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Agricultural land-use dynamics in the coastal areas of the Vietnamese Mekong Delta

An analysis on land-use decisions of farmers operating in changing hydrological regimes

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Agricultural land-use dynamics in the coastal area of the Vietnamese Mekong Delta

An analysis of land-use decisions of farmers operating in changing hydrological regimes

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Executive summary

The Mekong Delta is home to one the largest sedimentary deposits in the world. These mineral rich deposits make delta areas fertile and attractive for human settlement and economic activity due to a wide range of competitive advantages. The Delta is one of the most productive agricultural environments in the world. Simultaneously, the Mekong Delta is widely recognized as being highly vulnerable to climate change and relative sea level rise. Socio-economic developments, even more than climate change, determine to a large extent the ever-increasing pressure on the Mekong Delta's available land and water resources. Agriculture and aquaculture in the coastal province of Ben Tre, the case study of this thesis research, is threatened by the increasing effects of salinization. Large-scale investments in infrastructural measures to gain control over the hydrological regime are being disputed recently. The Mekong Delta Plan has been developed to integrate climate change adaptation, adaptation towards the adverse effects of socio-economic developments and to increase sustainable use of resources. With the approval of the Mekong Delta Plan, drafted from 2011 to 2013 and implementation foreseen in 2020, a strong emphasis is laid on increasing the sustainable use of land and water. The adaption of the governmental resolution 120 in 2017 brings sustainable development of the Delta high on the political agenda. One of the guiding viewpoints is to select livelihood models according to nature-based adaptation, environmentally sound and sustainable development, on the basis of actively living with flood, brackish and salt water. Such strategic plans and visions are a result of decisions and negotiations at the operational level but often lacks implementation aspects. This research aimed to answer the following research question:

How does a changing hydrological regime interplays with farmers' land-use decisions based on a MOTA-analysis conducted in different hydrological regimes?

Understanding how farmers are motivated to conduct certain land-uses plays an important role since they are expected to conduct the on-ground activities. To tackle these implementation gaps and to identify actions that are required to facilitate soft implementation actions, the MOTA-framework has been developed by Phi et al (2015). While applying this framework of analysis, the interests, perceptions on risks and solutions, and the abilities for implementation of various local and regional actors who are expected to collaborate in delivering on-the-ground implementation can be better understood. To analyse the motivation of farmers to choose a certain livelihood, a MOTA-analysis is conducted on each of the dominant livelihoods found within the brackish, intermediate and freshwater hydrological regime. Semi-structured interviews with local farmers operating in each of the hydrological regimes present in Ben Tre have been conducted during a fieldtrip of 24 consecutive days. Circumstances for conducting interview proved to be challenging. Nevertheless, this research was able to identify new insights in how farmers operating in different hydrological regimes are motivated to make certain land-use decisions.

It can be concluded that there is a noticeable interplay between changing hydrological regimes and land-use decisions of farmers in Ben Tre. This interplay is spatially bound and the motivation to change accordingly is most noticeable among farmers with limited abilities. This interplay is most of the time not reflected in crop-choice due to a variety of other factors influencing land-use decisions defined in this research. However, it is reflected in actions and measures that farmers undertake to adapt towards this changing hydrological regime.

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Chapter 1 Setting the scene of the research and problem statement

1.1 Introduction

River delta regions are home to the largest sedimentary deposits in the world. These mineral rich deposits make delta areas fertile and attractive for human settlement and economic activity due to a wide range of competitive advantages. One of these advantages is the abundance of water which is essential, particularly for agriculture. Water availability shapes land-use patterns while agriculture-based land utilization affects hydrological regimes which often leads to diminished water quality as well as soil-erosion and degradation. A hydrological regime refers to variations in the state and characteristics of a water body that are regularly repeated in time and space and pass through (seasonal) phases. Understanding the interplay between hydrological regimes and decisions in land-use is crucial in orders accurately address the above-mentioned problems.

