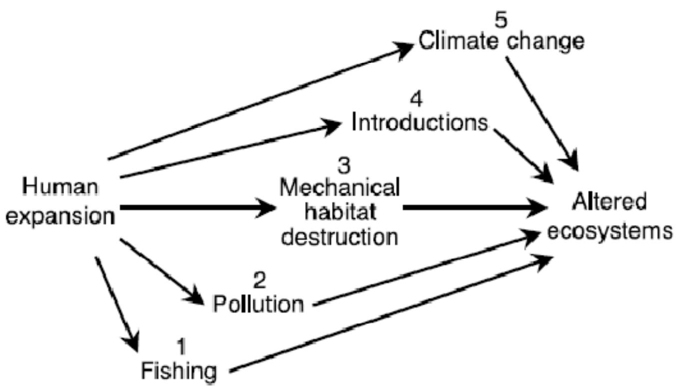


Figure 18: Historical sequence of human disturbances affecting coastal ecosystems (Jackson et al, 2001)

There are many pressures which can cause the problems and bad current state of the ecosystem. The most commonly mentioned problem is the inappropriate aquaculture extension inside the lagoon with enclosure nets of all types, low-tide ponds and fish corrals, which has reduced not only water circulation and the self-assimilative capacity of the lagoon, due to decreased aeration, but also interfered with migratory marine species. A range of activities has destroyed or degraded habitat and nursery grounds for natural aquatic wildlife and also of local and migratory birdlife (ADB, 2007). Fishing is also causing problems to the lagoon environment. The over-exploitation of the natural fishing resources and the way in which fishing is practiced (electric fishing, small mesh net sizes) has almost completely out-fished the lagoon of all but seasonal migrations of marine species (ADB, 2007). The overexploitation has resulted in a declined catch per unit effort of the natural fishing stocks. This will result in increased poverty for the people who depend on this activity and some already move back to cultivating rice as their main income activity.

5.3 Legal regulations regarding fisheries

5.3.1 Introductions to the lagoons' property regimes

Given that lagoons, fisheries resources and water resources are under the People's ownership; considering that Fisheries Law states that "Organizations and individuals have the rights to exploit the fisheries resources as provided for the legislation"; that the Law on Water Resources establishes that "Organizations and individuals are entitled to exploit and use the water resource for life and production"; but over all because of the characteristic of fisheries resources to freely move in their aquatic living environment, the water surface area of the lagoon is considered to be under an open access regime. This means that everybody (constituting the People) has the right to access, the right to use and the right to exploit the water surface area. And implicitly, nobody can possess and dispose of a delimited area of the water surface (IMOLA, 2006b).

In practice, the use of specific nets in the lagoon, specifically for culture of fishing resources purpose, has particular consequences. Fishing nets in general, because of their purpose and capacity of capturing fisheries, might be considered as the tools for exploiting natural resources such as water surface areas. In the specific case of net-enclosures for aquaculture activities, located in the water, these not only prevent fisheries resources to freely move in the whole water area (both the ones inside and the other outside the nets), but they also limit the right of access, use and exploit of the other users, at least in some parts of the lagoon. As a consequence, the theoretical structure of the open access regime fails (IMOLA, 2006b). Existing property rights over wetland resources in Vietnam are a mixture of state, private and common property regimes (Adger et al. in Do and Bennett, 205). This makes it more difficult for a well-defined property rights structure to be met. As a result, problems of open access have arisen (Turner et al. in Do and Bennett, 2005).

5.3.2 Coastal Zone Management in Vietnam

In 1977, Vietnam issued a declaration defining its marine waters. From 1989, great efforts were made to build a legal framework regulating marine relations in terms of (1) territorial space, (2) resource and marine operation management according to functional sectors, and (3) marine environmental management. The Vietnamese government will need to set up policies and laws on decentralized administration and provide more management rights to managers, local organizations, and communities, where possible, involving a co-management approach (usually relating to assisting communities in the setting of regulations to allow them to manage their own resources) (PRIMEX, 2006).

In Tam Giang lagoon, tradition dictates that each fishing village (van) be given a fishing area and only fishers from the village can fish freely using nets or traps in the area. Fishing using hook-and- line is open to all, including non-residents. This custom has been adopted by the government and continues today. Traditionally, a person who settled in an area and established a fishing village would have the right to allocate resources to subsequent arrivals. His children would inherit this right. The villages were thus self-managing. Fishing villages were defined by tradition as located "between two streams." All people from the area between two stream-mouths could use near shore areas for fishing. People from other areas were excluded unless invited by the residents, e.g., when fish were particularly plentiful. These areas could be quite large, extending to depths of up to around 40 m and to 40 km from shore. After the 1960s, with collectivization and the introduction of modern fishing vessels and fishing gear, this management system was lost. Thus, though people now think that marine resources are open to all, in past times, marine resources had a tradition of clan or village ownership. Research by the Institute of Fishery Economics and Planning indicates that many fishers are prepared to accept limited access, where it can be demonstrated to be necessary for resource conservation.

5.3.3 Legal framework for fisheries

Many legal documents have been created regarding fisheries in the last few years. These decrees focus on the form of organizations, the type of fishing gears and the kinds of permits which are being granted. For example Decision No. 4260/2005/QD-UBND gives some regulations for the management of lagoon fisheries, in which the State encourages community-based fisheries management, to promote democracy at grassroots level and decentralization and to reduce the management cost of coastal fisheries. Some articles in this decision can be seen below:

Article 3. *Individuals and households participating in lagoon fisheries must organize themselves in fisheries associations at the village's level, inter-village or commune levels. The State will only delegate the power of lagoon fisheries management to the fishery associations at the grassroots level.*

Article 4. *Fisheries associations at the grassroots level are social and professional organizations. Fisheries associations are under the Vietnamese Fisheries Society (VINAFIS). The fisheries associations are operated under the leadership of the Communist Party and authority of the communes, sponsored by the Department of Fisheries and Districts' Offices of Agriculture and Rural Development and professionally instructed by the higher Fisheries Associations.*

The Fisheries Associations who are allocated the lagoon resources rights are responsible for collaborating with competence agencies to manage and self-manage the fishing grounds; aquatic resources, the environment, water traffic, flooding outlet way, and birth and migration ways of lagoon species and to promote democracy in the management of aquatic in the local area (Guidelines for the implementation of Decision No. 6260/2005/QB-UBND.

Also some articles have been created for the protection of fishing grounds and aquatic resources. **Article 22** for example states that it is strictly forbidden to carry out the following activities to destroy fisheries resources and pollute the lagoon aquatic environment:

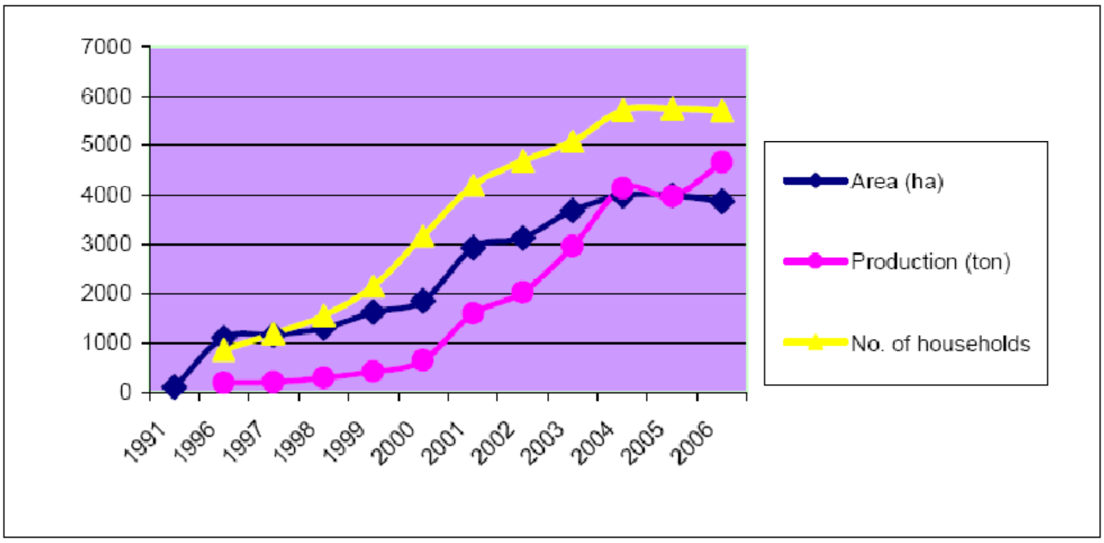
1. *Using poisonous chemicals, explosives, electricity to exploit fisheries resources.*
2. *Discharging garbage, letting pollutants and toxic substances leak beyond the limit.*
3. *Using such gear as push net, trawler, eel rake, stick net, drag net, mussel rake when fishing by motorboat.*
4. *Destroying mangrove forests, reefs and other special biological landscapes.*
5. *Discharging diseased fisheries species into the fishing farms or into the lagoon water bodies.*
6. *Building, destroying or changing construction works in the lagoon water bodies without the authorization of concerned authorities and thus causing great damage to aquatic resources.*

Except for these general regulations regarding fisheries management, also different zones have been created by the State (Decision No. 3677/QD-UB). The communes around the lagoon are either classified into extremely sensible, sensible or normal zones. These zones have different administrative regulations which have an effect on the type of fishing permits which are being granted, extension possibilities for shrimp farming and the enforcement on transgressing ponds without permits.

5.4 Economic benefits of aquaculture

Aquaculture is one of the main income generating activities in Quang Dien. The annual revenues for the whole district were US$ 4.16 million in 2006 according to the commune statistics. Of the three study communes, Quang Phuoc has the highest annual income which is being generated from aquaculture. In Quang Loi, the aquaculture sector is relatively small due to the problems with water inflow and extension in this area is also prohibited by law. The law regarding aquaculture still places Quang An and Quang Phuoc in a different zone, but even in this areas, the extension of aquaculture is not allowed. Fishing permits are still granted in these communes. The area which is used for aquaculture, the production and the no. of households which are involved in the aquaculture activities can be seen in *table 25*. In this table the rapid expansion can be seen, which has caused that nowadays the carrying capacity of the lagoon is exceeded in many areas; as a result the aquaculture crops are often failing.

Table 25: Aquaculture production in the Tam Giang- Cau Hai Lagoon (source: TTH Fishery Department, 2007)



Yield per aquaculture model:

The three main aquaculture models, which are mentioned in the classification (5.1), all have different characteristics when it comes to costs and yield. The highest yield comes from the semi-intensive systems, which apply industrial feed and have a stocking density of 10-20 heads/m^2. These systems have an average yield of 915 kg/ha (*see table 26*). Improved extensive systems mainly rely on natural feed and have a stocking density of 5-10 heads/m^2. Polyculture does not only have a yield of shrimps, but also of crabs and fish. The species in this model depend on natural feed at different layers.

Table 26: Yield per hectare for differente aquaculture models (source: HCE, 2008)

Yield per hectare	**Semi-intensive** *(kg/ha)*	**Improved-extensive** *(kg/ha)*	**Polyculture** *(kg/ha)*
Shrimp	915	610	520
Crab	-	-	33
Fish	-	-	157

Costs and benefits per aquaculture model

The costs of aquaculture depend on the model of aquaculture which is applied. The total costs of semi-intensive are by far the largest. This is caused by many factors, of which the industrial feed is the most important one. The total costs for improved-extensive and polyculture systems are nearly the same and do not have very big differences for the different costs. All different costs can be seen in *table 27*.

Table 27: The different costs per aquaculture model (source: HCE, 2008)

Costs per aquaculture model			Semi-intensive *(US$ per ha)*	Improved-extensive *(US$ per ha)*	Polyculture *(US$ per ha)*
Total costs			4.017	2.519	2.754
Inputs	***Total***		3.694	2.298	2.447
	Pond improvement		362	305	312
	Cleaning costs		322	197	212
	Breeder		201	185	223
	Disease preventing cost		247	136	99
	Feed cost	*(fresh)*	257	119	182
		(industrial)	1.353	667	604
	Hired Labor cost		185	122	126
	Interest cost		349	199	328
	Depreciation cost		334	317	311
	Other		84	49	51
Labor costs	Family		322	222	306

Not only the costs for the semi-intensive systems are the highest, but also the gross output (*table 28*). Whereas the mixed income for semi-intensive and improved-extensive is almost the same, the mixed income for polyculture is much higher. After extracting labor costs, the profit remains around US$ 500. The farmers with semi-intensive systems, on the other hand, lose money when taking into account labor.

Table 28: Gross margin per aquaculture model (source: HCE, 2008)

Gross margin per aquaculture model		Semi-intensive *(US$ per ha)*	Improved-extensive *(US$ per ha)*	Polyculture *(US$ per ha)*
Total costs		4.017	2.519	2.754
	Inputs	3.694	2.298	2.447
	Gross output	4.003	2.669	3.213
	Mixed income	309	371	765
Net-income		-14	150	459

When comparing the mixed income (gross output-inputs) of agriculture and aquaculture, some interesting differences can be seen. The mixed income for one year of rice cultivation (one or two crops) is for Quang An, Quang Phuoc and Quang Loi, relatively, *US$ 545*, *US$ 603* and *US$ 157*. The average for these three communes gives a mixed income for agriculture of US$ 435. For aquaculture the mixed income is on average US$ 481, which is not very different. The most beneficial aquaculture system is also the most sustainable one, which is polyculture. The differences between the communes for agriculture are larger than for the different aquaculture models; this is mainly caused by the unfavorable soil condition and lack of water in the commune with the lowest mixed income, Quang Loi. When looking at the net-income, the differences become larger. For agriculture, US$ 200 is needed per hectare per season, which is US$ 400 per year. This is almost as high as the mixed income, so this gives a very low net income. The labor for aquaculture is maximum US$ 300 for a polyculture system, so the net-income remains higher. This research by the HCE only focused on the main economic crop, whereas there are often more crops which are being cultivated in one year in an aquaculture pond.

Chapter 6: Economical benefits and environmental impacts of improved water infrastructure

6.1 Agro-ecological zones

Different zones can be distinguished, both aquatic and terrestrial. The aquatic zone is currently used for low-tide aquaculture and capture fisheries. The terrestrial zone, close to the lagoon has saline soils and is mostly used for rice cultivation (low productivity), whereas high tide aquaculture is also practiced in this zone in some communes around the lagoon. The third agro-ecological zone is relatively far from the lagoon and thus has no problems with salinity. In some communes, these zone is suitable for high productivity rice cultivation (Quang An & Quang Phuoc), whereas this zone has sandy soils in Quang Loi, which makes it unsuitable for the cultivation of rice. In the future, after the construction of dams, the problem with salinity and lack of water circulation will be lowered, which means the optimal use of water may be different compared to the present situation.

Table 29: Agro-ecological zones and the main activities inside the zones

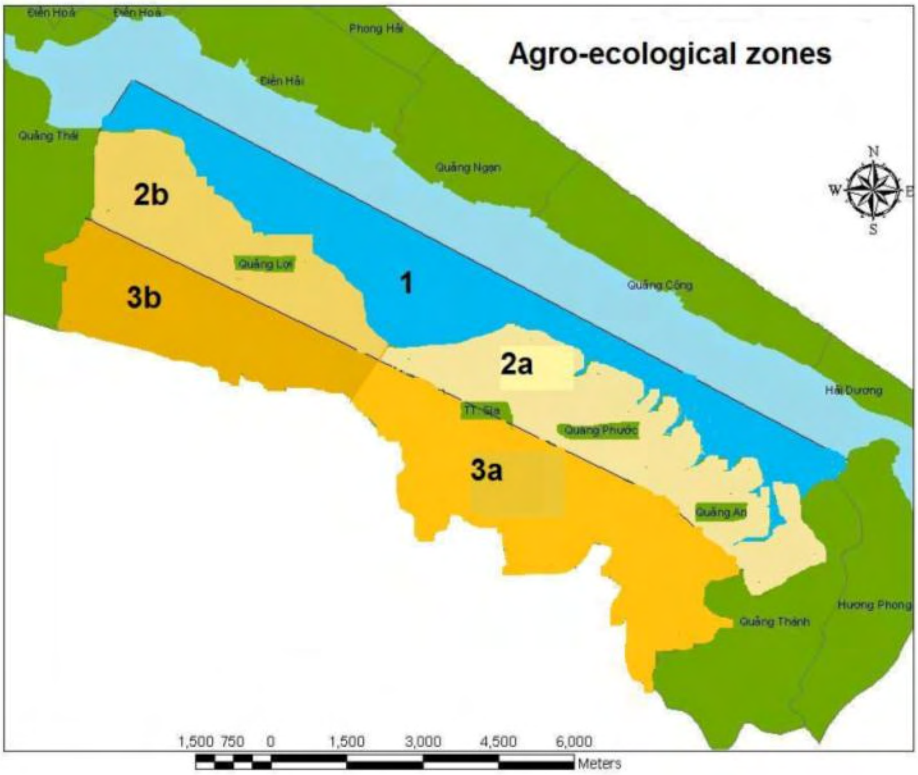
Zone	Activities	Possible transfers of value
Zone 1	**Activities:** Capture fisheries; Low tide aquaculture	**Possible transfers of value:** The best water-related activity per ecological zone varies over the years. In a controlled (future) situation, with flood protection and reservoirs, zone 1 can be expected to be brackish and suitable for well managed fishery, zone 2 has a fresh environment, suitable for aquaculture and zone 3 has the best soils for an increased intensity of rice.
Zone 2	**Activities:** High tide aquaculture; Rice cultivation (1)	
Zone 3	**Activities:** Rice cultivation (1); Rice cultivation (2)	

In order to see trends of productivity, not only a spatial distribution has to be made in agro-ecological zones, but also on a more local (farm/village) level. The productivity of different sectors depends on many factors, such as soil types, access to irrigation, fresh water inflow, inputs of nutrients and chemicals and varieties/species cultivated. To be able to see trends of productivity and relate these to other variables, the location and output of the household survey has to be put into GIS. In section 4.6 the influence of the different variables (*soil type, variety, irrigation state*) on the yield has been researched

Whereas zoning may provide a good way of finding possible trade-offs, output on farm level provide more insights on reasons for different farming practices. Farmers in some areas near the lagoon cultivate different varieties of rice, and in some areas they do not use chemicals. These different farming practices are not always the best way to deal with certain limitations, but are caused by different trainings by (non-) governmental agencies and the lack of farmer-to-farmer training beyond the village level. The higher the accuracy of the actual location of the farms which have been surveyed during the household surveys, the more trends can be found which explain the farming practices and differences in productivity.

The agro-ecological zones are created by comparing the GIS maps (see annex 13-22) and the conclusions of chapter 4.6 on the influence on the different factors on the actual yield. In this chapter is has been shown that variables, such as chemicals and nutrients do not play an important role. The most important variable in the different seasons is the irrigation system; since this will be improved in the feature, this is not taken into account as a fixed variable in the zoning. The most important fixed variable which also is quite influential for the output is the soil type. These are clearly different from the upstream communes of Quang An and Quang Phuoc (also TT Sia), compared to Quang Loi. Another important factor, which for a large part depends on the soil type, are the varieties. Although not all varieties can be cultivated in the whole area, the cultivation of HYV can be improved in the future.

Figure 19: Map of Quang Dien district, divided into agro-ecological zones



The above map is the new map of Quang Dien, divided into the different agro-ecological zones, based on the distance from the lagoon and the soil types, as described by the farmers. A map of the soil types can be found in Annex 14. Soil types have been taken as the most important fixed variable in the area. The soils in Quang An and Quang Phuoc are more often the combination of clay and alluvium, whereas the soils in Quang Loi are either sand or a combination of sand and clay. This soil type seems to also influence the output of rice (Annex 19 & 20). For this reason, the area is not only divided into the three zones as mentioned earlier, but the terrestrial soils have also been divided into a & b, which is related to the soil fertility. Whereas zone 2a and 2b have similar problems, such as saline soils, the soils contain more sand in 2b, which makes the overall fertility lower compared to area 2b.

The limitations to this approach are that the current changes over the year (inlets move, flooding occurs on a regular base) make it hard to predict the water quality and quantity over a longer period of time. The controlled situation will make it better to predict the water inflow and its related quality, but make the overall ecological situation of the lagoon worse. The yearly flooding(s) are to a certain extent good for the ecosystem; since it is a natural way of washing away the nutrients and other pollutants. The yields of aquaculture for example were increasing a lot after the 1999 flood. Controlling the situation thus gives a contradiction, since it can provide policy with the most sustainable activity per zone, but it will prevent the natural fluctuations which give the lagoon its distinct complex character.

6.2 Possible transfer of value

6.2.1 Introduction to the current activities in the agro-ecological zones

The transfer of value which will occur after the construction of the new dams can be analyzed per agro-ecological zone. Capture fisheries, aquaculture and rice cultivation all have their own economic, social and ecological value. Rice production is most important from a social perspective, but aquaculture and capture fisheries have a higher economical value. The ecological value differs, but the current inputs for agriculture can probably lowered, as well as the inputs of antibiotics for aquaculture, since diseases will probably be less frequent with the higher inflow of fresh water. In ArcGIS, layers can be created in which the current average input and output per sector can be seen. This will give the opportunity to see in which zones the transfer of value is most urgent in the future.

Table 30: Present and future options per agro-ecological zone

Zone 1	**Present**: This zone is an aquatic zone, with fresh water during the wet season and more brackish water during the dry season, in which less fresh water flows in. This difference in water quality influences the productivity of the tiger shrimps. **Future**: After the construction of the new dams, the inflow of freshwater will be higher, causing a more constant water quality and higher water circulation. This might limit the occurrence of diseases and the problem with water pollution in the area.
Zone 2a	**Present**: This terrestrial zone is a low lying area, which is prawn to flooding during the wet season. During at least one month every year, this area is completed flooded. During the dry season, salinity and a lack of water limit the productivity or rice. **Future**: After the construction of the upstream dams, there will be more flood protection and a higher inflow of water during the dry season. This might give opportunities for more productive rice varieties and thus a higher value of the water.
Zone 2b	**Present**: This zone has fewer problems with flooding than zone 2b, but has more problems with the bad, sandy, soils and with a lack of water during both seasons. The irrigation infrastructure is insufficient to have to currently have two crops per year. **Future**: In the future, the inflow of water will limit the problems with salinity and lack of water, so that two crops per year will be cultivated. Still the infertile zones cause this zones to have different rice varieties than zone 2, with lower productivity.
Zone 3a	**Present**: This terrestrial zone is located higher and further from the lagoon. Flooding and salinity are smaller problems; the problems are more wind, diseases, coldness and heat. Profit is mainly limited by bad farming practices, such as too high inputs. **Future**: This area will be least influenced by the construction of new dams, although flood protection will give some benefits. The main problem is the too high inputs, which cause the actual benefit in these areas to be lower than what can be expected.
Zone 3b	**Present**: Due to the infertile soils (light sand) and the lack of water, this zone is currently for the largest part un-used. Forests occur in some parts of this zone and the reservoirs, which provide water to the land in Quang Loi are aconstructed in this zone. **Future**: After the construction of the dams and improved irrigation infrastructure, the zone will still be unsuitable for most agricultureal production. Forests will remain the main land use, but maybe some economical benefits can be obtained from this.

6.2.2 Water mosaics

When combining the agro-ecological zones with the data from chapter 4 and 5 (analyses of the rice- and the aquaculture sector), water mosaics can be created. Water mosaics can give an indication of the differences in relative value between various water users in one sector (rice/aquaculture) or can give potential transfers of value from one sector to another (see 2.1). This means that the data from the GIS maps will be compared with the data from the different cropping systems and aquaculture system in order to see the potential benefits of improved water infrastructure. In figure 20 a combination is made from the cropping systems (*figure 16 and 17*) and the agro-ecological zones (*figure 19*). Zone 1 (lagoon) is taken to be a zone with similar characteristics alongside the Quang Dien district. This is done due to lack of more detailed data about the location and yields of the different aquaculture models. The effect is that the shift in the entire zone can be made from one aquaculture model to another in this research. Within other agro-ecological zones shifts are harder to make due to soil related limitations.

Cropping systems (CS) are all based within one agro-ecological zone. CS 1 is based in the high part of Quang An and Quang Phuoc. Flooding is not a big problem in this area. CS 2 and 3 are based in the low part of Quang An and Quang Phuoc. The soils here are comparable to the soils in the high area and are of good quality. The main problem here is flooding during the WS season. For CS system 3, another problem is salinity due to a lack of water during the SA season. Cropping systems 4 and 4 are located in the low part of Quang Loi. The soils here are of reasonable quality, but there is a problem with a lack of water during both seasons. Two crops per year can be cultivated in CS 4, which is located more upstream and closer to the main irrigation than cropping system 5. CS system 4 and 5 can be expected to have similar benefits when the water infrastructure will be improved and CS 2 and 3 can have similar benefits. When flood protection will also be included, cropping system 2 and 3 can have the same benefits a cropping system 1. The varieties in all cropping systems could even become the same, but whether the yield will be equal is hard to assess. Now already the yield of 4B is lower in CS 3, where the soils are of a worse quality as where CS 1 and 2 are now located

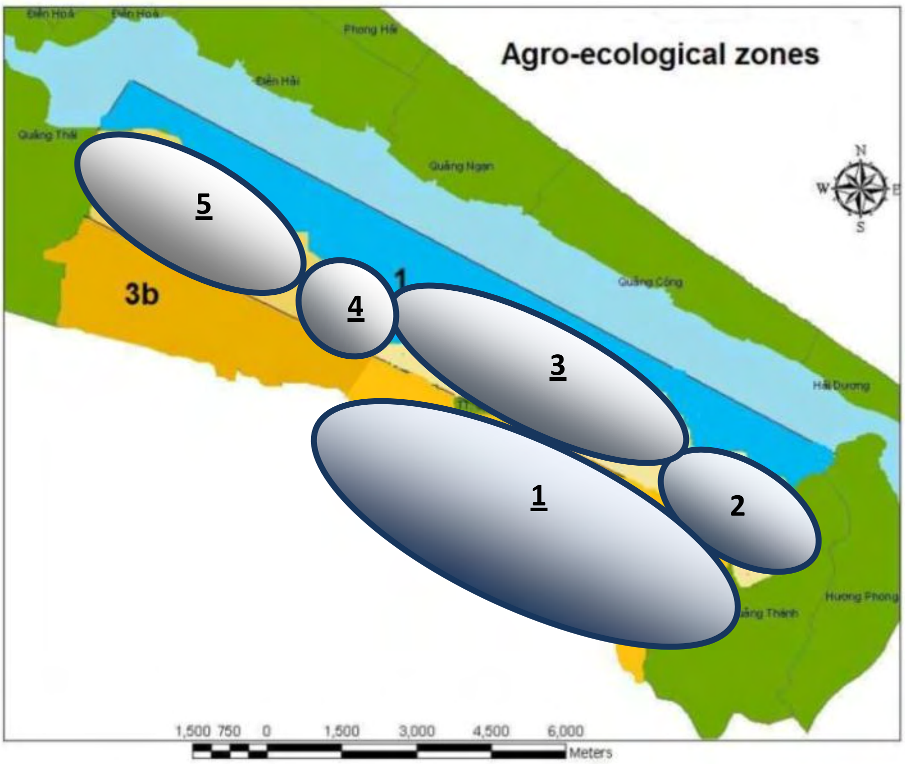


Figure 20: Combination of cropping systems and agro-ecological zones to create water mosaics

6.2.3 Potential transfers of value

The potential benefits of the new water infrastructure and better management of the Huong River Basin will be calculated by looking at the difference between the present benefits per water mosaic with the potential future value. The size of the different water mosaics will be estimated to get a clear view on the real economic benefits of the dams and irrigation system on the agricultural sector. In this calculation the township of Sia will also be taken into account, since it is located in between Quang Loi and Quang Phuoc. This area is taken to have the same characteristics as Quang Phuoc and is located in the same two agro-ecological zones for the high and the low areas. For the aquaculture sector, the current size will be estimated from literature. The current benefits will be compared with the most beneficial economic and environmental aquaculture model (polyculture) and the economic value will be taken as the future benefits minus the current benefits.

Water mosaic one located in the high area of Quang Phuoc, Quang An and Sia. This means the size of this mosaic will be taken as half the area of Quang Phuoc, Quang An and Sia (*see table 5*); this is 920 hectare. Water mosaic two is located in the low half of Quang An, which means the area size will be taken to be 320 hectare. Water mosaic three is also located on the low part, but now in the Quang Phuoc commune and Sia town. This means the size of this area is 600 hectare. Water mosaic 4 is estimated to be around one third of the low area of Quang Loi (only this part has access to the irrigation system). This is one third of 360, which is 120 hectares. Cropping system 5 can be found in the other two thirds of the low area of Quang Loi, this means water mosaic 5 is 240 hectare.

The high part of Quang Loi has sandy soils, which means improved water access does not really influence this area. The benefits in this area can be improved by other activities, such as forestry or the cultivation of peanuts and cassava. These crops can grow on sandy soils with only few water. Since some data is available on this area, this will be now be called 'upland area' and is 360 hectares. The lagoon area in the three studied communes plus the township Sia is, according to DOFI statistics from 2006, around 350 hectare. Currently only low tide aquaculture is practiced in these communes.

Table 31: The size of- and the activities in the different water mosaics and other important zones

Zone	Area size (ha)	Current activities
Water mosaic 1	920	Two yield of rice per year. In the WS- season 4B and in the SA season TH5. These two crops are best from an economic perspective.
Water mosaic 2	320	Two times TH5 per year, because of the problem with flooding in the SA season. TH5 is of a lower quality as 4B, but the price is nearly the same.
Water mosaic 3	600	Due to salinity, the SA crop is T92. The WS crop is the same as in zone 1, which is 4B. Due to a lower soil quality, 4B yields lower than in WM1.
Water mosaic 4	120	Two crops are cultivated per year, but with low yields. The WS variety is either KN of C23. Only KN is cultivated in the SA season.
Water mosaic 5	240	Only one crop can be cultivated per year, either C23 or Khang Nhan.
Lagoon area	350	Many different forms of aquaculture currently take place. Tiger shrimps are often still cultivated in a monoculture system in closed ponds.
Upland area	360	Not many activities currently take place in the upland area.

The future value of each water mosaic will be taken as the area size multiplied by the value per hectare of the best cropping system. The maximum values of each cropping system can be found in table 9. For the lagoon area, the highest output can be found in the HCE data. The maximum for the lagoon area is not know, so the data from the polyculture will be taken as the best option. This is because both the income which can be generated from it and the environmental effects are the best. For the upland area, data will be taken from the work of the Asian Development Bank in 2007. The current and future output and income from the different water mosaics can be seen in table 32. The data comes from the results from the HCE (table 28), from the ADB (annex 11) and from this work (table 21). The present output of the lagoon will be taken as the average output of the three different aquaculture models, since the exact distribution in the studied communes is not known. For the upland area, the present value will be taken as zero and the future benefits will be taken as the average benefits of year with *peanuts-fallow* or *cassava-fallow*. For the future benefits of rice, the price will be taken as the same as it is now. Future increases in the price of rice will thus not be taken into account. The output will be the maximum yield for the best possible cropping system. One ton per hectare will be extracted from the maximum yield of 4B (7t) and half a ton per hectare from TH5 (6.5), Khang Nhan and C23 (5.5t) to get a more realistic picture. The inputs of rice will be taken to be the same as now, which is US$ 1.750 per year for the first three water mosaics and US$ 1.600 for the last two.

Table 32: Present and future output of the different water mosaics

		Water mosaic 1	**Water mosaic 2**	**Water mosaic 3**	**Water mosaic 4**	**Water mosaic 5**	**Lagoon area**	**Upland area**
Output present *US$/ha*	**Selling price (0,19 US$/kg)**	2.113	2.205	1.856	1.596	716	3.295	0
	Buying price (0,31 US$/kg)	3.522	3.675	3.093	2.659	1.194		
Income present *US$/ha*	**Selling price**	346	374	214	2	-135	198	0
	Buying price	1.754	1.844	1.451	1.066	342		
Output future *US$/ha*	**Selling price**	2.531	2.531	2.531	2.061	2.061	3.213	526
	Buying price	4.218	4.218	4.218	3.435	3.435		
Income future *US$/ha*	**Selling price**	781	781	781	462	462	459*1	320*2
	Buying price	2.468	2.468	2.468	1.836	1.836		
Benefits in output *US$/ha*	**Selling price**	400	326	675	465	1.345	0	526
	Buying price	696	543	1.125	776	2.241		
Benefits in income *US$/ha*	**Selling price**	435	407	567	460	597	261	320
	Buying price	714	624	1.017	770	1.494		

*1. This is the income which is currently generated in the polyculture model and thus is not the maximum.

*2. This is the average of the income from cassava and peanuts, as can be seen in Annex 11 (ABD).

There are some irregularities in table 32, since the calculations have been done by different parties. It is possible that more costs for family labor have to be extracted from the income in the rice sector, but these costs have not been given by most of the surveyed farmers. The total benefits of the increased water infrastructure is US$ 1.445.000. This can be found by multiplying the area of each water mosaic with the benefits in output (selling price). For the farmers, who have one sao per household member, the benefits will be around US$ 20 / person. Benefits for the environment (polyculture) are also quite high.

6.3 Environmental effects of a changed water use

The water quality was seen as one of the main factors influencing productivity. Especially in the areas near the coast, at the end of the Bo River, the water quality was much polluted. Mainly in the dry season this causes a problem, but also in the rainy season the use of fertilizer and chemicals causes a production limiting factor according to the farmers. When it is raining a lot during the different seasons, the water would flow from the fields towards the river, killing most of the fish due to the large quantity of nutrients and chemicals.

In research by UNESCO (2004), the loss rates of fertilizer and pesticides are calculated for the two seasons. 'The loss rates of fertilizers and pesticides are taken from literature (Khoa L. V., 1996; WL, 1997). With the loss rates of 40 % for N; 12 % for P in wet season, and the loss rates of 15 % for N; 5 % for P in dry season'. For pesticides, it is assumed that rates of loss rate to water are about 10% in dry season and 30% in wet season. These rates are only applied for agriculture loads. For aquaculture loads, 100% of waste loads eliminate to the lagoon in dry season. There is no aquaculture load in wet season.' The graphs of this research are given in *table* 37 (UNESCO-IHE, 2004).

Of the interviewed farmers in this survey, 37% sees pollution as a big problem in both seasons, 33% does not see pollution as a problem and the rest sees pollution either as a small or seasonal problem. On the question whether the farmers disposed their chemicals into the environment, a surprising 56% answered yes. Mostly by leaving their chemicals at the field or throwing it in the water. Another often heard cause of pollution was the throwing of dead animals into the river. Many people in the area threw their dead animals in the river, causing a serious problem to the water quality. Domestic waste was also a problem, but the main cause was mainly local to the opinion of the farmers and waste from the city was seen as a smaller problem. IPM has been practiced in Quang Phuoc in the past, but was not seen as sufficiently effective, so the people quit using it. Nowadays they use C (ontrolled) PM, a limited use of fertilizer which has been successful in some areas.

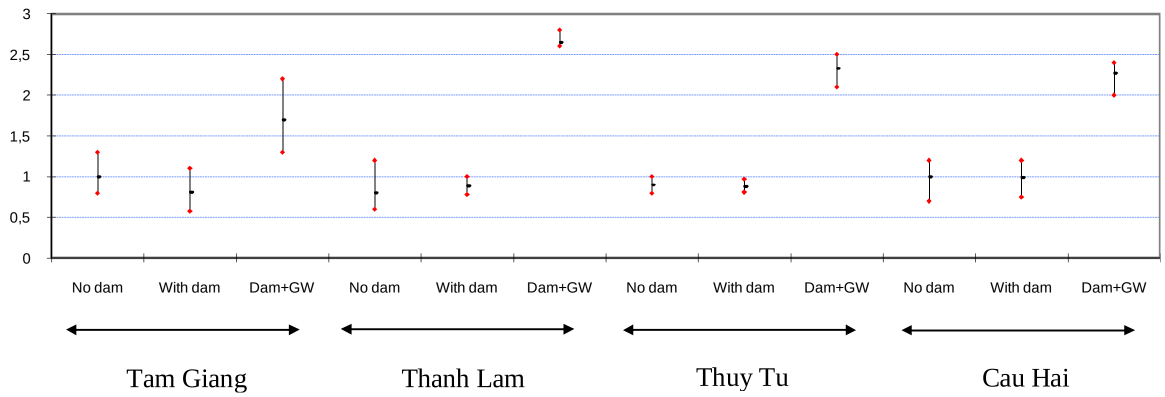
The results of calculations by UNESCO show that at present the lagoon is polluted somewhat by nutrients during dry season with average concentrations close to the standard. The most polluted areas have been found at river outfalls and aquaculture lots. Agricultural waste is the main pollution source. For the future situation, nutrient level rises alarmingly in the entire lagoon during dry season. With the expansion in aquaculture area by 80% and the increase in waste load per ha by 50% together wth the slight increase in agricultural load (the future scenario with low aquaculture load), the future nutrient content is about 1,3 times for TN and 2 times for TP as much as the present concentrations. The average TN is 20% higher than the USA standard value and 44% higher than that for Japan. In term of TP, it is 100% higher than the standard value for USA This situation is even worse when the future scenario with higher aquaculture load is considered. Nutrient concentrations during wet season are also very high.

For pesticides at present situation, given the assumed pesticide quantity used in agriculture, pesticide concentrations in the lagoon are acceptable for aquaculture purposes, with average value in order of 5-6 µg/l. High pesticide residue can be seen at the river estuaries. Pesticides concentrate in the vicinity of the outfall during dry season. But in wet season, they spread and are present in the whole lagoon system, particularly at the Tam Giang and Cau Hai lagoons. However, the amount of pesticides used to simulate the water quality situation seems to be under estimated because it is rather low compared to pesticide quantity applied in Red and Mekong River Deltas (UNESCO, 2004). The real concentration of total pesticides might be 8 or 9 µg/l or even reaches the standard value. If it is true, the river mouths and part of the lagoon nearby the river mouths have problems of pesticide pollution and need to be examined. The model simulation for the future situation shows that pesticide concentration violates the Vietnam standard for aquaculture area.