Vietnam's Mekong Delta, home to nearly 20 million inhabitants, is one of the most productive agricultural environments in the world. (Dang et al., 2018) Following economic reforms such as the Doi Moi in 1986 and governmental food security policies, Vietnam has gone from a chronic importer of rice to the second largest global exporter. This increase in rice production and, at a later stage crop diversification, has been realized with investments in infrastructure to better manage the delta's hydrological regimes. (Tran et al., 2018) Recently, the ability of these man-made infrastructure to control hydrological regimes in the Mekong Delta is disputed as they are becoming cost-ineffective and are failing to provide the desired security and control. (Tran et al., 2018) The Mekong Delta is widely recognized as being highly vulnerable to climate change and relative sea level rise. (IPCC, 2007) The adverse effects of climate change on the Mekong Delta include an increased frequency and intensity of extreme climate events including droughts, floods, storms, and heat weaves. More frequent and prolonged droughts, fluctuating rainfall patterns and relative sea level rise have already begun to alter the hydrological regime. Rainfall and sea level rise models suggest that this alteration will become more severe. Furthermore, shortages of freshwater are likely to be further accelerated by the increasing impacts of upstream hydropower dams reducing freshwater flows reaching the Mekong Delta. (Dang et al., 2018) Saline is predicted to occur for longer periods in the coastal zone and extend further inland. This has already begun to severely damage aquaculture- and agriculture. (Tri et al., 2013; Trung and Tri, 2014) The recorded salinity levels during the recent drought of 2016 surpassed the tolerance of local aquaculture- and agriculture causing major damages and economic losses.

The Mekong Delta Plan has been developed to integrate climate change adaptation, adaptation towards the adverse effects of socio-economic developments and to increase sustainable use of resources. Such strategic plans are a result of decisions and negotiations at the operational level but often lacks implementation aspects. To tackle these implementation gaps and to identify actions that are required to facilitate soft implementation actions, the MOTA-framework has been developed by Phi et al (2015). Applying this framework of analysis can help better understand the interests, perceptions on risks and solutions, and the abilities for implementation of various local and regional actors who are expected to collaborate in delivering on-the-ground implementation. For this study, the MOTA-framework was used to gain insights on the land-use decisions of farmers and the relations with a changing hydrological regime. One of the provinces hit most severe by the drought of 2016 is the coastal province Ben Tre. The drought is still causing distress amongst the farmers because it caused a disruption of their previous practices. Thus, the farmers have to make a difficult decision - will they continue with their previous practices or are they able and willing to adapt? Semi-structured interviews were conducted with farmers operating in the Ben Tre province to collect the data needed

for the MOTA-analysis. 7 communes operating in different hydrological regimes were visited and a total of 35 interviews with farmers and local authorities were conducted.

1.2 Problem statement

Farmers and communities in Ben Tre are at a difficult turning point when it comes to land-use decisions due to the socio-economic developments and the adverse effects of climate change. This turning point is recognized by the national government of Vietnam by means of resolution 120. One of the guiding viewpoints of this governmental resolution is to select livelihood models according to nature-based adaptation, environmentally sound and sustainable development, on the basis of actively living with flood, brackish and salt water. International communities involved in strategic planning have the same view as these guidelines are reflected in The Mekong Delta Plan. Both parties advocate for a more diversified agricultural industry able to meet international market demands. With the approval of the Mekong Delta Plan and implementation foreseen in 2020, questions regarding the implementation are emerging. One of the characteristics of strategic planning is that exact implementation aspects are not prescribed but are a result of decisions and negotiations at the operational level. The outcomes of such negotiations could result in implementation in which it was not intended, or no implementation at all. (Haasnoot et al. 2013; Pressman and Wildavsky 1984; van der Voorn et al. 2017). Implementation of Delta plans essentially involves a change of minds regarding the delta managements priorities and strategies for sustainable livelihoods. Such change of mindset, or a ''soft implementation'' is must come prior to material or ''hard implementation'' can take off. (Seijger, Hoang, and Van Halsema 2019) The importance of shared knowledge, commitment, and understanding between actors involved in the implementation phase are pointed out within this perspective. This can only be achieved when the local farmers are able and willing to change their livelihoods. It is therefore relevant to increase understanding off why farmers make certain land-use decisions.

A study conducted by Le et al (2018) regarding the interplay between land-use dynamics and changes in hydrological regimes concluded that from 2001 to 2012, the annual percentage of change in land-use in the Mekong Delta was 14.94%. Most changes occurred in cropping patterns. This amount is considered highly dynamic compared with regions elsewhere. For instance, Goldewijk (2001) found out that land-use changes with a rate of 1.45% annually for Southeast Asia. The dynamics in land-use in the upper and central delta evolved in line with trends at the delta scale and the interaction with changes in hydrological regimes as a result of man-made infrastructure. Major areas turned into permanent fresh zones and became less prone to flooding. Land-use changed from single or double rice harvest into triple rice harvest. However, the research of Le et al (2018) was not able to analyse changes in inland aquaculture and fruit orchards in coastal regions due to limited available data. Therefore, it is not clear whether land-use change in coastal areas is in line with changing hydrological regimes. Furthermore, in the upper and middle parts there is no interference of a saline/brackish hydrological regime. Also, there are examples of brackish aquaculture that is practiced within the infrastructural boundaries of salinity control systems. It is likely that infrastructural measures leading to changing hydrological regimes are not the only drivers for land-use change in coastal zones. The different land-use pattern dynamics in the coastal zone and the upper and middle delta suggest a need for a detailed exploration of the way land-use decisions are made by famers and communities in coastal zones. Therefore, better understanding of the motivation of a farmer operating in coastal zones to adopt a particular type of land-use and the analysis of factors, besides changing hydrological regimes, that are determine land-use decisions is necessary.