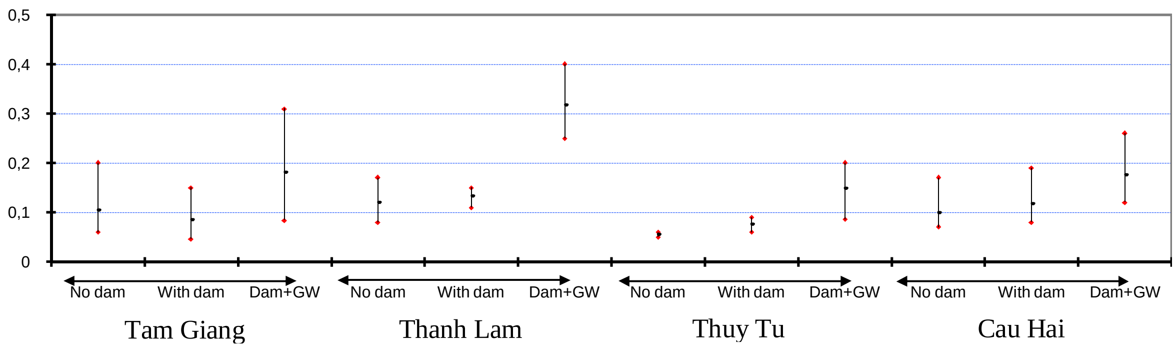
The maximum values (16-17 µg/l) occur during dry season in the river mouth areas but polluted area in wet season is larger than in dry season. At present, Formalin content is much lower than the drinking water standard for WHO but the use of Formalin is toxic for aquatic life in large area outside shrimp ponds. In a future situation, the Formalin concentration is still lower than the drinking water standard but the peak level is above the toxicology data to algae. About 50% of the lagoon is affected by Formalin and some aquatic species can be killed. (UNESCO, 2004). The total nitrogen, phosphorous and pesticide concentration in the lagoon in a present and future situation are shown in *table 33* (the meaning and details of the situation 'Dam+GW' is not known).

Table 33: Total nitrogen, phosphorus and pesticide concentration in a situation with and without dam (source: UNESCO, 2004)

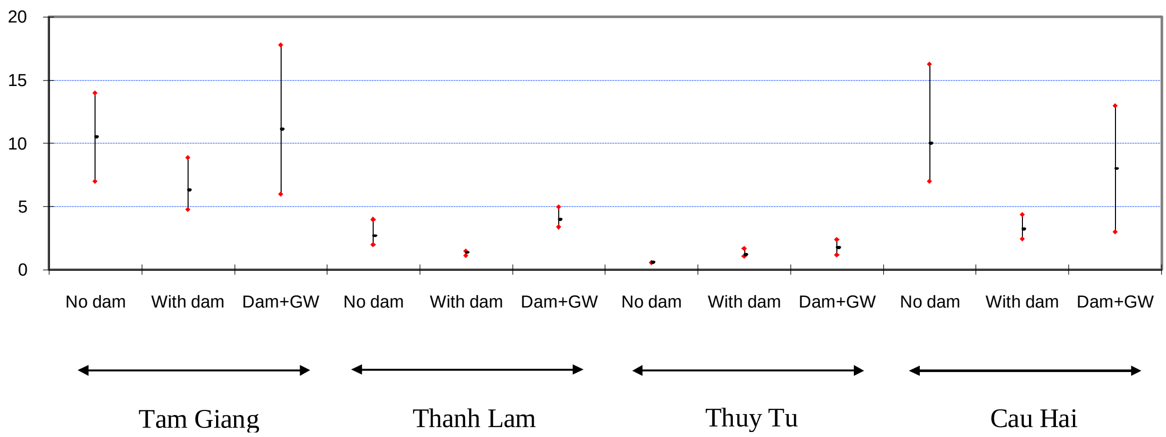
Total Nitrogen – Dry- Future



Total Phosphorus – Dry- Future



Total Pesticides – Dry- Future



6.4 Social effect of the changed water use

6.4.1 Current situation of farming households in Quang Dien

The average household, which is involved in rice farming, consists of 5 persons, of which half work in off-farm activities. Still, according to the farmers, only around 40% of their income comes from these off-farm activities. The main activities which are taking place in the commune are pig husbandry, aquaculture, laborers, civil servant and fishery. The main off-farm activity of pig husbandry (around 15%) has been seriously damaged due to the outbreak of the blue-ear disease in April 2008, which killed more than 80% of the pigs in the commune (100% was expected to die at the time of research).

The average household consumption of rice is around 75%, which means not much of the rice is going to the market. Rice if often used for home consumption and the feeding of the animals; rice is only sold by many people to pay for the inputs for the next season. Around forty percent of the households use all the rice they cultivate for home consumption, some even have to buy extra. Although many of the farmers are thus very poor, all have access to safe drinking water (filtered, boiled).

At present, capital is borrowed from Agriculture and Rural Development Bank, Social Policy Bank and other sources such as rich private owners, GO's and NGO's programs or projects. The total loan is 20 billion VND lent by the Vietnamese Bank for Agriculture and Rural Development (VBARD) and the Bank for Social Policy (BSP), of which 17 billion VND (US$ 1.062.500) from VBARD bank have been used for shrimp farming, 3 billion VND (US$ 187.500) from BSP used for service production. The loan of the agricultural family ranges from 3 million to 20 million VND (188-1250 US$) (IMOLA, 2006a).

Almost all farmers are member of some kind of organization (Farmer Union, Women Union, Youth Union or Former Soldier Union). But the organizations which are involved in farming (Farming Union) are not involved in the management of water, which is done by the commune. Farmers have had problems in the past, because, although there was sufficient water, the distribution of this did not go fast enough to provide all farmers with adequate water. 60% of farmers have good access to an irrigation which is in a good state, only one farmer doesn't have access to an irrigation system, 10% of farmers have a good access, but a deteriorated system and 20% have poor access and a bad system. Most of the farmers who complain about the irrigation system are located in the lower area.

Conflicts between agriculture farmers and other sectors find place in the commune, especially with the aquaculture sector. More than 60% of the farmers are aware of this conflict and are located in areas where this is a problem. The main issue is that the aquaculture farmers are complaining about the inflow from nutrients and chemicals from the rice farmers. Since the aquaculture farmers are located at the end of the Bo River, also domestic waste is causing problems for them.

Rice farmers have different problems in the wet and the dry season. In the wet season (winter-spring), the main problem is flooding, followed by cold weather and mice. In the dry season, the main problem is salinity, followed by warm weather and mice. Other main problems are insects, diseases and flooding. Some problems which are more general for the rice farmers and are not limited to a certain season are expensive materials (inputs), the agricultural services costs too much and that the product is low valued. Most people expect the productivity of rice to be able to grow for some years, but in order to make this beneficial for the farmers, the price of input has to be decreased and the price of rice that farmers receive has to be increased. This, together with improved water availability and better prevention of plant diseases could help the farmers in Quang Dien to escapte the poverty trap.

6.4.2 Government reactions to the increased price of rice

Vietnam is a predominately agrarian society which is still relatively poor. One of the main features of the labor markets in the poor countries, to which Vietnam belongs, is that large shares of the people work outside the formal *wage labor* market. In 1993, only 19% of the people aged 20-64 in Vietnam worked for wages. 90% of the people in Vietnam worked within their own household (Edmonds and Pavcnik, 2006). In the same year, 73% of the people were employed in the agricultural sector. The fact that Vietnam is still an agrarian society means that rice is the dominant commodity in the economy. When Vietnam lifted its domestic and international restrictions on the trade of rice, between 1993 and 1998, the increase in price of rice averaged around 30%, relative to the consumer price index (Edmonds and Pavcnik, 2006). Vietnam is currently the third biggest exporter of rice.

Vietnam has liberalized the trade in rice in the 1990s in two ways. The *first* is that Vietnam started to regulate its international rice trade with the implementation of an export quota in the late 1980s. This export quota was implemented out of concern for the domestic food security, so that the price of rice on the domestic market would not become too high. In the 90s, the quota on the export of rice was liberalized and by 1997 it became no longer binding. According to research the price, before the quota was *lifted*, was a lot lower than afterwards, in the mid 90s (Edmonds and Pavcnik, 2006). The *second* liberalization measure, after the lifting of the quota, has been implemented in 1997 and meant the easing of the restrictions on the internal trade of rice within Vietnam. The initial purpose of this restriction was that all areas in Vietnam become self sufficient in the production of rice (Edmonds and Pavcnik, 2006).

The measures to liberalize the trade of rice became a problem once the price of started to rice in 2007. A high food price started to cause problems in many countries. The reason for the high price of food is not only caused by a reflection of scarcity, caused by crop failure (drought, diseases in the last three years), which is normally the main reason. Other reasons for the high food price are the increased consumption of meat in rising economies (farmers give more feed to their animals) and especially the increased demand of ethanol as fuel for cars. Since maize is converted to ethanol, the increased demand of bio-fuel is causing much more maize to being cultivated compared to other years. This is at the expense of other food crop (Economist, 2007). The high demand of food crops for fuel and meat production is also causing a higher price of other crops, such as rice. Vietnam has already been hit by drought and by an obscure plant virus, which caused annual output to become lower over the last three years (NY Times, 2008). This together with the high world price of food is the reason that the government in Vietnam announced in March 2008 that it would cut rice exports by around one quarter in 2008. This should help to relatively hold down the price of rice. The price of rice has almost doubled in the first three years of 2008, which is causing large problems to millions of poor Asians.

6.4.3 Effect of the high price of rice for the farmers in Quang Dien

Since nowadays the high price of rice is getting increasingly more attention, a small example will be given by using some averages from the collected data, to show what will happen to an average household in Quang Dien district. Averages from all three communes which are studied will be taken for this example. The average household size is 5 persons, all of which are allocated with one sao of land. This means 2.500m2 is available per household. Per sao, there will be **520** kilo rice harvester per year. For household consumption, 12x 15 kilo of rice is needed (lowest poverty limit), so **180** kilo is used for home consumption. The amount which has to be paid for inputs will be taken as US$ 19 per season per sao, this is a bit lower than the current average, but the farmers expect (hope) there will be state support for the price of inputs. This will mean that on yearly basis US$ 38 will have to be extracted per sao. For community costs (water, land making, cutting and separating), around **70** kilos of rice has to be paid per season per sao. Of the 340 kilograms that are left after home consumption, **270** kilo will be left when the community costs are extracted. With a price of rice of US$ 0.19 per kilogram, this will mean a value of US$ 50. Of this fifty dollar, only US$ 12 will be left when extracting the costs of basic inputs (US$ 40). The calculations per poverty line are given in table 34.

When taking a home consumption of 20 kilograms per person per month, only **210** kilo will be left after extracting household consumption and community costs from the 520 kilo which can be harvested. This will mean the value of this yield is US$ 40, of which only US$ 2 will be left per sao when extracting the costs of basic inputs. When taking the highest poverty limit (25 kilograms/person/month), there will be only **150** kilo left when extracting the household consumption and basic inputs. This means farmers will lose money (*around US$ 10*) per sao. When the price of rice would be ***US$ 0.31***(5000 VND) per kilogram (*the world price in June 2008 is US$ 0.84 per kilogram*) and the household consumption and price of basic inputs will remain the same. The profit for the different poverty limits can be seen in the *table 24* below. Even with the highest poverty limit, there would be a small profit on an average farm.

Table 34: Profit per poverty line per sao when the price would be US$ 0.31 per kilogram

Poverty limit		After home consumption	After community costs (70kilo/y)	Profit per sao after extracting basic inputs (US$ 38/y)
Low	(15 kg/p/m)	340	270	US$ 47
Medium	(20 kg/p/m)	280	210	US$ 28
High	(25 kg/p/m)	220	150	US$ 9

The main problem is that the current market price is different from the price in the harvesting season; farmers expect the price to go back down to around 3.500 VND/kg. The inputs have to be bought throughout the season and are often linked to the current price of rice, which means that the inputs are relatively higher than the output. This causes the effect of the current high market price, to be very small for the farmers, unless state support will be given to reduce the price of inputs and to keep the price of rice high during the season when the farmers will sell their product.

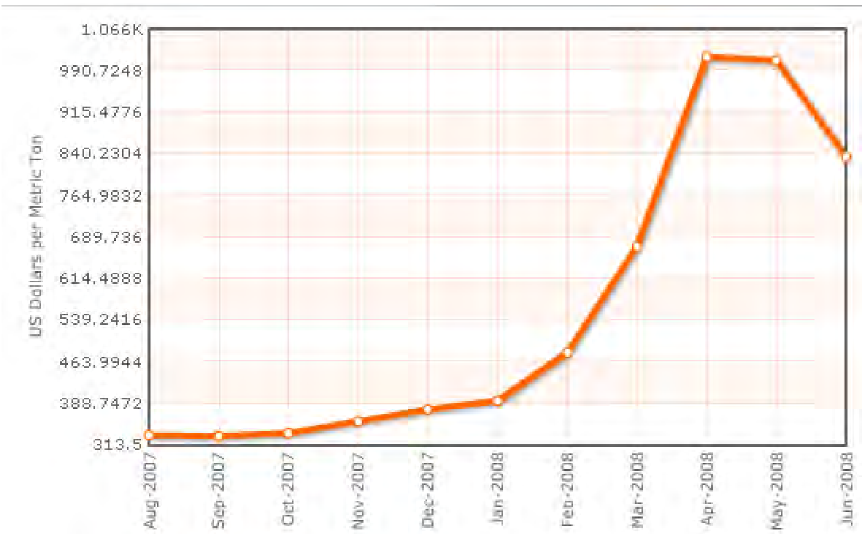


Figure 21: Rice monthly price in US$ per metric ton (source: Index Mundi, 2008)

Since more than eighty percent of the rice which is produced in the study area is used for home consumption, the actual value of rice is higher than the price for which farmers sell their rice. Farmers pay a higher price for rice when they buy rice at the market than the price that they receive for their rice. When the amount of rice, which is used for home consumption, will be multiplied by a more realistic market price instead of the low price which they now receive for it, a more realistic picture of the actual value of rice for the farmers will emerge. Although the price of rice is not very high, it is the most important source of food for the farmers and if they do not produce it themselves, they will have to buy it. The price of rice is now only estimated to be around US$ 0.19 per kilogram and has been estimated to be US$ 0.30 per kilo on the market. How this influences the value of rice can be seen in *table 35*. For the selling price, 100% is taken to be used for home consumption and nothing goes to the market. For the buying price, the output and income for 100% of the yield is multiplied by the consumption price.

Table 35: The effect of an increased price of rice on the future output and income in the study communes

		Quang An	Quang Phuoc	Quang Loi
Output (selling price)	*US$/ha*	2.141	1.978	1.548
Income(selling price)	*US$/ha*	545	603	157
Output (buying price)	*US$/ha*	3.623	3,228	2.553
Income (buying price)	*US$/ha*	2.027	1.853	1.162

In the above table, the costs of family labor and some small inputs are not taken into account. This means the actual income will be around US$ 400 lower. From the above table can be concluded that the actual benefits for the farmers are much higher, since they do not have to pay for rice on the market but can produce it for home consumption. This table shows the economic rationale for farmers to cultivate rice, although it in the first place did not seem beneficial to do so.

6.4.4 Comparison of the rice sector and the aquaculture sector

The different cropping systems and aquaculture model all have different inputs and output. The mixed income (no labor costs) of the different models is given in table 36 below. Aquaculture model **1** is semi-intensive, **2** is improved extensive and **3** is polyculture. The main differences between agriculture and aquaculture are the total input and output (also initial costs). These are much higher for the aquaculture sector, what means that the risks are much higher in this sector compared to the rice sector. Cultivating rice in cropping system 5 does not seem rational from an economic perspective, but when taking into account the buying price of rice instead of the selling price, there are also significant benefits in this cropping system (see table 32). The benefits increase from US$ -135 to US$ 342 per hectare.

Table 36: comparison of the income from the rice sector and aquaculture sector

Cropping system	WS output *US$/ha*	WS input *US$/ha*	SA output *US$/ha*	SA input *US$/ha*	WS profit *US$/ha*	SA profit *US$/ha*	**Mixed income** *US$/ha*
1	1172	979	941	788	193	153	**346**
2	1169	964	1036	867	205	169	**374**
3	941	935	915	707	6	208	**214**
4	881	896	715	698	-15	17	**2**
5	716	852	-	-	-135	-	**-135**

Aquaculture model	Total costs	Total input *US$/ha*	Gross output *US$/ha*	Net income *US$/ha*	**Mixed income** *US$/ha*
1	4.017	3.694	4.003	-14	**309**
2	2.519	2.298	2.669	150	**371**
3	2.754	2.447	3.213	459	**765**

Chapter 7: Limitations, conclusions, recommandations

7.1 Limitations

There have been some limitations during the research, regarding the analysis of the data. The first limitation is the creation of agro-ecological zones and water mosaics for a very large area with only 120 surveys. It is hard to create a clear spatial division between zones, since farmers had to point out their fields on a map. A GPS was not available at the time of this research, which can cause some spatially incorrect data. Soil types have been extrapolated from the data of the survey.

Another problem is the knowledge of the farmers regarding the soil types and state of the irrigation system. Soils could only be characterized in three main types and many farmers could only indicate the suitability for their soils for agricultural practices and not the type of soil. Farmers also often hired someone to give them their water turn and do not know the real state of the system. In some cases neighboring farmers claim their system to be completely different. Another limitation for this research has been the lack of knowledge of farmers of the inflow of water. Whereas they know the inputs they buy at the market (seed, nutrients and chemicals), they pay in order to have a right to water, but do not know how much they actually receive unless it is insufficient.

The assessment of the value of the new water infrastructure for the study communes has been calculated by taking a yield just below the maximum yield for rice in the different agro-ecological zones. This has been done, based on the assumption that water is causing the main limitations to the current productivity. The main limitations in the different areas are indeed water related (flooding, salinity and lack of water), but in how far they will be solved by the new infrastructure is hard to assess. There are also many other limitations which will cause the rice never to reach the maximum throughout the whole area or which give other problems. In order to acknowledge the effect of other limitations on the productivity of rice, a yield has been taken which is 0.5-1 ton per hectare lower than the maximum.

Although the initial plan was to assess the value of the new infrastructure on the rice sector, the aquaculture sector and the lagoon, the main focus has been places on the agricultural sector. The amount of time has been insufficient to cover all three sectors in a good scientific way and since much work has already been done on the aquaculture sector by the FAO-IMOLA project, this sector has not been studied for this thesis. The data from the case study of the Hué College of Economics (HCE) in the Quang Dien district has been used for the economic value of the aquaculture sector. This data has been adjusted to be comparable with the data from the agriculture sector (excluding labor costs), but can still have some inconsistencies. The data regarding the state of the ecosystem and how this has changed over the last decades is only available from anecdotal sources and it thus also not based on scientific methods, such as monitoring of water quality and biodiversity in different areas of the lagoon.

Another limitation regarding the analyses of the data is that several farmers cultivate two different varieties during the WS season. Since some farmers cultivate both the long season variety 4B as the short season variety TH5 during the winter-spring (long) season, it is hard to put these farmers into one cropping system. Several farms have been placed into a cropping system, based on the spatial location, although two different varieties from two different cropping systems are cultivated during at least one of the season. The last limitation of this research is the lack of an in-depth statistical analysis. The benefits of such an analysis for this research would be very high, since it gives more detailed information on fluctuations within different yield-influencing variables and can give better trends of these variables. The current analysis gives some useful insights, but the trend lines which have been created are not the optimal way to analyze the number of survey and the large differences within the different categories. A thorough statistical analysis would be very useful for future research of this kind.

7.2 Conclusions

The current state of the Tam Giang – Cau Hai lagoon is causing problems to the aquaculture sector. Diseases cause many farmers to lose their main aquaculture species (tiger shrimps). The people who work in the aquaculture sector, who also suffer from decreasing catches, together with the aquaculture sector blame the uncontrolled use of pesticides by the upstream farmers for the pollution/ eutrophication problem. Especially during the dry season, the inflow into the lagoon is very low, which cause problems with domestic waste and other forms of pollution in the lagoon. During this season, the lack of inflow of freshwater causes salinity to intrude in the agricultural areas. The most important aquaculture varieties are brackish water species and would thus profit from a stable brackish environment near the borders of the lagoon. The agricultural area in Quang Dien has different limitations for rice cultivation in the different areas. In most areas, the farmers have adapted to the main limitations (flooding, sandy soils and salinity) by using different varieties. Short season varieties are for example used during the long (WS) season to escape from the flooding. The state of the irrigation system also seems to be limiting for the productivity. Yields in areas with good access to a concrete system or to irrigation by boat have a considerable higher yield than the areas in which there is either no system or where the system is made from clay and in a bad state. Quang Loi commune has only in a small area access to the main irrigation system from the Bo River and the rest of the water comes from reservoirs. The capacity of these reservoirs and the bad irrigation system cause most farmers to leave their field fallow or cultivate other crops (cassava, peanuts) during the SA season.

There are five main factors which influence the different yields of rice in the area. These factors are the varieties, the soil type, and the state of the irrigation system, the input of nutrients and the inputs of chemicals. The yield is also limited by different limitations in the area, which are flooding, lack of water, salinity, diseases, mice and extreme cold or warm temperatures. When looking at all the different factors, the state of the irrigation system, and thus the availability of water, seems to have the biggest effect on output. The yields in the wet season already differ from 4.4 tons/ ha for no irrigation to 6.4 tons/ha for irrigation by boat. In the dry season the difference is even higher and more than 80% of farmers without irrigation cannot cultivate a crop. Since different varieties are cultivated with different states of the irrigation system, this does not give clear benefits of the irrigation system. To get a better view of the effect of different variables, cropping systems have been created. A cropping system is a combination of the area type (high/low), soil type and varieties of rice during the different season. The variables which influence the productivity within these systems are the state of the irrigation system, input of nutrients and chemicals. When making the distribution into cropping systems, the benefits of the different variables becomes less significant. Only for the irrigation state trend lines can be found, which show that a better irrigation state gives a higher output of rice. Since nutrients and chemicals do not have a clear effect on the output and are negative for the environment, it would be good to better adjust the inputs to the different areas. To do this, either color leaf charts can be used to decide how much nutrients should be applied or IPM could be practiced to lower the input of chemicals.

The main limitations for rice in the area are flooding during both seasons. Whereas this is the main problem in two of the three study communes, the third commune (Quang Loi) has a lack of water as the main problem, together with salinity during the dry season. Diseases and climatic factors, such as coldness, wind and hot temperatures also limit productivity. These problems occur less frequent and with lower effects as flooding and a lack of water, which occur on a yearly base. Lack of water cause part of the Quang Dien district (Quang Loi commune), to only be able to cultivate one rice crop per year. The high social value of rice (80% is used for home consumption and only 40% of their income comes from off-farm sources) creates a demand for a higher intensity of rice cultivation in the future. A future scenario is created in which a dam, salinity barriers, flood protection and aquaculture zoning should create a stabilized ecosystem, with more sustainable aquaculture and more water for the rice sector.

Vietnam is currently facing the problem of increased food prices. Whereas Vietnam started to liberalize its trade in the 1990s by lifting an export quota and also increased to internal trade of good such as rice, the export is now being limited again. The cause for the high world food price is not only caused by crop failures throughout the world, but especially by the increased demand for bio-fuel and the increased consumption of meat in many countries, which also requires a lot of wheat. Vietnam also experienced three years of relatively low yields due to drought and plant viruses. When in the beginning of 2008 the price of rice started to increase further and Vietnam had new problems with extreme cold temperatures, the government decided to cut down the rice exports by a quarter. This is done to keep the prices low on the domestic market, which is needed since many Vietnamese are still living below the poverty limit. Although many of the poor people cultivate rice for the home consumption, the high price of rice also caused a higher price of inputs, for which many people in the study area had to borrow money at a bank. Since most people already had debts, this puts many people even further in a poverty trap.

The price of rice the farmers receive in the Quang Dien district is only around 3.500 VND per kilogram; this averages around US$ 0.20 per kilogram whereas the world price of rice was more than US$ 0.90 at this time. The amount of rice people need for home consumption varies from 15 to 25 kilograms per months, depending on the poverty line. Since farmers in the Quang Dien district are only allocated with one sao of land (0.05ha), they need to have to good yields per year to stay above the poverty line. One sao can have a yield of 300 kilograms per season, so one season should be sufficient for home consumption. Since inputs amount to 50% of output, cultivations has to take place in two season. Whereas it seems like many farmers lose money by the cultivation of rice, this is mainly caused by the low price which farmers receive when they sell their rice. When the farmers would have to buy the rice, which they currently produce, the costs would be a lot higher. When multiplying the output by the market price instead of the selling price, the profit would be a lot higher. This shows the economic rationale of farmers to keep cultivating rice, whereas it does not seem profitable in the first place.

To answer the main research question, what the potential increases or transfers of value will be in the future, cropping systems have been created in the different water mosaics. After the new water infrastructure will be in place, cropping systems can be changed to fit the agro-ecological zone without the current water-related limitations. Different cropping systems give a very different output and thus income for the farmers. The output varies from 700 to 2.200 US$/ha and the income from -135 to 374 US$/ha when looking at the selling price. When looking at the buying price, the output varies from 1200 to 3.700 US$/ha and the income from 340 to 1.850 US$/ha. When removing the limitations related to water (lack of water and flooding) it can be expected that the five current cropping systems will be changed into the two most profitable ones. These cropping systems are now related to the agro-ecological zone and are not limited by water related problems. The two main cropping systems will be 4B-TH5 in the agro-ecological zone with the best soils and C23-Khang Nhan in the agro-ecological zone with the sandier soils. The benefits of improved water infrastructure for the rice sector in Quang Dien will be over one million US dollars per year when looking at the selling price. The benefits to farmers will be between US$ 20-50 per sao, depending on how much rice goes to the market.

The aquaculture sector will also benefit from the new water infrastructure. The net income which can be generated from the different aquaculture models has been studied by the Hué College of Economics. Of the three models (semi-intensive, improved extensive and polyculture) which can be found in the lagoon, the polyculture model gives the highest income. This is also the best model from an environmental perspective. When taking into account the 350 hectare in the lagoon, which is currently used for aquaculture in the three study communes plus the township of SIA, the benefits of the new water infrastructure will even be over US$ 1.4 million per year. This means that the benefits of a higher inflow of freshwater, flood protection and improved water circulation do not only have high benefits from an ecological perspective, but are also very high in Quang Dien from an economic perspective.

7.3 Recommendations

The recommendations from this research are especially focused on the improvement of the water infrastructure. The main limitations are currently related to water, mainly flooding and a lack of water, and can be solved relatively easy. The most upstream communes of Quang An and Quang Phuoc have a flooding problem, especially in the wet season. There are no dams in this area and water covers the agricultural fields and main roads during several weeks every year. The flooding causes the farmers to adapt by cultivating short season varieties, but they still have a lower profit due to the long periods of flooding. The downstream area of Quang Loi does not have much water infrastructure and flooding is almost never a problem in this area. The main problem in both seasons is the lack of water. When water would be diverted from the places where it is causing problem (Quang An and Quang Phuoc), to the place where it is needed (Quang Loi), there would be considerable economical benefits.

It can be seen in this research that additional input of nutrients and chemicals do not have a very strong positive effect on the yield, whereas they have a proven negative effect on the ecosystem. Many ngo's have tried to train farmers in different areas on practices such as IPM, but still the farmers have not adapted such measures. In some areas the farmers use the economical equivalent of 100 kilograms of rice on nutrient inputs. This is very high, since total output is only 300 kilograms after these inputs. The organizations that train the farmers should focus more on the best positive conservation method per area. The area in which IPM has been promoted in the past is the least suitable for this method, according to the farmers. Other easy methods can be introduced in the area to limit the inputs, such as the *color leaf charts,* which allows farmers to better assess how much nitrogen they must apply.

Aquaculture is an important source of income, but should be done in a more sustainable model. The benefits of polyculture are high from both an ecological as economic perspective. This model of aquaculture already gives the highest net income to the farmers and also has fewer problems with diseases, which in other model causes the need for the use of antibiotics that are bad for the environment. Although this is the case, the extension should be better regulated or even restricted in the future. The ponds should be created in a way that water circulation is not being restricted. The aquaculture farmers can also create benefits by better organizing and focusing more on the market.

For agriculture farmers, pig farming is the main source of income outside the cultivation of rice. This means that animal manure should be better promoted. The farmers currently think that it is too difficult to transport the manure to the field. Since the use of animal manure will have ecological benefits, a method should be found which will support the farmers to use their animal manure. The basic environmental awareness of the local people in the area should also be improved, since many farmers still leave the bottles of chemicals on their fields, which means that they will wash away to the lagoon. The production of rice is expected to increase for some more years, but this has to be done in a more sustainable way in order to also have increased overall benefits. To defeat pests, the farmers should for example be trained to alternate the rice crop with corn. Also the off farm incomes should be further promoted. The poorest area is currently furthest away from the lagoon and is thus not the most suitable area to create handicrafts which have to be transported to Hué city. Instead of handicrafts, other activities, such as sustainable forestry, aquaculture or pig husbandry would probably be better.

Recommendations for future research of this kind are especially related to the statistical analysis and the use of a GPS. Using a GPS gives a more exact location of the farms and can thus be used to create the cropping systems with more detail. Since the number of survey was quite high and the yield varies a lot, even in the same categories which have been created, a good statistical analysis can be very useful to give better trends of the influence of different variables on the yield. The last recommendation is to have a better indication of water availability, since using the irrigation state has some clear limitations.

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Annexes:

Annex 1: Additional data collected from the HH-survey

Annex 1	Additional questions of the household survey, related to social and productivity limiting factors	Quang Dien (n=118)				Quang An (n=42)				Quang Phuoc (n=37)				Quang Loi (n=39)			
		Yes		No		Yes		No		Yes		No		Yes		No	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Do you pay a fee to use agriculture land?	*73*	**62**	*45*	**38**	*38*	**90**	*4*	**10**	*10*	**27**	*27*	**73**	*25*	**64**	*14*	**36**
2	Do you own a title deed (redbook)?	*68*	**58**	*50*	**42**	*36*	**86**	*6*	**14**	*15*	**41**	*22*	**59**	*17*	**44**	*22*	**56**
3	Do you use pesticide?	*115*	**97**	*3*	**3**	*42*	**100**	*0*	**0**	*37*	**100**	*0*	**0**	*36*	**92**	*3*	**8**
4	Do you use herbicide?	*112*	**95**	*6*	**5**	*42*	**100**	*0*	**0**	*37*	**100**	*0*	**0**	*33*	**85**	*6*	**15**
5	Do you use nitrate?	*96*	**81**	*22*	**19**	*27*	**64**	*15*	**36**	*31*	**84**	*6*	**16**	*38*	**97**	*1*	**3**
6	Do you use phosphorous?	*73*	**62**	*45*	**38**	*10*	**24**	*32*	**76**	*27*	**73**	*10*	**27**	*36*	**92**	*3*	**8**
7	Do you use kali?	*96*	**81**	*22*	**19**	*29*	**69**	*13*	**31**	*29*	**78**	*8*	**22**	*38*	**97**	*1*	**3**
8	Do you use NPK?	*106*	**90**	*12*	**10**	*41*	**98**	*1*	**2**	*28*	**76**	*9*	**24**	*37*	**95**	*2*	**5**
9	Do you use cattle manure?	*27*	**23**	*91*	**77**	*7*	**17**	*35*	**83**	*3*	**8**	*34*	**92**	*17*	**44**	*22*	**56**
10	Do you use green manure?	*3*	**3**	*115*	**97**	*0*	**0**	*42*	**100**	*1*	**3**	*36*	**97**	*2*	**5**	*37*	**95**
11	Do you dispose chemicals in the environment?	*95*	**81**	*23*	**19**	*40*	**95**	*2*	**5**	*25*	**68**	*12*	**32**	*30*	**77**	*9*	**23**
12	Do you have conflicts with other water users?	*80*	**68**	*38*	**32**	*40*	**95**	*2*	**5**	*26*	**70**	*11*	**30**	*14*	**36**	*25*	**64**
13	Is the soil suitable for agriculture?	*84*	**71**	*34*	**29**	*37*	**88**	*5*	**12**	*27*	**73**	*10*	**27**	*20*	**51**	*19*	**49**
14	Does the soil quality limit the productivity?	*38*	**32**	*80*	**68**	*5*	**12**	*37*	**88**	*13*	**35**	*24*	**65**	*20*	**51**	*19*	**49**
15	Do you experience flooding?	*102*	**86**	*16*	**14**	*42*	**100**	*0*	**0**	*34*	**92**	*3*	**8**	*26*	**67**	*13*	**33**
16	Is this a problem for productivity?	*93*	**79**	*25*	**21**	*40*	**95**	*2*	**5**	*34*	**92**	*3*	**8**	*19*	**49**	*20*	**51**
17	Do you experience salinity intrusion?	*43*	**36**	*75*	**64**	*12*	**29**	*30*	**71**	*16*	**43**	*21*	**57**	*15*	**38**	*24*	**62**
18	Is this a problem for productivity?	*42*	**36**	*76*	**64**	*12*	**29**	*30*	**71**	*15*	**41**	*22*	**59**	*15*	**38**	*24*	**62**
19	Do you experience rice diseases?	*111*	**94**	*7*	**6**	*40*	**95**	*2*	**5**	*36*	**97**	*1*	**3**	*35*	**90**	*4*	**10**
20	Is this a problem for productivity?	*109*	**92**	*9*	**8**	*39*	**93**	*3*	**7**	*35*	**95**	*2*	**5**	*35*	**90**	*4*	**10**
21	Is the water quality suitable for agriculture?	*80*	**68**	*38*	**32**	*32*	**76**	*10*	**24**	*27*	**73**	*10*	**27**	*21*	**54**	*18*	**46**
22	Does water quality limit productivity?	*45*	**38**	*73*	**62**	*10*	**24**	*32*	**76**	*15*	**41**	*22*	**59**	*20*	**51**	*19*	**49**
23	Is the water quantity suitable for agriculture?	*71*	**60**	*47*	**40**	*34*	**81**	*8*	**19**	*23*	**62**	*14*	**38**	*8*	**21**	*31*	**79**
24	Does water quantity limit productivity?	*35*	**30**	*83*	**70**	*8*	**19**	*34*	**81**	*19*	**51**	*18*	**49**	*34*	**87**	*5*	**13**
25	Is the access to the field easy?	*46*	**39**	*72*	**61**	*11*	**26**	*31*	**74**	*25*	**68**	*12*	**32**	*10*	**26**	*29*	**74**
26	Does field access limit agriculture activity?	*82*	**69**	*36*	**31**	*31*	**74**	*11*	**26**	*22*	**59**	*15*	**41**	*29*	**74**	*10*	**26**
27	**Rank the main production limiting factors:**	*flooding*	*Diseases*	*lack of water*	*salinity*	*flooding*	*diseases*	*salinity*	*field access*	*flooding*	*diseases*	*Salinity*	*quantity*	*quantity*	*diseases*	*bad soils*	*salinity*

Annex 2: Price and harvest of rice from 2003-2007

Price and harvest from 2003 2007	2003 WS yield (000kg/ha)	2003 SA yield	2003 price VND/kg	2004 WS yield	2004 SA yield	2004 price	2005 WS yield	2005 SA yield	2005 price	2006 WS yield	2006 SA yield	2006 price	2007 WS yield	2007 SA yield	2007 price
Quang Dien (n=118)	4,871	4,797	1.704	4,939	4,818	1.854	5,346	5,066	2.133	5,441	4,987	2.376	5,364	4,977	2.941
Quang An (n=40)	6.171	5,257	1.800	6,295	5,342	1.963	6,415	5,535	2.209	6,455	5,560	2.386	6,244	5,444	2.844
Quang Phuoc (n=38)	5.437	4,542	1.632	5,484	4,689	1.790	5,816	4,768	2.168	5,879	4,895	2.499	5,610	4,805	3.037
Quang Loi (n=40)	3,063	3,500*	1.693	3,182	3,600*	1.818	3,792	4,500*	2.023	3,934	3,500*	2.250	4,174	4,062	2.939

**The number of farmers cultivating in the summer-autumn season in Quang Loi is too small to give a good indication of the real yield potential*

Annex 3: Area, output and yield of rice, according to crop

Area: ha, output: 000kg/ha, yield: ton (DPC yearbook, 2007)

		Total	Season	
			Winter-spring	Summer-autumn
Area	1997	7991,95	4204,32	3787,67
	1998	7771,59	4032,07	3739,52
	1999	7898,38	4075,5	3822,88
	2000	7953,90	4104,70	3849,00
	2001	7933,90	4109,40	3824,50
	2002	7996,85	4090,85	3906,00
	2003	7917,20	4096,40	3820,80
	2004	7703,45	4009,75	3693,70
	2005	7407,50	3822,10	3585,40
	2006	7219,30	3720,70	3498,60
Output	1997	4,486	4,720	4,225
	1998	4,371	4,320	4,425
	1999	4,580	4,630	4,530
	2000	3,890	4,550	3,190
	2001	4,320	3,900	4,770
	2002	4,610	5,240	3,960
	2003	4,990	5,360	4,600
	2004	5,330	5,600	5,040
	2005	5,060	4,910	5,230
	2006	5,400	5,940	4,830
Yield	1997	35851,00	19850,00	16001,00
	1998	33966,45	17418,00	16548,45
	1999	36186,60	18869,20	17317,40
	2000	30951,70	18670,30	12281,40
	2001	34249,30	16024,90	18224,40
	2002	36902,70	21450,20	15452,50
	2003	39532,30	21956,70	17575,60
	2004	41080,00	22464,00	18616,00
	2005	37518,80	18766,70	18752,10
	2006	38991,90	22089,60	16902,30