1.3 Research objective

One of the research objectives is to gain an understanding of the different hydrological regimes present in Ben Tre in order to explore the influence on land-use changes. To do so, a meta-analysis at the provincial level is conducted. Provincial level is chosen as provincial polices impact hydrological regimes. Within this analysis, historical, pre and post 2016 land-use changes and the relation with changing hydrological regimes are mapped. The change in land-use overtime provided an insight into decision making and motivation to adopt a certain land-use. Furthermore, it takes time in order to appropriately asses the actions or measures taken. Given the severity of the impact of the drought of 2016, it was decided to analyse the changes in land-use before and after the drought in order to better compare the dynamics surrounding the change in land-use. To analyse the motivation of farmers to choose a certain livelihood, a MOTA-analysis is conducted on each of the dominant livelihoods found within the brackish, intermediate and freshwater hydrological regime.

1.4 Background information Ben Tre province

This chapter starts with background information relevant for Delta as whole. Furthermore, this chapter provides essential background information on Ben Tre province to increase understanding of spatial setting and meteorology of the project area.

1.4.1 General background information of the Mekong Delta

Production growth rates are slowing down as prices of commodities have declined recently. They are predicted to continue falling for the next decade. The agro-food export is commonly deriving from low value commodity sales such as rice due to the former focus on quantity growth, mainly concentrated towards the production on rice, and little on commodities of high quality and value. Most of the current farming practices are not eligible for international certification standards of sustainability and quality. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) As the job creation in the non-agricultural sector grows, migration out of the agricultural sector increases resulting in higher agricultural labour cost. Although higher costs for labour opens opportunities for adopting new technologies and encourage large scale farming, it may reduce overall competitiveness as labour-saving techniques are not readily accessible or adaptable due to a dominance of small-scale farmers. (OECD, 2015)

1.4.2 Spatial settings of Ben Tre

Ben Tre Province is located between Tra Vinh province to the southwest and Tien Giang province to the north. The province consists of a large-scale alluvial fan delimited by the Tien River up north and the Co Chien River down south. The alluvial fan is composed of two islets, North and South Ben Tre delimited by the Ham Luong river as presented in Figure 1. Ben Tre is divided into 9 districts. Similar to other regions of the Mekong Delta, Ben Tre is flat with an altitude ranging from 0.5-1.5m above sea level. From the Northwest to the southeast direction, it gradually slopes downwards. The highest terrains are found in Chau Thang, Cho Lach and Giong Trom with average altitudes ranging from 1.25-1.50m. The coastal areas range from 0.75-1.25m with districts such as Binh Dai, Ba Tri, and Thanh Phu having altitudes between 0.30 and 0.50m. These districts are often subjected to waterlogging in the wet season. (JICA, 2016)

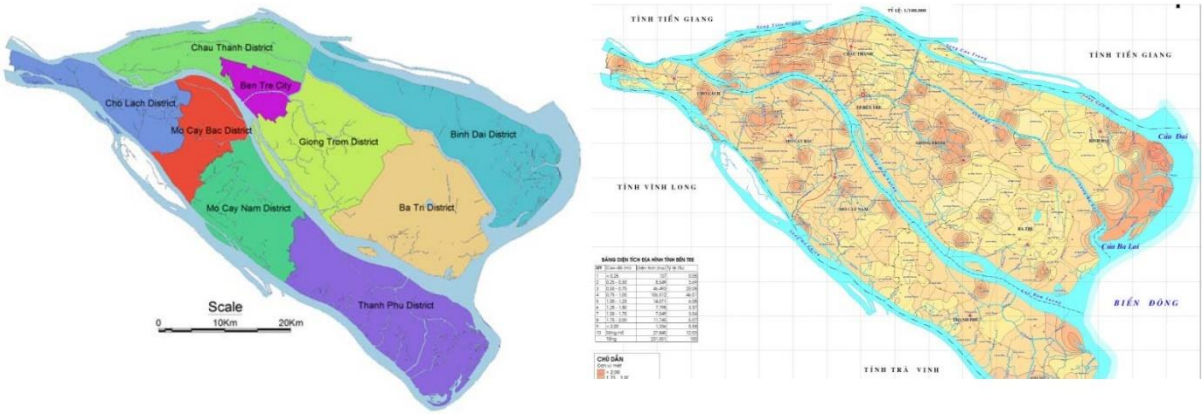


Figure 1 Spatial settings of Ben Tre Province (JICA, 2016)