Annex 4: Area, output and output of rice overyear for different communes:

a. Area of rice overyear, according to town and commune

UNIT: ha

	2003	2004	2005	2006
All district	**7917,2**	**7703,45**	**7407,5**	**7219,3**
Sëa town	949.1	873,0	836,4	809,6
quang ngan commune	171,0	166,0	159,0	155,0
quang cong commune	152,0	141,0	121,6	126,6
quang thai commune	635,6	611,8	603,6	516,0
quang loi commune	472,3	466,55	403,3	401,9
quang phuoc commune	649,3	731,5	713,6	720,6
quang vinh commune	1205,2	1168,8	1185,2	1169,0
quang phu commune	926,6	877,3	807,9	789,2
quang tho commune	709,1	640,4	620,5	609,0
quang an commune	969,1	963,6	939,0	924,0
quang thanh commune	1077,9	1063,5	1017,4	998,4

b. Rice output overyear, according to town and commune

Unit: 000kg/ha

	2003	2004	2005	2006
All district	**4,99**	**5,33**	**5,06**	**5,40**
Sëa town	4,82	5,11	4,85	4,88
quang ngan commune	3,42	3,97	3,83	4,30
quang cong commune	3,28	3,89	4,04	4,36
quang thai commune	3,62	3,85	4,17	4,49
quang loi commune	2,43	3,11	3,65	3,89
quang phuoc commune	5,16	5,76	5,40	5,64
quang vinh commune	5,12	5,18	4,92	5,23
quang phu commune	5,15	5,52	4,92	5,55
quang tho commune	5,56	5,86	5,00	5,90
quang an commune	5,82	6,36	5,98	6,20
quang thanh commune	6,08	6,22	5,88	6,08

Annex 5: Area and output of rice during the WS – season

a. Rice area in the WS – season, according to town and commune

UNIT : Ha

	2003	2004	2005	2006
All district	**4096,40**	**4009,75**	**3822,14**	**3720,7**
Sëa town	461,61	414,50	395,00	386,4
quang ngan commune	96,00	96,00	94,00	90,0
quang cong commune	93,80	85,80	68,00	73,0
quang thai commune	325,00	338,10	329,70	285,2
quang loi commune	344,95	345,05	288,30	289,8
quang phuoc commune	324,40	364,80	358,30	361,6
quang vinh commune	607,93	582,50	599,50	582,4
quang phu commune	464,60	437,30	398,90	391,7
quang tho commune	357,10	332,00	312,20	307,0
quang an commune	484,55	482,00	469,50	462,0
quang thanh commune	536,46	531,70	508,74	491,6

b. Rice output in the WS – season, according to town and commune

Unit: 000/ha

	2003	2004	2005	2006
All district	**5,36**	**5,60**	**4,91**	**5,94**
Sëa town	5,39	5,39	4,55	5,59
quang ngan commune	3,74	4,11	4,05	4,65
quang cong commune	3,45	3,78	4,00	4,63
quang thai commune	3,95	3,91	4,17	4,86
quang loi commune	2,76	2,89	3,68	4,16
quang phuoc commune	5,70	6,26	5,35	6,12
quang vinh commune	5,53	5,58	4,55	5,60
quang phu commune	5,43	5,89	4,84	5,96
quang tho commune	6,34	6,45	5,24	6,42
quang an commune	6,05	6,86	5,81	7,15
quang thanh commune	6,76	6,84	5,77	7,11

Annex 6: Area and output of rice during the SA – season

a. **Rice area in the SA - season, according to town and commune**

Unit: ha

	2003	2004	2005	2006
All district	**3820,80**	**3693,7**	**3585,36**	**3498,6**
Sëa town	487,49	458,5	441,40	423,2
quang ngan commune	75,00	70,0	65,00	65,0
quang cong commune	58,20	55,2	53,60	53,6
quang thai commune	310,60	273,7	273,90	230,8
quang loi commune	127,35	121,5	115,00	112,1
quang phuoc commune	324,90	366,7	355,30	359,0
quang vinh commune	597,27	586,3	585,70	586,6
quang phu commune	462,00	440,0	409,00	397,5
quang tho commune	352,00	308,4	308,30	302,0
quang an commune	484,55	481,6	469,50	462,0
quang thanh commune	541,44	531,8	508,66	506,8

b. **Rice output in the SA – season, according to town and commune**

Unit: 000kg/ ha

	2003	2004	2005	2006
All district	**4,60**	**5,04**	**5,23**	**4,83**
Sëa town	4,28	4,86	5,13	4,23
quang ngan commune	3,00	3,77	3,50	3,82
quang cong commune	3,00	4,05	4,10	4,00
quang thai commune	3,27	3,78	4,18	4,03
quang loi commune	1,56	3,77	3,59	3,20
quang phuoc commune	4,62	5,27	5,45	5,15
quang vinh commune	4,70	4,78	5,30	4,86
quang phu commune	4,88	5,15	4,99	5,15
quang tho commune	4,76	5,23	4,76	5,36
quang an commune	5,60	5,85	6,15	5,24
quang thanh commune	5,41	5,61	5,99	5,08

Annex 7: Area and output of sweet potato in Quang Dien

a. Sweet potato area in the WS – season, according to town and commune

Ha

	2003	2004	2005	2006
All district	**196,3**	**199,7**	**140,3**	**157,2**
Sëa town	14,1	13,5	25,0	14,9
quang ngan commune	10,0	10,0	1,0	5,0
quang cong commune	22.0	8,0	8,0	8,0
quang thai commune	29,8	33,1	24,1	36,1
quang loi commune	30,9	30,6	25,6	27,1
quang phuoc commune	1,0	4,6	2,3	2,5
quang vinh commune	26,0	28,3	12,3	13,1
quang phu commune	13,0	19,0	2,3	13,5
quang tho commune	40,0	45,0	29,8	25,2
quang an commune	4,5	7,0	9,9	11,8
quang thanh commune	-	-	-	-

b. The output of sweet potato in the WS - season, according to town and commune

000KG/HA

	2003	2004	2005	2006
All district	**7,00**	**5,83**	**9,21**	**9,53**
Sëa town	6,80	6,00	9,50	10,83
quang ngan commune	6,40	4,00	6,00	13,00
quang cong commune	6,40	4,00	6,00	7,75
quang thai commune	6,48	4,14	7,09	4,92
quang loi commune	6,69	4,19	8,59	10,03
quang phuoc commune	6,90	5,00	9,52	10,48
quang vinh commune	7,20	5,97	6,52	14,53
quang phu commune	7,50	7,00	11,00	12,87
quang tho commune	7,80	7,87	12,00	11,38
quang an commune	7,27	9,00	12,64	7,00
quang thanh commune				

c. The area of sweet potato in the SA - season, according to town and commune

Unit: ha

	2003	2004	2005	2006
All district	**195,0**	**221,4**	**225,4**	**221,0**
Sëa town	22,0	10,0	10,0	18,0
quang ngan commune	4,0	13,0	15,0	15,0
quang cong commune	10,0	20,0	20,0	10,0
quang thai commune	19,4	16,0	16,7	12,8
quang loi commune	23,6	26,0	25,8	46,8
quang phuoc commune	1,0	-	-	3,0
quang vinh commune	44,0	16,4	14,9	32,9
quang phu commune	23,0	45,0	48,0	32,5
quang tho commune	45,0	65,0	65,0	50,0
quang an commune	3,0	10,0	10,0	-
quang thanh commune	-	-	-	-

Annex 8: Area and output of peanuts in Quang Dien

a. The output of peanuts overyear, according to town and commune

UNIT: 000kg/ha

	2003	2004	2005	2006
All district	**1,67**	**1,98**	**1,96**	**1,99**
Sëa town	1,56	2,20	1,87	1,87
quang ngan commune	0,80	1,20	1,30	1,05
quang cong commune	1,44	1,60	2,00	2,00
quang thai commune	1,60	1,65	2,24	1,78
quang loi commune	1,64	1,79	1,76	1,75
quang phuoc commune	-	2,00	1,90	1,80
quang vinh commune	1,73	2,15	2,20	2,37
quang phu commune	1,78	2,30	2,02	2,14
quang tho commune	1,80	2,39	2,09	2,25
quang an commune	1,80	2,40	2,67	2,80
quang thanh commune	-	-	-	-

b. The yield of peanuts overyear, according to town and commune

UNIT: ton

	2003	2004	2005	2006
All district	**1271,6**	**1632,3**	**1791,2**	**1791,3**
Sëa town	113,4	84,5	73,4	94,1
quang ngan commune	1,6	2,4	2,6	2,1
quang cong commune	34,6	24,0	46,0	40,0
quang thai commune	166,0	202,7	248,4	172,3
quang loi commune	481,4	601,4	604,8	567,6
quang phuoc commune	-	12,6	5,5	6,3
quang vinh commune	73,0	85,5	155,8	268,2
quang phu commune	286,4	373,0	412,7	396,7
quang tho commune	108,0	231,8	240,4	220,2
quang an commune	7,2	14,4	1,6	23,8
quang thanh commune	-	-	-	-

Annex 9: Yield of aquaculture and fishery in Quang Dien

a. Fishery capture

UNIT: ton

	2003	2004	2005	2006
yield	**2586,2**	**2588,0**	**2970,0**	**2986,9**
- sea	2166,0	2142,0	2500,0	2490,9
- river and lagoon	420,2	446,0	470,0	496,0
COMMUNE AND TOWN				
Sëa town	6,0	6,0	6,9	7,0
quang ngan commune	831,0	831,0	953,7	959,1
quang cong commune	1378,0	1379,0	1582,5	1591,5
quang thai commune	142,0	142,0	163,0	163,9
quang loi commune	140,0	140,0	160,7	161,6
quang phuoc commune	9,0	9,0	10,3	10,4
quang vinh commune	3,6	4,0	4,6	4,6
quang phu commune	34,0	34,0	39,0	39,2
quang tho commune	8,5	9,0	10,3	10,4
quang an commune	16,0	16,0	18,4	18,5
quang thanh commune	18,1	18,0	20,6	20,7

b. Fishery yield

Unit: ton

	2003	2004	2005	2006
Total	**3354,2**	**3417,9**	**3812,6**	**3899,5**
yield from sea	**2166,0**	**2142,0**	**2500,0**	**2490,9**
- fish	1775,7	1861,0	2126,7	2184,7
shrimp	30,1	23,0	23,3	22,7
- others	360,2	258,0	350,0	283,5
Fishery yield of fresh and brackish water	**420,2**	**446,0**	**470,0**	**496,0**
- fish	337,0	325,0	342,4	350,9
- shrimp	65,3	41,0	43,1	48,5
- others	17,9	80,0	84,5	96,6
Fishery yield of aqaculture and capture	**768,0**	**829,9**	**842,6**	**912,6**
- fish	269,3	349,1	366,3	430,9
- shrimp	476,7	456,8	451,3	467,7
- crab	22,0	24,0	25,0	14,0

Annex 10: Decision of the Huong River Projects Management Board (HRPMB)

THE PEOPLE'S COMMITTEE OF THUA THIEN HUE PROVINCE	SOCIALIST REPUBLIC OF VIETNAM Independence-Freedom-Happiness
No. 1264/2006/QD-UBND	*Hue, May 18, 2006*

DECISION

Re: Amending and supplementing functions, mission, authority and apparatus of Management Board of the Huong River Projects

THE PEOPLE'S COMMITTEE OF THUA THIEN HUE PROVINCE

- Pursuant to Law on the organization of People's Council and People's Committee dated November 26, 2003;
- Pursuant to Decision No. 936/QD-UB dated April 27, 1996 by the People's Committee of Thua Thien Hue province on the establishment Management Board of the Huong River Projects;
- In view of the proposal of The Director of Home Affairs Department and Head of Management Board of the Huong River Projects;

HEREBY DECIDES

Article 1: Amending and supplementing functions, mission, authority and apparatus of the Management Board of the Huong River Projects

1. **Position and functions:**
   Management Board of the Huong River Projects is a profit administrative unit directly under the provincial People's Committee. Management Board of the Huong River Project enjoys legal personality and has its own seal and account for operation.

2. **Mission and authority**

   2.1 Acting as a counselor for the provincial People's Committee in the sphere of managing projects belonging to Huong River Başin, Lagoons and organizing international and national cooperation relating to conservation, restoration and development of Huong River Basin and Lagoons

   2.2 Coordinately making proposals, doing researches and mapping out plans on integrated management of Huong River Basin and Lagoons; establishing approaches of operating, exploiting and using water resource of Huong River Basin and Lagoons; projects for treating Huong River Banks and Lagoons in order to minimize and repair damage caused by water, projects of protecting nature and environmental landscapes, restoring and promoting the value of Huong River and Lagoons

   2.3 Setting up plans for constructional designs, conservation, repair, and restoration of the environmental landscapes of riversides and main flow of Huong River, Lagoons as well as implementing approved projects.

2.4 Organizing workshops on issues relating to Huong River Basin and Lagoons and proposing measures to be submitted to the provincial People's Committee for consideration

2.5 Collaborating with domestic and international organizations in the aspect of researching, appealing for investment and construction. Studying, building and consulting for implementing domestic and international projects relating to the management, exploitation and using of resources and environment on the basin of Huong River and Lagoons

2.6 Collecting documents of Huong River and Lagoons Systems from agencies, organizations at home and abroad for studying and analyzing with a view to serving the mission of socio-economic development.

2.7 Doing researches and monitoring rainfall, flow, topography, tide, salt penetration, flood, and ecological environment of Huong River and Lagoons in order to establish database for planning and project design.

2.8 Collaborating with Department of Natural Resources and Environment, People's Committees of Huong Tra, Huong Thuy, Phu Vang districts and Hue city to study and propose for legal exploitation of sand and stone in Huong River, particularly attaching great importance to cultural and historic monuments, water supply constructions, eroded areas; setting up plans for protecting environmental landscapes along riversides and main flow of Huong River

2.9 Being licensed to do consultancy work for projects and constructions relating to the management, exploitation, using and development of water resources in the area.

2.10 Doing researches, applying scientific breakthroughs, technologies in the sphere of development, integrated management of water resources in the area; organizing eduactional and propagational activities and training courses with a view to raising the communities' awareness of the integrated management of river basins and lagoons; receiving and transferring techniques, technologies of relevant aspects assigned by the provincial People's Committee.

2.11 Making periodical and extraordinary reports on mission implementation as stipulated by law

2.12 Implementing other mission assigned by the provincial People's Committee.

Annex 11: Valuation of different sectors in Quang Dien by the ADB

a. Area, yield and economic efficiency of annual crops

Crops	*Area (m^2/hh)*	*Yield (ton/ha /season)*	*Total revenue (US$/ha /season)*	*Total cost (US$/ha /season)*	*Gross margin (US$/ha /season)*	*NFI (US$ /ha/season)*	*Man-day (US$/d)*
W-S rice	3,047	4.76	655	288	367	168	2,82
S-A rice	2,177	4.22	580	281	299	131	2,77
W-S Peanut	1,400	2.10	752	284	467	248	3,34
Beans	250	2.40	688	318	370	183	3,08
Sweet potato	1,750	4.60	288	111	161	50	2,24
Cassava	1320	4.86	300	128	173	48	2,16
Leafy vegetables	150	9.00	1690	675	1013	700	5,06
Cassava + peanut	1438	12 (Cassava) 1.58 (peanut)	873	402	471	221	2,94
Sugarcane (fresh eating) + peanut	1420	36.00 (Sugar.) 1.42 (Peanut)	2264	984	1280	811	4,27
Peanut + bean	1630	1.52 (Peanut) 0.58 (Bean)	762	291	470	252	3,36

b. Economic efficiency of cropping systems in Quang Dien

Cropping systems	*Total revenue* (US$/ha/ year)	*Total expenditures* (US$/ha/ year)	*Gross margin* (US$/ha/year)
Irrigated and Rainfed paddy land			
Rice -rice	1235	569	666
Rice - Fallow	655	288	367
Rice - Sweet potato	942	398	544
Dry land			
Peanut - Fallow	752	284	467
Peanut - Sweet potato	1039	395	644
Corn/bean+Peanut	762	291	470
Sweet potato - Sweet potato	575	221	354
Cassava	300	128	173
Peanut + sugarcane	2264	984	1280
Peanut + cassava	762	291	470

Annex 12: Agricultural and aquaculture inputs in the past, present and future

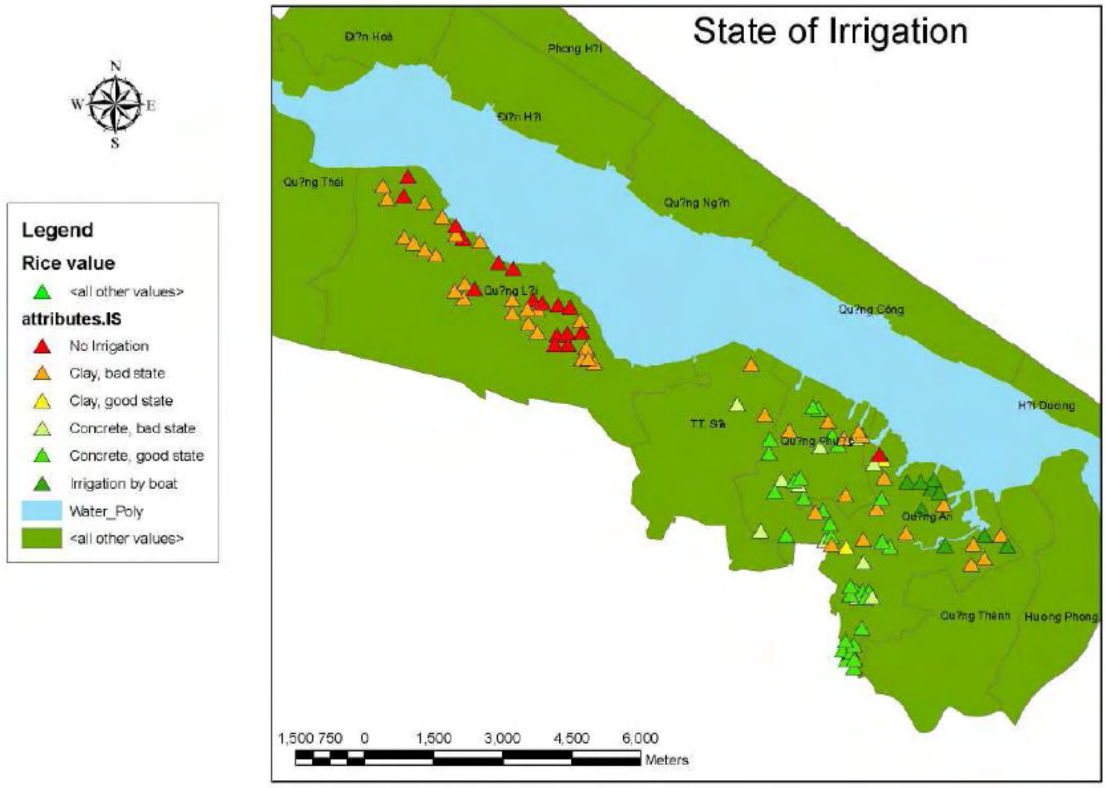
a. Selected substances and their average applied amounts (UNESCO-IHE)

Situation	Substances	Amount (kg/ha)	Reference
Rice culture			
Past	**Fertilizer** (kg/ha/crop) + N + P	 86 13.6	The average value of Vinh Hien, Loc Bon, Loc Dien and Phu Loc town in Phu Loc district.
	Pesticide (kg/ha/year) + Methamidophos + Metyl parathion	 0.4 0.4	Reference to the average value for Vietnam
Present	**Fertilizer** (kg/ha/crop) + N + P	 120 22	Standard values recommended by MARD for varieties X21 and CR203
	Pesticide (kg/ha/year) + Fenobucarb + 2,4-D	 0.8 0.8	Reference to the average value for Vietnam
Future	**Fertilizer** (kg/ha/crop) + N + P	 150 30	Values recommended by MARD for high yielding varieties
	Pesticide (kg/ha/year) + Fenobucarb + 2,4-D	 2.2 3.2	Values recommended by PPD
Aquaculture			
Past	**Nutrient** (kg/ha/crop	0	
	Formalin (ppm)	0	
Present	**Nutrient** (kg/ha/crop) + N + P	 37 12	Tacon (1995) and Le Trong (2001)
	Formalin (ppm)	120	
Future (High load)	**Nutrient** (kg/ha/crop) + N + P	 117 38	Tacon (1995) and Le Trong (2001)
	Formalin (ppm)	120	Vietlinh (2003)
Future (Low load)	**Nutrient** (kg/ha/crop) + N + P	 57 19	
	Formalin (ppm)	120	Vietlinh (2003)
Domestic			
No treatment	**Total Coliforms** (MPN/ind)	$3.3 * 10^{11}$	Fleming and Ford, 2001
Treatment	**Total Coliforms** (MPN/ind)	$1.98 * 10^{11}$	50% reduction

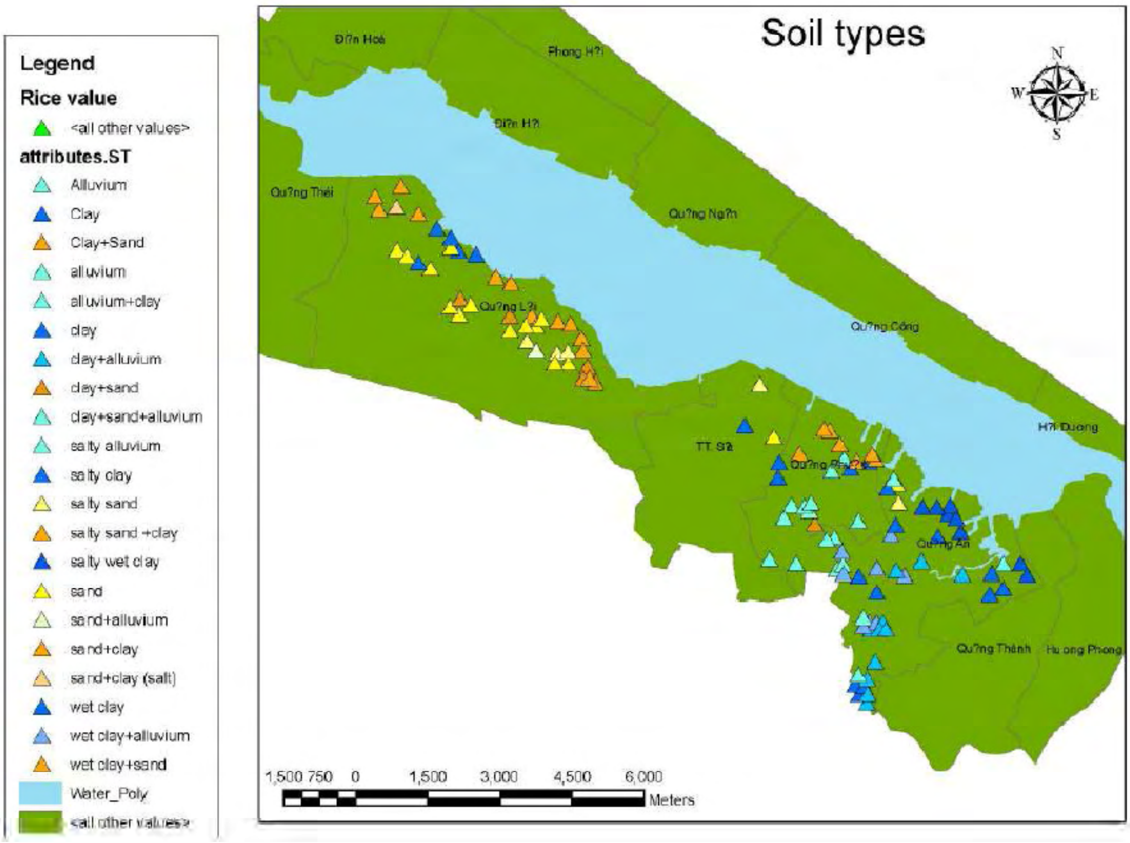
b. Polluted area in the present and future scenario (UNESCO)

Substance	Reference standard value	Situation	Wet season		Dry season	
			ha	%	ha	%
Total Nitrogen	0.9 mg/l (US standard)	Present-No dam	0	0	7,807	35
	0.6 mg/l (Japan standard)	Present-No dam	18,000	82	9,827	45
	0.9 mg/l (US standard)	Present-With dam	22,000	100	1,617	7
	0.6 mg/l (Japan standard)	Present-With dam	14,306	65	0	0
	0.9 mg/l (US standard)	Future-No dam	6,483	29	11,100	50
	0.6 mg/l (Japan standard)	Future-No dam	16,400	75	19,000	86
	0.9 mg/l (US standard)	Future-With dam	22,000	100	18,140	82
	0.6 mg/l (Japan standard)	Future-With dam	15,883	72	9,854	45
	0.9 mg/l (US standard)	Future-With dam+GW	22,000	100	22,000	100
	0.6 mg/l (Japan standard)	Future-With dam+GW	22,000	100	12,000	55
Total Phosphorus	0.05 mg/l (US, Japan and China standard)	Present-No dam	0	0	6,540	30
		Present-With dam	5,730	26	2,349	11
		Future-No dam	2,234	10	19,200	87
		Future-With dam	8,776	40	17,800	81
		Future-With dam+GW	9,807	45	22,000	100
Total' Pesticides	10 µg/l (Vietnam standard)	Present-No dam	0	0	0	0
		Present-With dam	118	1	0	0
		Future-No dam	7,600	35	2,450	11
		Future-With dam	11,800	54	920	4
		Future-With dam+GW	16,000	73	2,600	12
Formalin	1 µg/l (minimum toxic value to aquatic life)	Present-No dam	-	-	8,658	39
		Present-With dam	-	-	7,330	33
		Future-No dam	-	-	11,418	53
		Future-With dam	-	-	11,377	52
		Future-With dam+GW	-	-	9,043	41

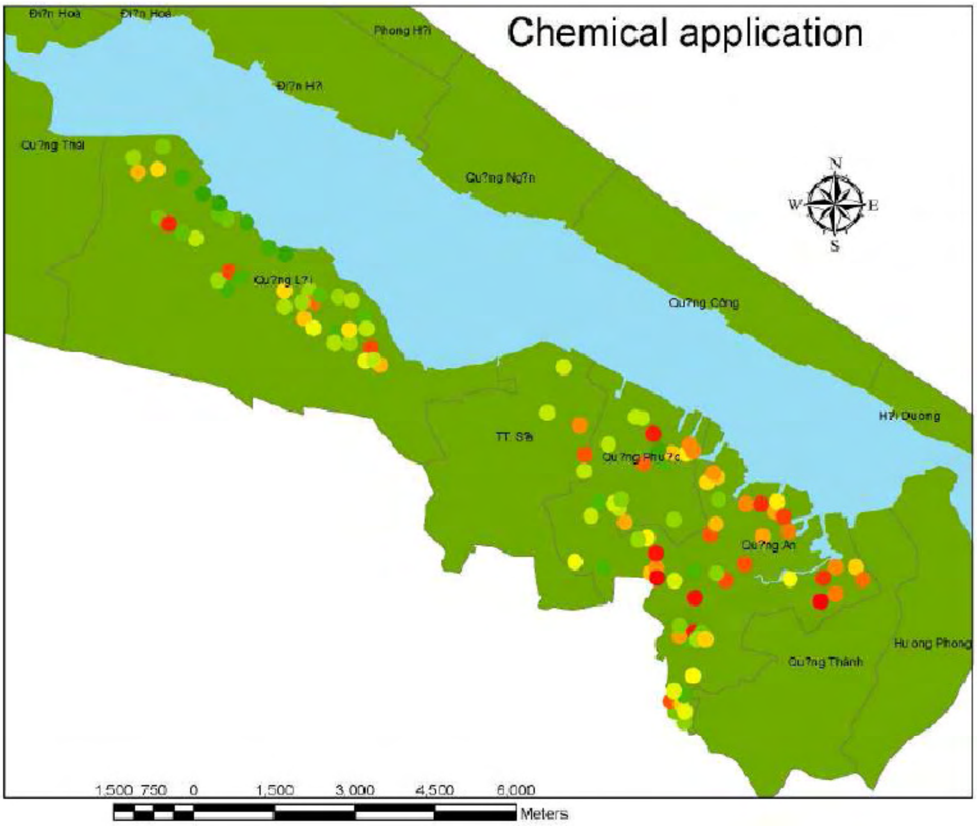
Annex 13: GIS map: State of the irrigation system