Ben Tre ranks 5th in the delta with regards to the population density with 535 persons per km2 and a total of 1.26 million inhabitants. Due to its large proportion of land, over 80% of which is dedicated to agricultural activities, Ben Tre is a typical Mekong Delta province. A dense network of about 6.000km provides favourable waterways, rich aquatic resources and water for crops. The canals are connected to the main rivers Co Chien, Tien, Ba Lai, and Ham Luong. The average canal-length is about 1-2km with more than 60 canals having a width that exceeds 50m. The composition of livelihoods in Ben Tre province is diverse. In terms of land-use, there are four major crops. These consist of tropical fruits, coconut, paddy and brackish shrimp aquaculture. These four crops form 5 major crop patterns as displayed geographically in Figure 2. These consist of (1) the intensive cultivation of triple harvest rice, (2) the cultivation of double rice harvest combined with freshwater aquaculture during the dry-season, (3) a combination of single harvest rice with brackish aquaculture, (4) brackish aquaculture in coastal areas, (5) and the cultivation of perennial crops such as coconut trees and fruit trees throughout the year.

Upstream, alluvial soil is prevailing and is the best soil type in Ben Tre for crop production. The relatively high-value crops are cultivated in that area. Coconuts trees are popular in the mid-stream area where the soil type is saline alluvial soil coupled with clay maintaining a low fertility and poor drainage. Paddy is predominant in the downstream areas of Ba Tri and Thanh Phu where saline alluvial soils and saline soil are the major soil types. Paddy is commonly cultivated in the saline soil area with freshwater availability. Brackish aquaculture is predominant in the coastal region located outside of sea dikes where salinity levels are the highest and brackish water is the main water source.

Figure 2 provides a general picture of the livelihoods found in Ben Tre. There are many small variations of livelihoods found. For example, coconut trees along with fruit trees are planted in mid-stream areas. In addition, paddy and shrimp rotation systems are found in Binh Dai and Thanh Phu districts. A table highlighting the major cropping patterns is found in Appendix I. (JICA, 2016)

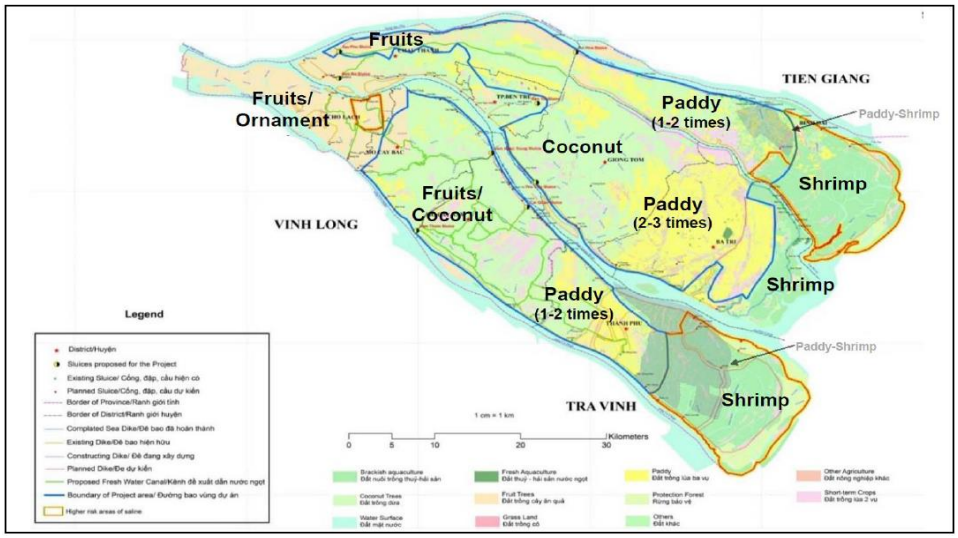


Figure 2 Map of Ben Tre's main livelihoods (JICA, 2016)

1.4.2 Meteorology

The Mekong Delta has a tropical monsoon climate. Seasonal rainfall patterns form distinct dry and rainy seasons. The dry season starts from December and ends in April whereas the rainy season starts from May and ends in November. Monthly rainfall patterns in the rainy season show fluctuations with peak months changing annually. Rainfall is characterized as short cloudbursts mainly concentrated in the afternoon. Average temperatures range from approximately 25°C to 30°C with lowest temperatures in January and highest in May. Monthly average temperatures and rainfall recorded in Ben Tre (2010-2014) derived from the statistical yearbook of Ben Tre (2014) show a relative stable temperature of around 27°C as presented in Figure 3. The monthly precipitation recordings derived within the same timeframe from Ben Tre's hydro-meteorological station demonstrates the severe precipitation fluctuations.