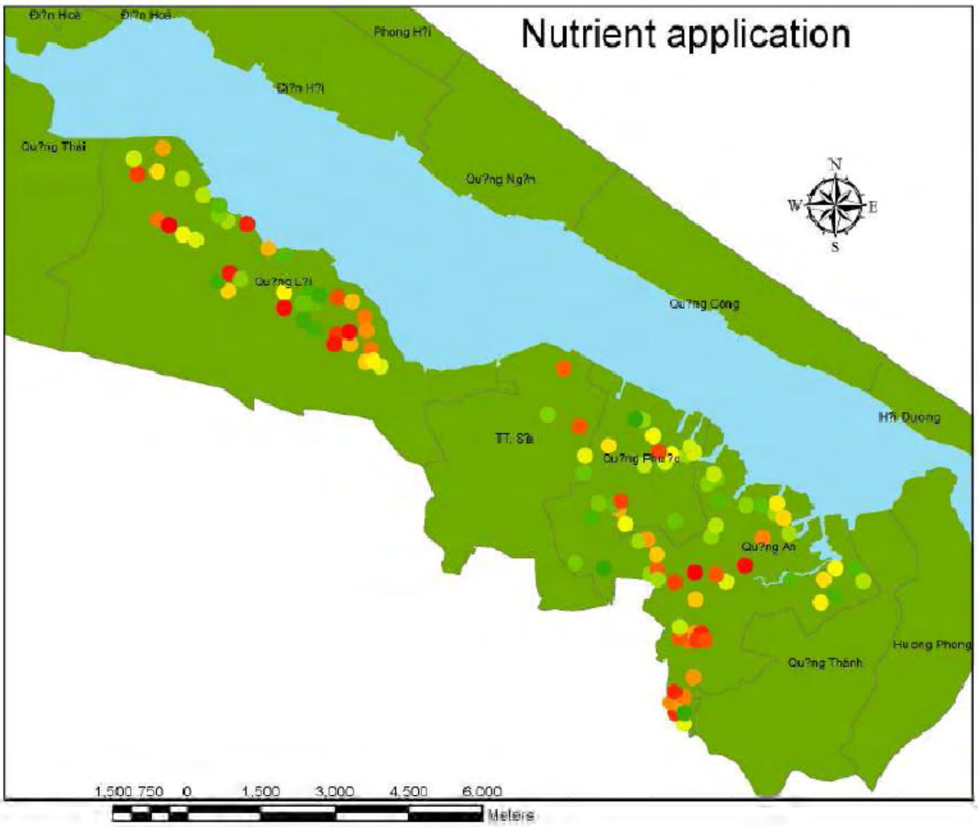
Annex 14: GIS map: Soil types



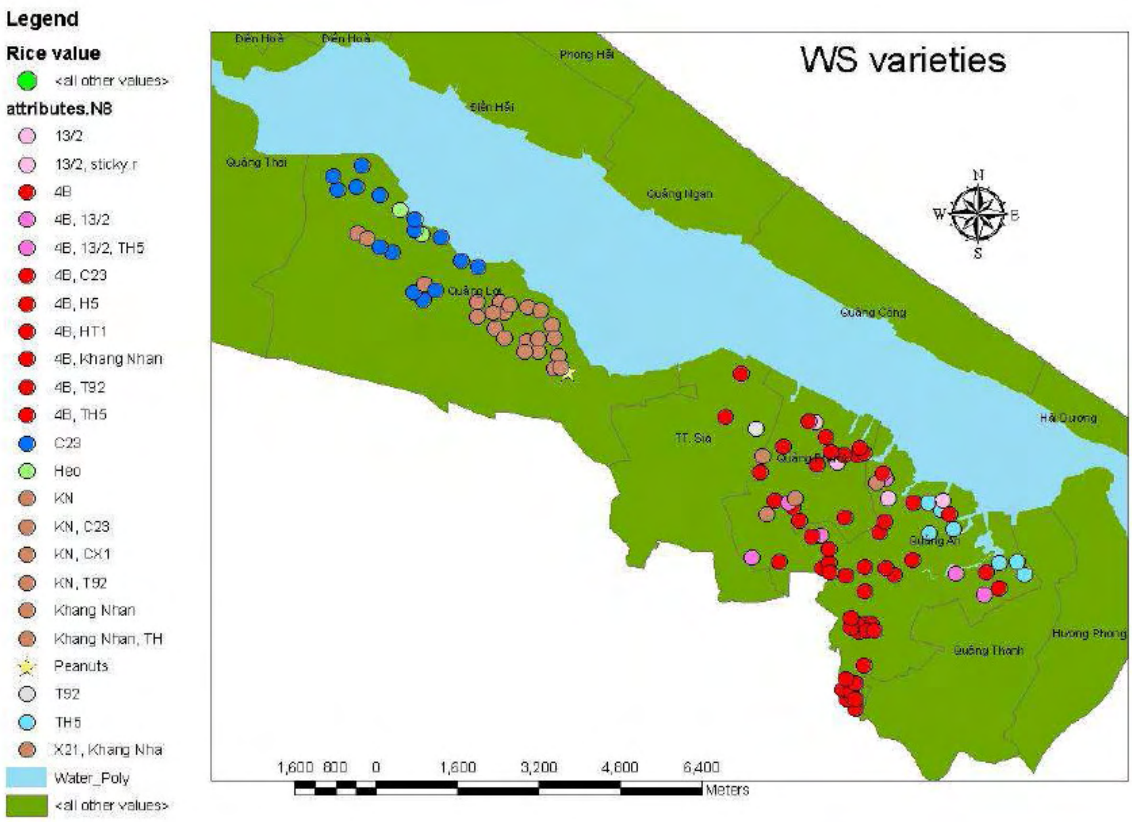
Annex 15: GIS map: Chemical application



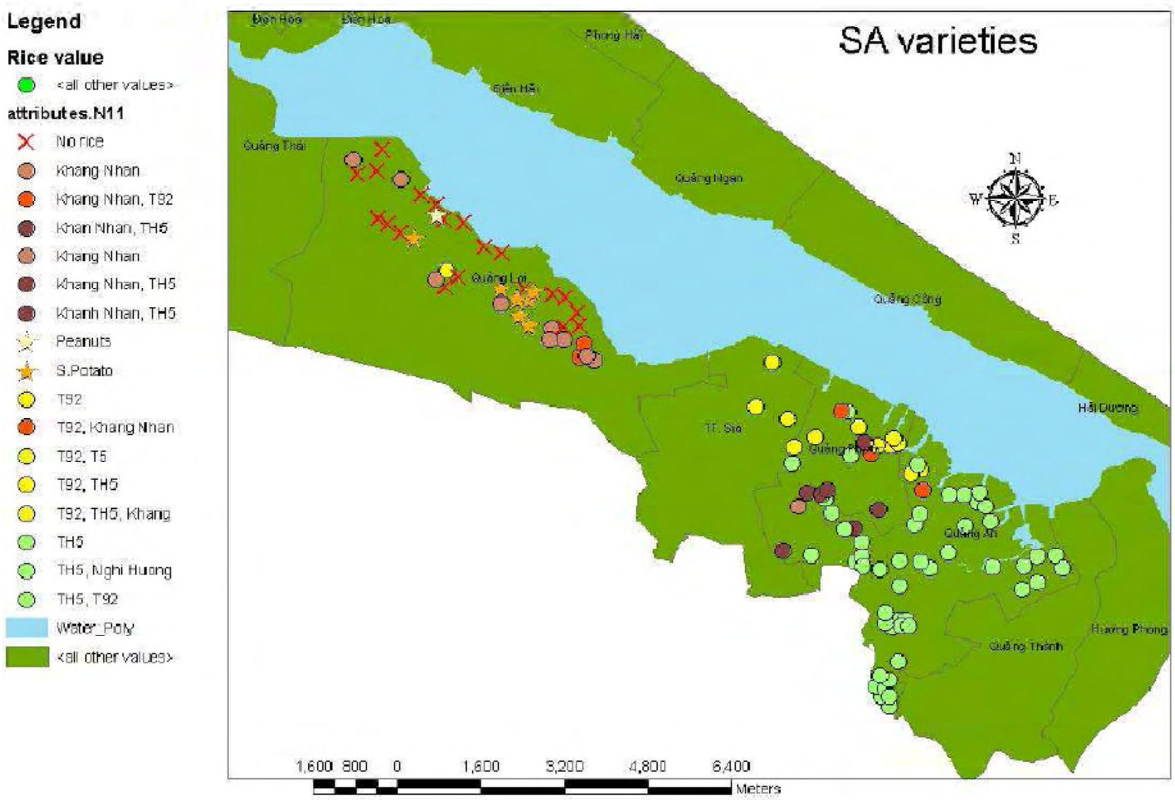
Annex 16: GIS map: Nutrient application



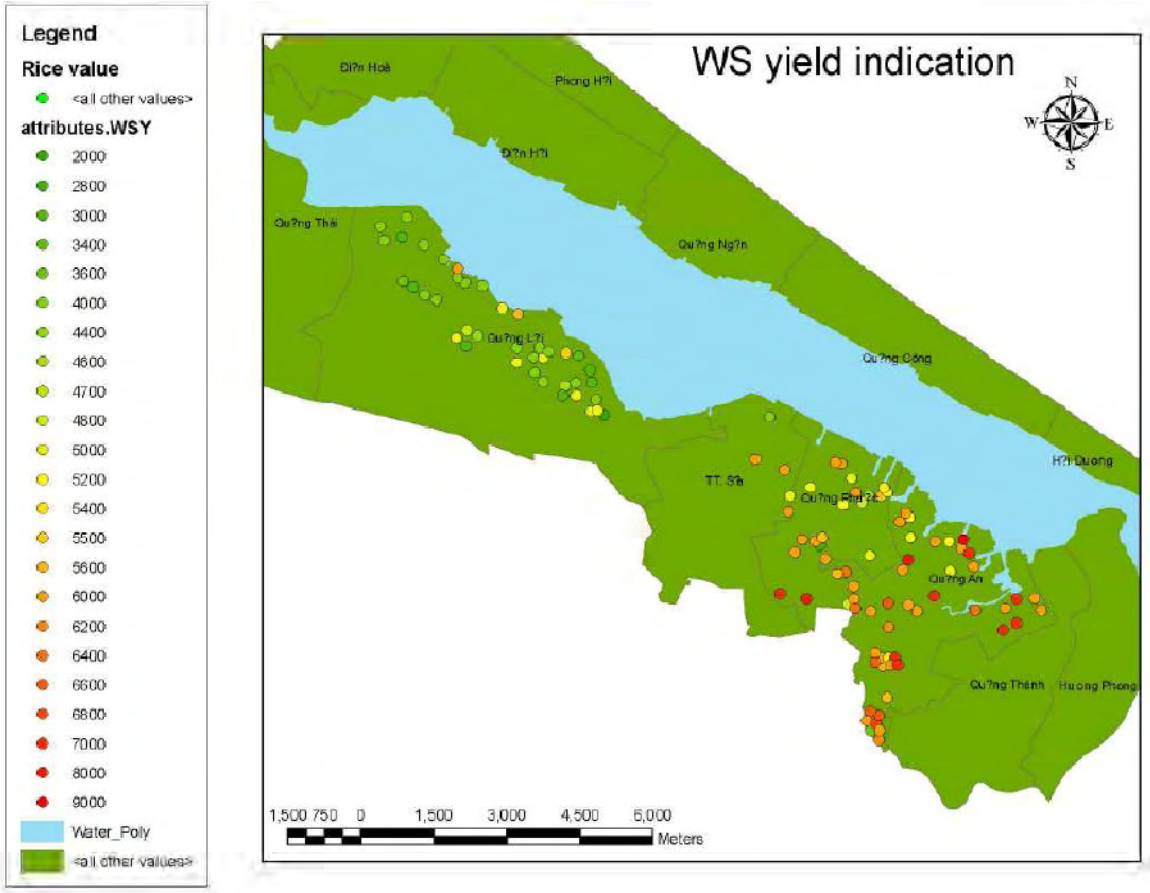
Annex 17: GIS map: WS varieties



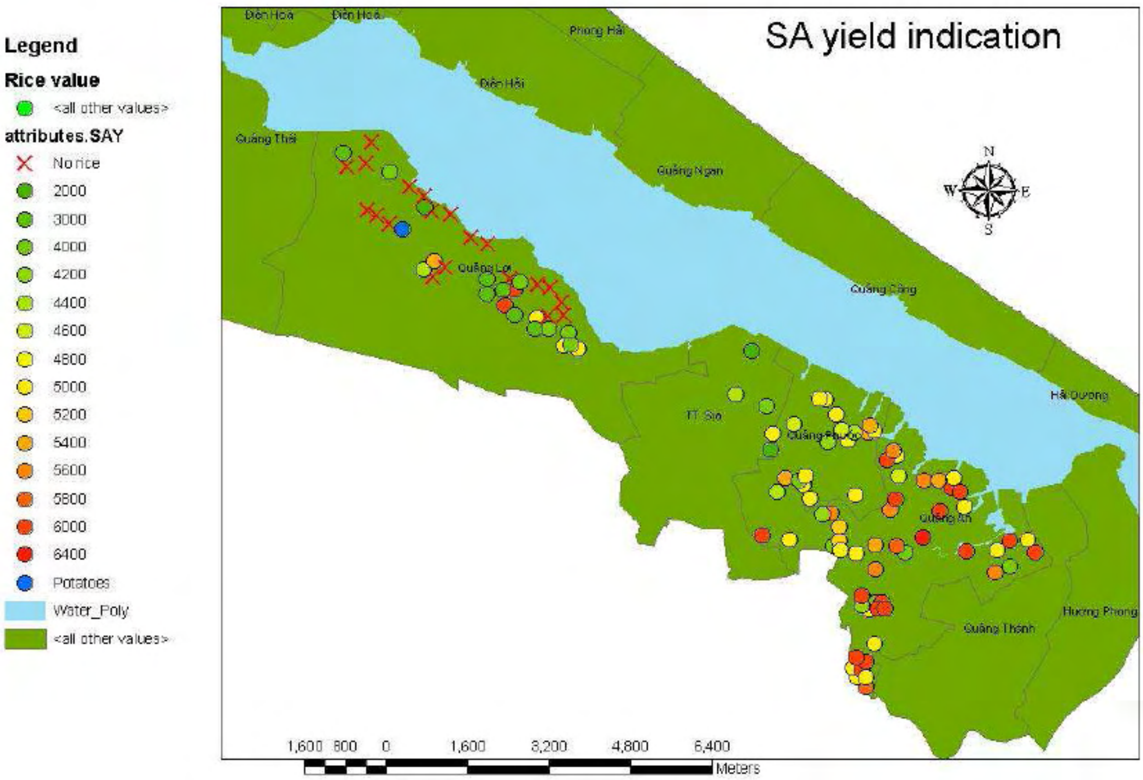
Annex 18: GIS map: SA varieties



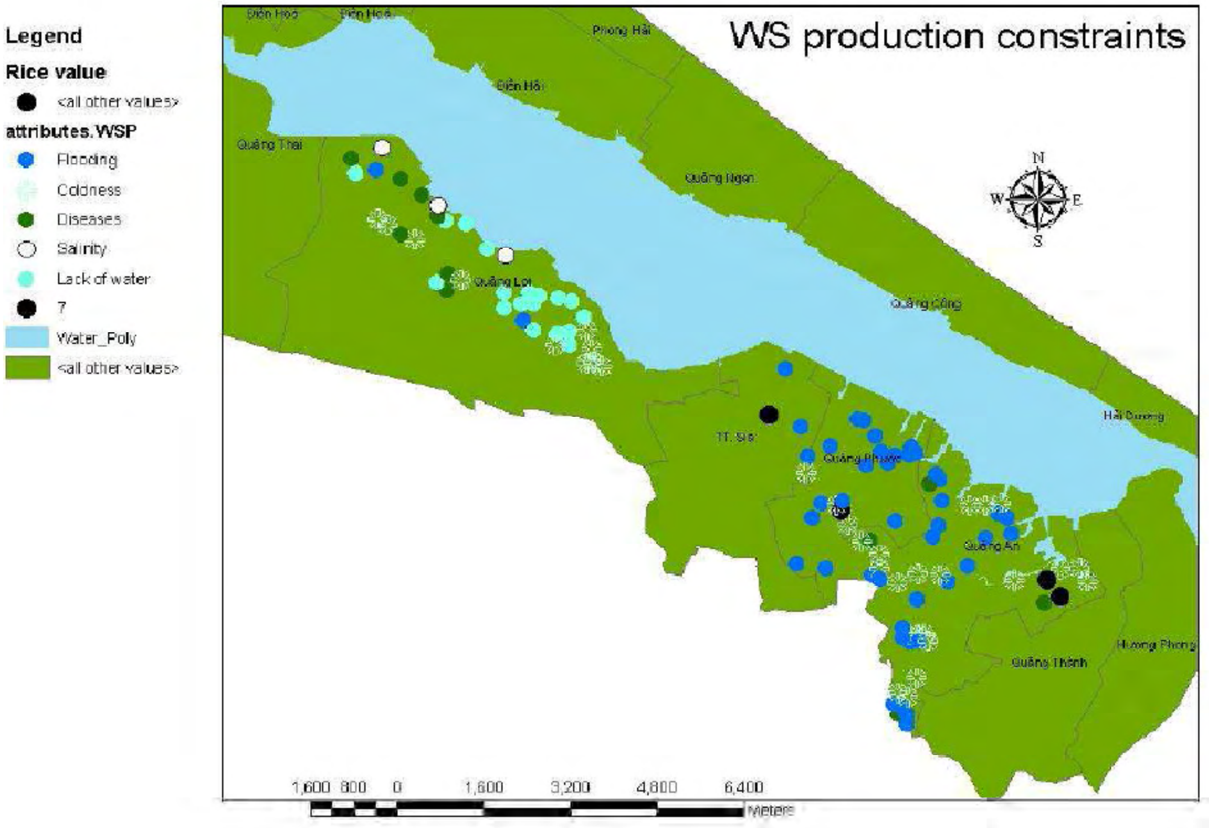
Annex 19: GIS map: WS yield indication



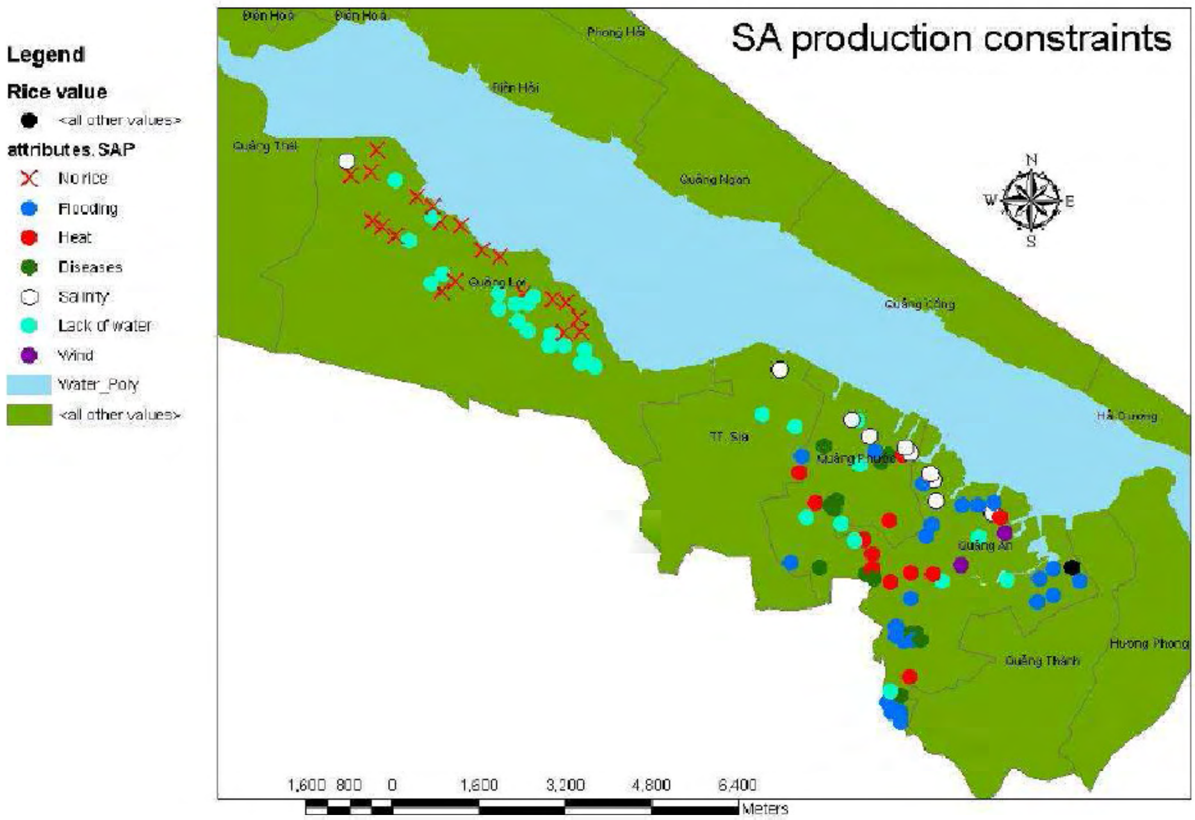
Annex 20: GIS map: SA yield indication



Annex 21: GIS map: WS production constraints

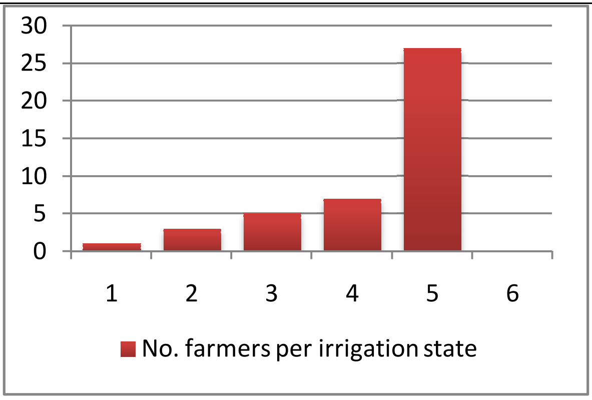


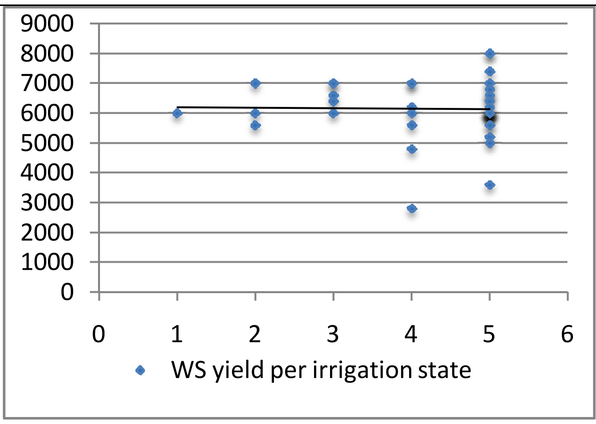
Annex 22: GIS map: SA production constraints

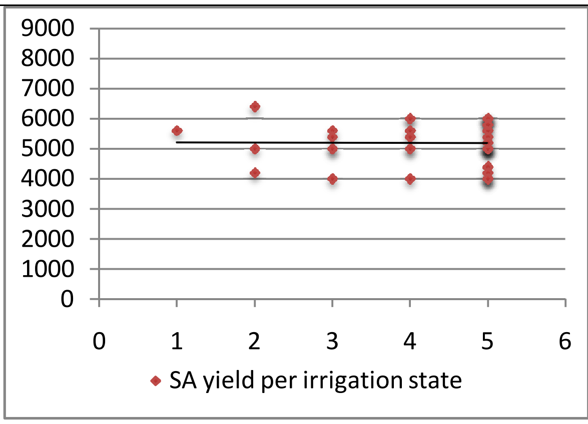


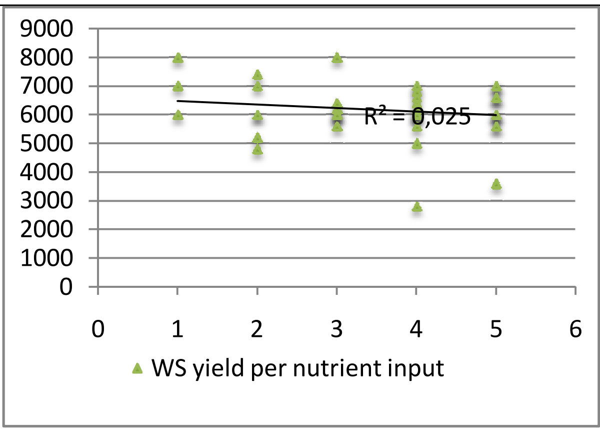
Annex 23 : Cropping system 1Characteristics

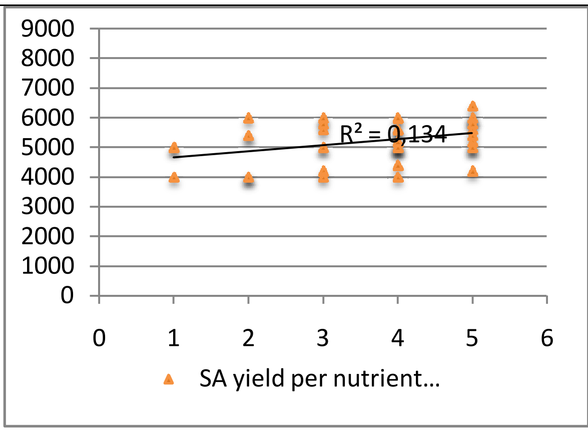
- WS variety is 4B, SA variety is TH5
- Good soils, relatively high area
- Sufficient water during both season
- Main problem is flooding
- No problem with salinity

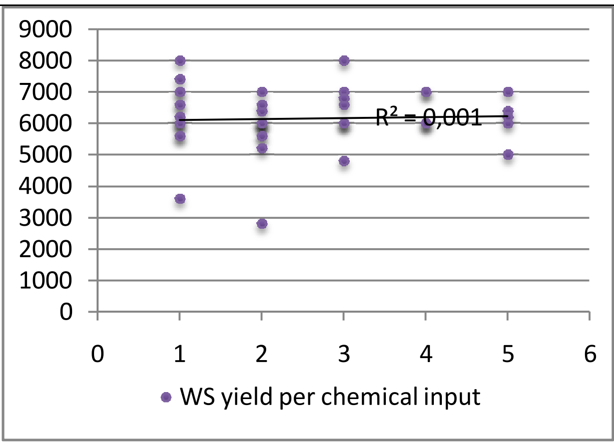


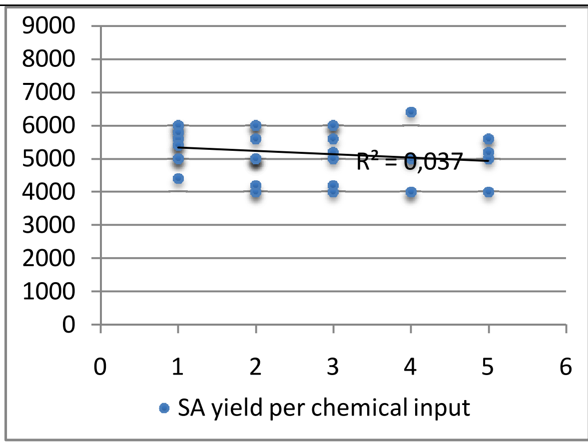








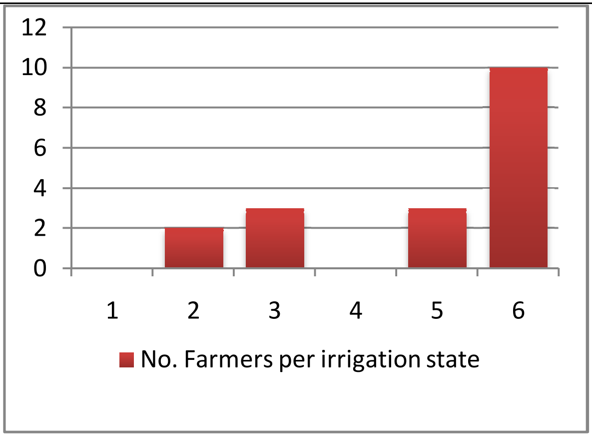


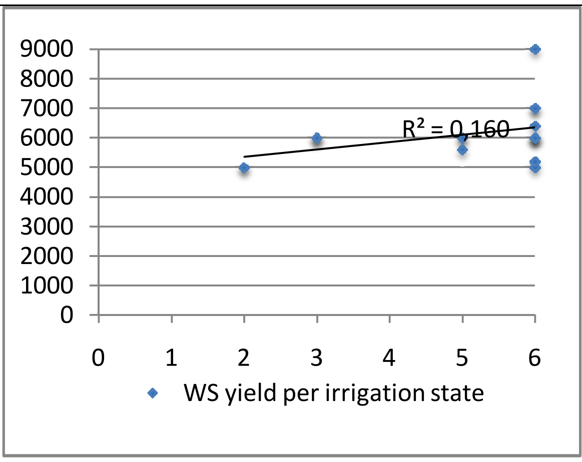


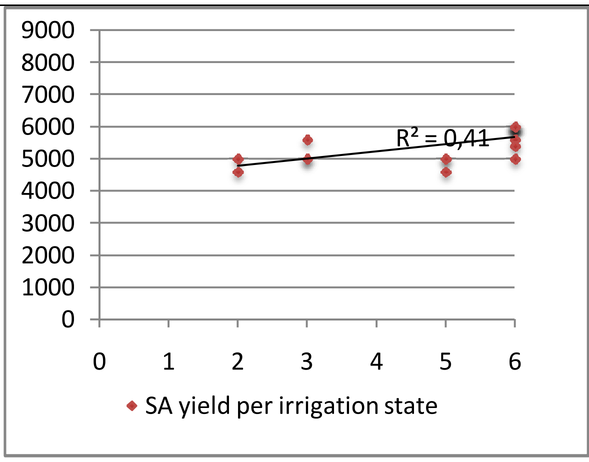
Annex 24: Cropping system 2

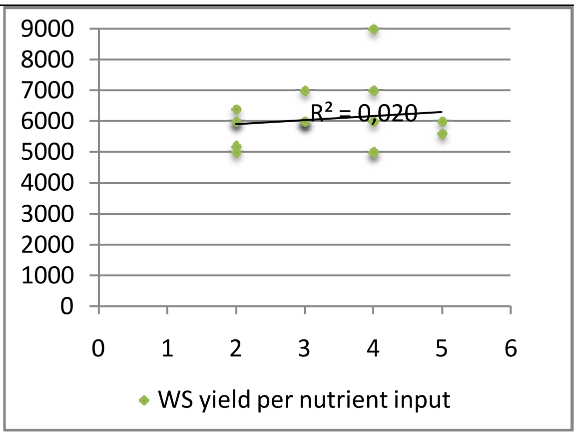
Characteristics

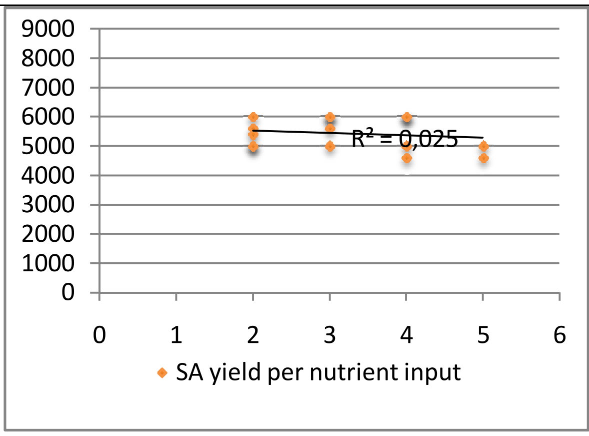
- WS variety is TH5, SA variety is TH5
- Good soils, relatively low area
- Too much water during both season
- Main problem is flooding
- No problem with salinity

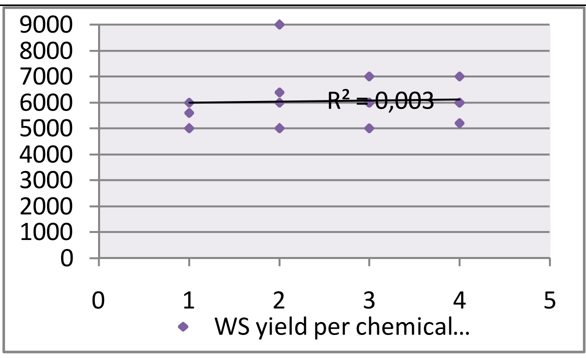


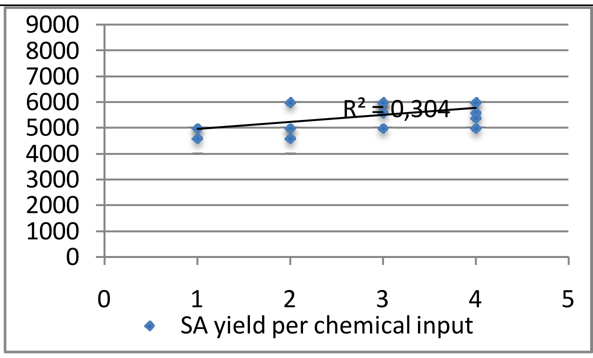








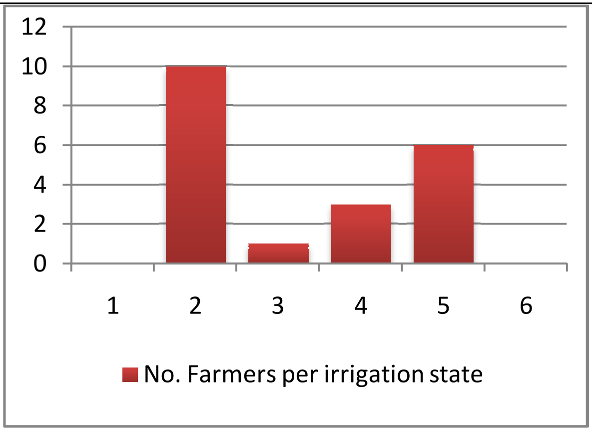


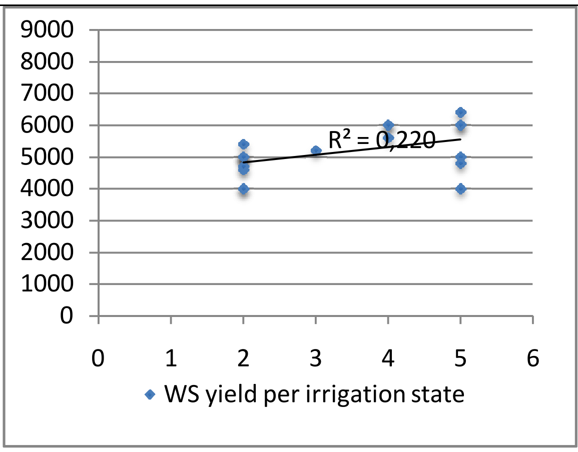


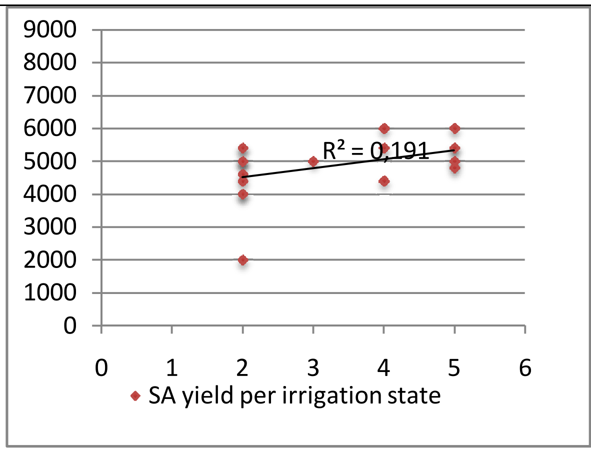
Annex 25: Cropping system 3

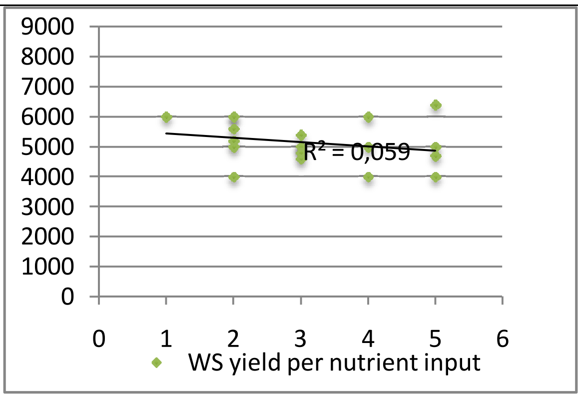
Characteristics

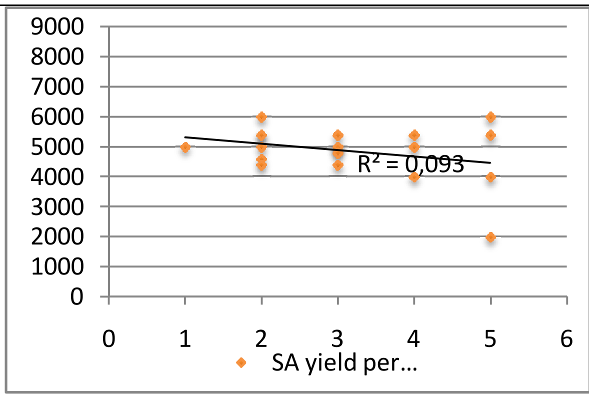
- WS variety is 4B/KN, SA variety is T92
- Medium soils, low area
- Not enough water during SA season
- Main problem is flooding in WS season
- Salinity is a problem in the SA season

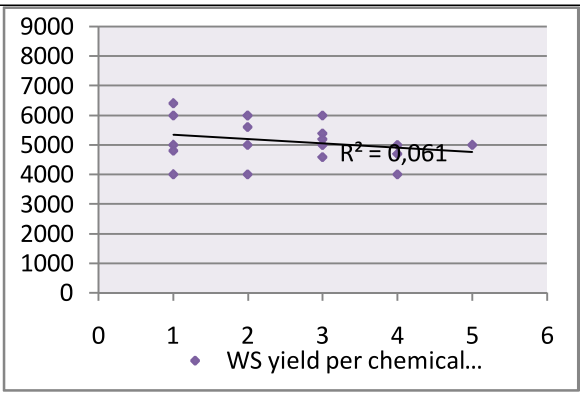


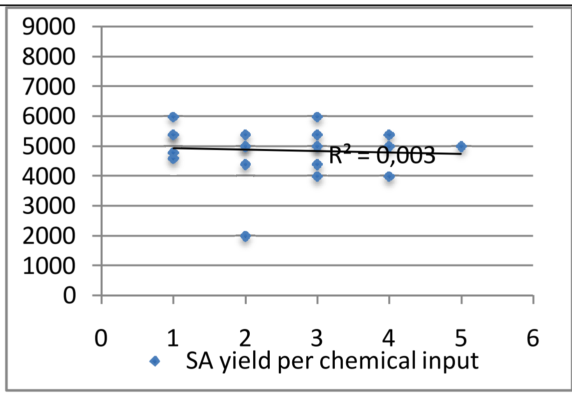








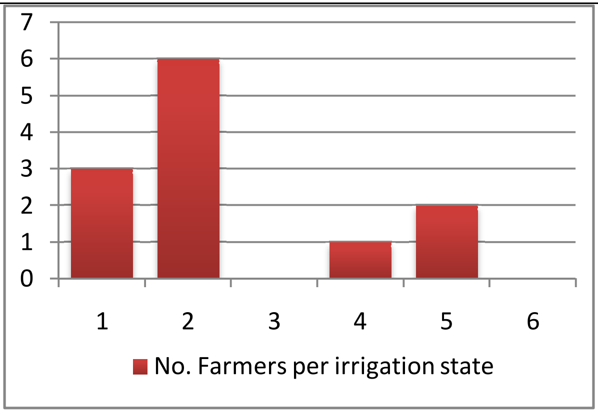


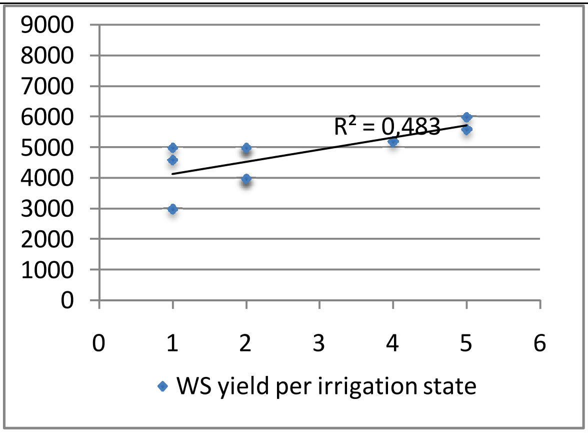


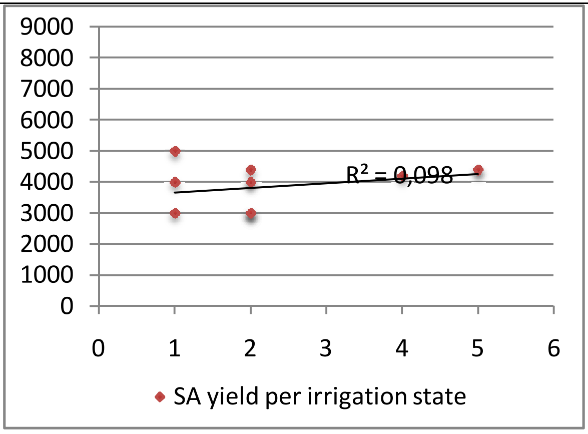
Annex 26: Cropping system 4

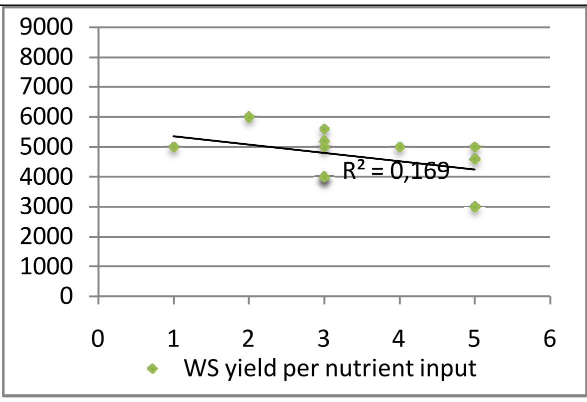
Characteristics

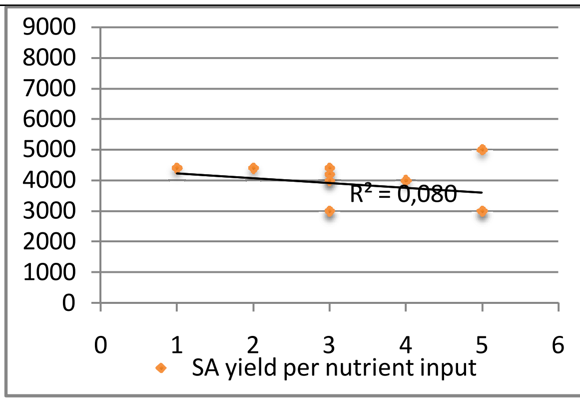
- WS variety is C23/KN, SA variety is KN
- Medium soils, high area
- Not enough water during both season
- Salinity is a problem during both seasons
- Rice diseases occur in many areas

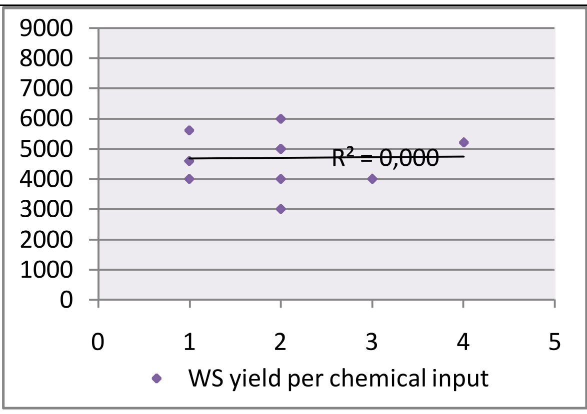


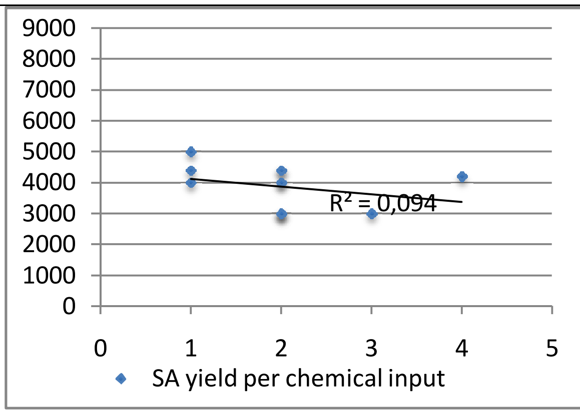








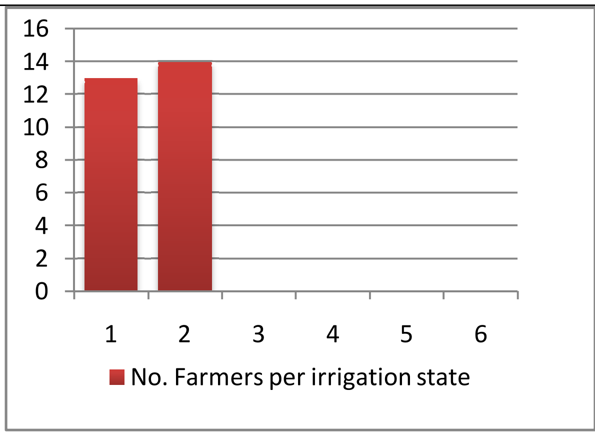


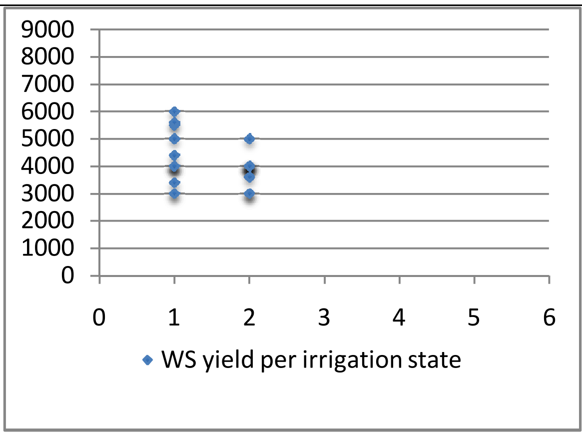


Annex 27: Cropping system 5

Characteristics

- WS variety is C23/KN, no SA rice
- Poor soils, both low and high areas
- Not enough water during both season
- Salinity is a problem during both seasons
- No good irrigation infrastructure





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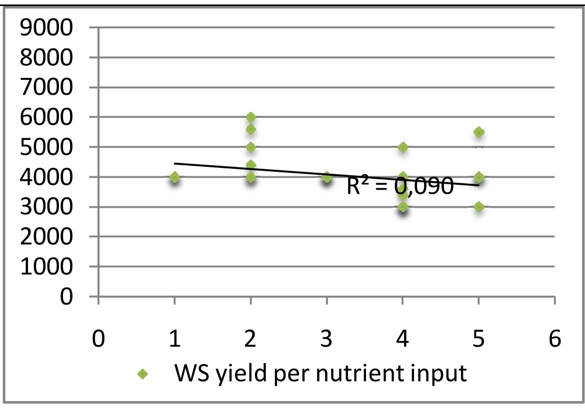

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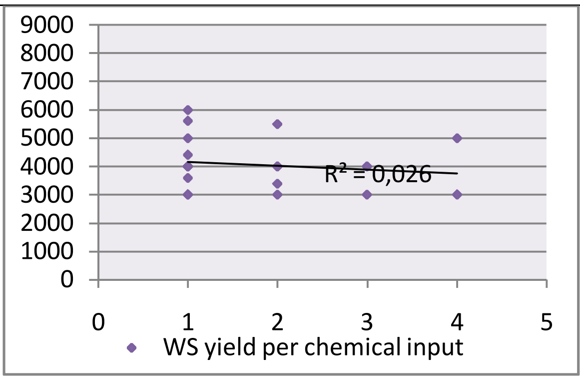

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