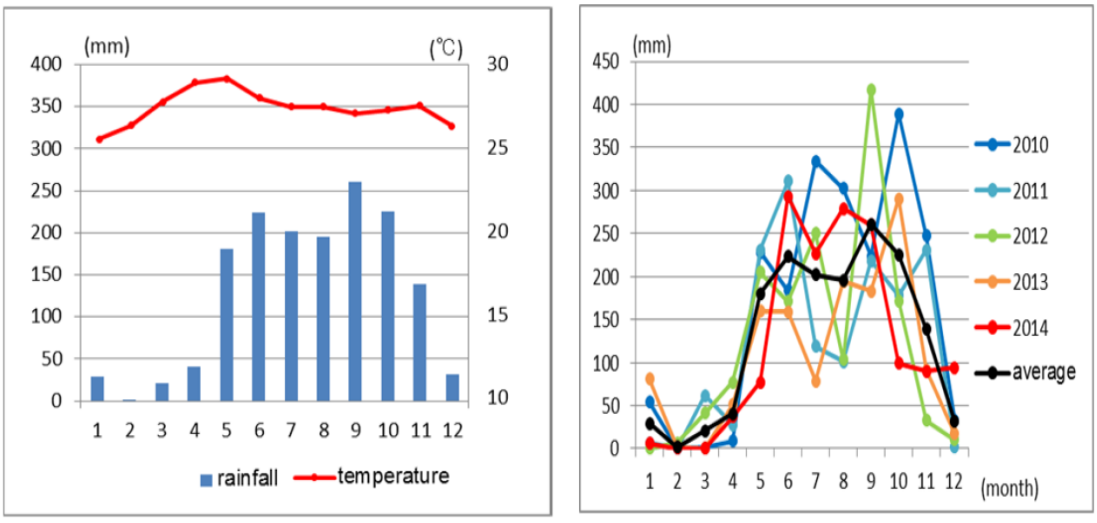


Figure 3 (left) derived from statistical yearbook Ben Tre 2014, (right) derived from Ben Tre hydro-meteorological station

In chapter 2 the relevant literature is discussed. The results of the fieldtrip are presented in chapter 3. The discussion and conclusion are presented in chapter 4. The references and the appendix of this research are found in chapter 5 and 6.

Chapter 2 Theoretical framework

2.1. Climate change

Climate change profoundly affects the conditions under which agricultural activities are conducted. The changing prevailing climatic conditions are difficult to predict precisely making it difficult for humans to adapt accordingly. All sectors of agriculture- crops, livestock, forestry and fishery will be, for the most part negatively affected by climate change in different ways as previously mentioned. These effects are already noticeable and are predicted to become more severe. Coastal southern provinces are expected to be impacted the most. (Tran, et al., 2016). Amongst the thirteen provinces of the Mekong Delta, Ben Tre is most vulnerable to climate change and sea level rise. (JICA, 2013) From 1970 to 2007, the average temperature in Vietnam rose by 0.6 °C and is projected to rise between 1.7°C and 3.5°C, over the 21st century under all the assessed emission scenarios from the IPCC. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013). Dry seasons are becoming hotter and dryer, thereby reducing fresh water surface flows reaching Ben Tre. Many studies have used climate models to simulate upstream flows in the Mekong Delta. For low emissions scenarios, the water flows simulated vary from -6.9% to -8.1% whereas high level scenarios simulations vary up to -10.6% to 13.4%. (Hoang et al., 2016; Lauri et al., 2012; Thompson et al., 2013) Data derived from the Mekong Delta Plan highlights decreases in dry-season flows ranging from -15% to -60%, whereas the rainy season showed increases of 10% to 50% for both moderate and high emission scenarios. During the dry season when freshwater supply reduces, East Sea tidal differences, often accelerated by strong east winds, interfere with the water supply. This aggravates freshwater shortage and is damaging crops that are unable to withstand high levels of salinity. Sea level is expected to rise between 57cm and 77cm at the end of the 21st century. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) Given the low elevation of the Mekong Delta, this sea level rise is an unsettling finding. Being a coastal province with most livelihoods depending on freshwater, the agricultural productivity of Ben Tre is highly vulnerable to salinization.

2.2. Socio-economic developments & changing hydrological regimes

Nature, when allowed to run its course, can adapt much quicker to changes in climate than humans. The environment and climate determines which crops can grow. Problems starts to emerge when humans try to tackle the changes with interventions often with limited success. Therefore, socio-economic developments, even more than climate change, determine to a large extent the ever-increasing pressure on the Mekong Delta's available land and water resources. Rapid population growth and a sharp increase in intensive agriculture and aquaculture development over the past decades caused significant environmental degradation. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) Agricultural intensification in Ben Tre has been accompanied by large amount of mangrove deforestation causing the province to slowly lose its natural protection against severe cyclones. (Kuenzer & Renaud, 2012) In particular, the ''rice first'' policy, framed as a national food security initiative, led to a large-scale intensification and expansion of triple harvest rice production. To facilitate this, dikes, sluice gates and water supply canals were built. Several recent studies identified the long-term negative side effects, both environmental and economic. For instance, the use of fertiliser, pesticides and other chemicals increased dramatically. Another economic side effect is that constructing and maintaining this type of high dike infrastructure is quite expensive, while the economic returns, especially for rice, are low. (Tran et al., 2018). The construction of dikes, sluice gates and embankments has historically been the dominant strategy of the Vietnamese government to provide freshwater for irrigation and to mitigate the effects of salinity intrusion on agricultural production. Despite these efforts, salinity levels increased and moved upstream substantially reducing agricultural production. (Smajgl et al., 2015) Controlling salinity by means of

dikes and embankments may shift the problem upstream, as Figure 4 illustrates, mainly because the freshwater flow in the dry-season is too limited. Furthermore, the high dike infrastructure in the former flood plain of the upper delta affects the water regimes in downstream areas. The high dikes reduced the retention capacity of the upper delta and causes higher peak flows in the wet-season and is diminishing dry-season flows in downstream areas including Ben Tre province. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013)

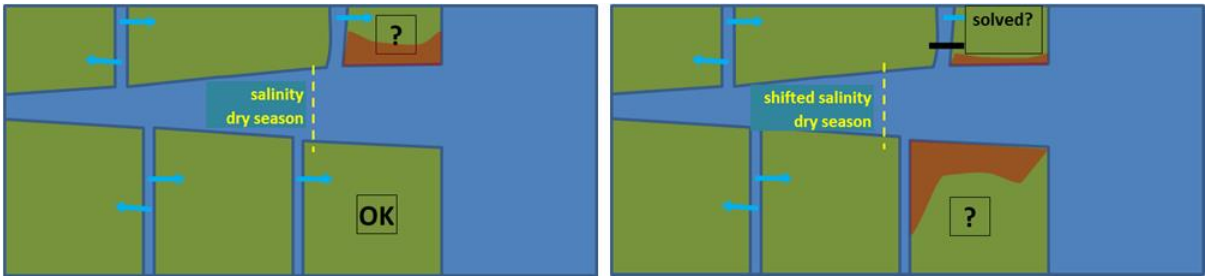


Figure 4 Illustration of a possible shift of salinization due to (hard) infrastructural measures such as a sluice-gate (Gerardo van Halsema, Michel Tonneijck, 2015)

An economic evaluation of dike construction for flood prevention in the Mekong Delta by Kien (2014) identified that low-dike systems provided greater net-benefits for livelihoods than the actual high dike infrastructure. Furthermore, a study conducted by Tong (2017) identified the hidden and often not calculated costs of heightening dikes for rice production such as loss of natural floodplains, increasing need for pesticides, and reduced profits with successive crops. In Ben Tre, the Ba Lai sluice gate was put into service in 2004 to ''sweeten'' the river upstream. The effectiveness of this sluice gate has been disputed as it is proven impossible to flush out pollution for most of the year. Flushing out pollution has become impossible as the Ba Lai sluice gates closes off the interaction with the estuary. This causes the freshwater used for agriculture and often pollutants to stagnate behind the sluice gate resulting in highly polluted water. Recently, the water upstream the sluice gate has become too saline to irrigate vegetables and fruit.

During the dry seasons, saline water infiltrates from upstream branches of the Mekong river that are ungated surpassing the Ba Lai sluice gate. To solve this, more sluice gates are being planned by the Japanese International corporation agency. (JICA, 2016) Agricultural canals in Ben Tre are often unequipped with sluices that prevent salt water intrusion. A lack of funding for maintenance of the canals leads to overall reduction in capacity of the irrigation systems. Farmers operating canals equipped with sluice-gates often have conflicts regarding salinity levels in irrigation water as some riparian farmers sharing the same canal for water supply are demanding freshwater for agriculture while others demand brackish water to regulate favourable salinity levels for shrimp farming. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) Other means to control salinity levels is to extract fresh groundwater from deep phreatic aquifers. Concerns are raised regarding groundwater use as the aquifer is already depleting causing significant sustainability issues and land-subsidence. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) Over the past 25 years, average land-subsidence levels were 18cm and some coastal areas reached levels of 30cm adding significantly to the relative sea level rise and salinization problems. (Minderhoud et al., 2018)

Remedial and management initiatives by the Vietnamese government are influenced by the conditions, investments and potentially opposing decisions in countries adjacent to the Mekong river as displayed in Figure 5. These uncertainties lay in the large-scale upstream developments of dams, water diversion for irrigation, the effects of climate change, and the capacity of household adaptation.

In general, the concessions for constructing and operating dams are negotiated independently and not subject to a coordinated basin-wide strategy in terms of operation. (Smajgl et al., 2015) Shortages of freshwater are likely to be accelerated by the increasing impacts of upstream hydropower dams. The effects of climate change and the socio-economic developments causes a trend of higher salinity levels reaching more land inwards during the dry season as illustrated in Figure 6.

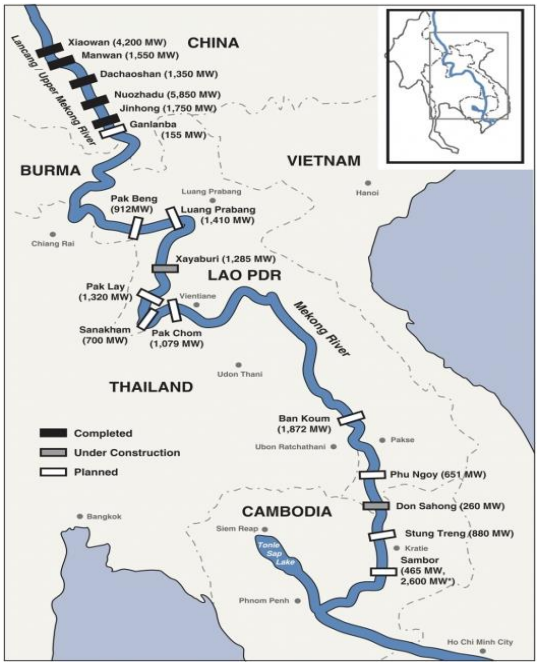


Figure 5 (Future) dams of the Mekong River (ICEM 2010)

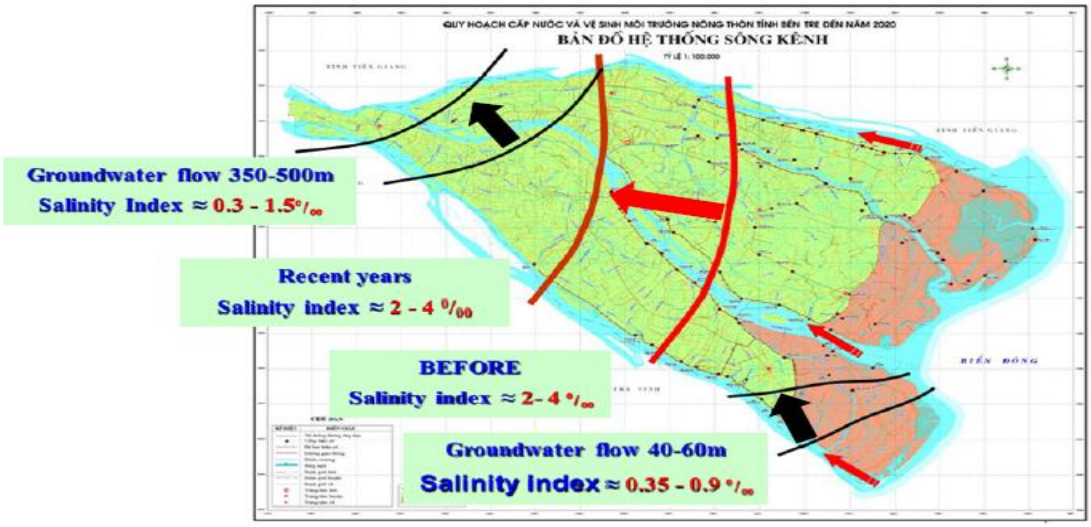


Figure 6 The upward trend of saline intrusion in Ben Tre Province (JICA, 2016)

2.3 The interplay between land-use dynamics and changes in hydrological regimes in the Mekong Delta

Surface water quality and quantity is essential for a wide range of human activities. In particularly, it shapes to a large extent agriculture, aquaculture, and forestry as land-use is shaped by the availability of water resources and vice versa. Hydrological regimes have changed due to afforestation, intensive agriculture and urbanization often leading to diminished water quality in developing countries across the globe. (Calder, 2005) A hydrological regime is a result of the interplay between natural processes and human interventions. For Ben Tre, natural manifestations such as flooding during the rainy season and salinity intrusion during the dry season are influencing the hydrological regime. (Sakamoto et al., 2007; Smajgl et al., 2015) It is important to understand that without human interventions, coastal areas in the Mekong Delta would have an intermediate regime. The droughts and rising sea levels creates a trend of increasing saline intrusion further inland resulting in less areas with permanent freshwater. However, in large areas where agriculture is the dominant livelihood, the interplay between changes in land-use and available water resources are particularly manifested. To a greater extent, the local governmental interventions in Ben Tre, such as sluice gates, dikes, and embankments influence the hydrological regime. And even at farm-level, interventions are developed to manipulate the hydrological regimes in their favour. Those interventions consist of, for instance building canals, growing trees on raised ridges, and increase water storage capacity. Therefore, hydrological regimes can be considered as the function of both the physical variables and human interventions.

Prior to 1995, when the current sluice gates and dikes started to be constructed, the whole coastal zone was affected by saline intrusion lasting more than 6 months per year. (Tri et al, 2012) Since the beginning of the 21st century, infrastructural projects have created a freshwater regime for most of Ben Tre with exceptions found in coastal areas were aquaculture is practiced. Production rates increased rapidly when new high-yielding rice varieties were introduced leading up to three harvests a year. However, several events showed that the water management infrastructures are not able to fully protect freshwater hydrological regimes. This has recently been displayed during the drought of 2016. Salinity intruded further inland through the estuary canal network behind the gates and entered through the ''back door''. This ''back door'' can be closed as proposed by the JICA-project but then the freshwater supply is closed off as well. When those gates are close for too long, there will be a shortage of freshwater as salinity will infiltrate through seepage as a result of capillary rise. (Rahman et al., 2019)

2.4. Political agenda regarding land-use decisions

Recently, the Mekong Delta is receiving attention from national leaders and gaining support from the national and international community. With the approval of the Mekong Delta Plan, drafted from 2011 to 2013 and implementation foreseen in 2020, a strong emphasis is laid on increasing the sustainable use of land and water. Site-specific policy recommendations are given which would lead to more climate resilient and market-oriented forms of aquaculture and agriculture. For coastal areas, a dual zone coastal management strategy, as presented in Figure 7 is proposed. This strategy mainly focuses on aquaculture livelihoods operating in the saline/brackish hydrological regime. To increase sustainable water use, the present monoculture based brackish aquaculture practices, mostly consisting of farming shrimp, should transfer into modern poly-culture based aquaculture systems of multiple fish and shrimp species that thrive on each other's water discharge. This proven method has the capacity to sustainably improve the brackish water quality, reduce disease occurrences and yield losses, and diversify income. For such system to be effective, this outer shoreline which will be regenerated by means of natural mangrove protection needs more space to settle and remain open for tidal inundation. Therefore, to create such morphological conditions the current hard sea-defence

dikes should be place further inland. This will change part of the current intermediate water regime into permanent brackish regime. Therefore, livelihoods need to change accordingly. An intermediate regime is not defined within the Mekong Delta Plan and specific recommendations are therefore lacking.

In 2017 a loan was approved for the Integrated Climate Resilience and Sustainable livelihood project from the World Bank. Proposed livelihoods for certain areas in Ben Tre consist of alternating rice-shrimp systems which are better adapted to increasing salinity levels and a shorter freshwater season than double/triple rice cropping. Instead of maintaining a freshwater regime throughout the year, sluice gates are opened in the dry season to allow saline water to enter and closed to maintain appropriate salinity levels. For higher elevation, sandy coastal areas, operating in the freshwater regime, investments should be made in freshwater storage to enable the cultivation of high-value horticulture and fruits. (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013) Resolution 120 is a governmental resolution on Sustainable and Climate-Resilient Development of the Mekong Delta of Vietnam. The adaption of the governmental resolution 120 in 2017 brings sustainable development of the Delta high on the political agenda. One of the guiding viewpoints is to select livelihood models according to nature-based adaptation, environmentally sound and sustainable development, on the basis of actively living with flood, brackish and salt water.

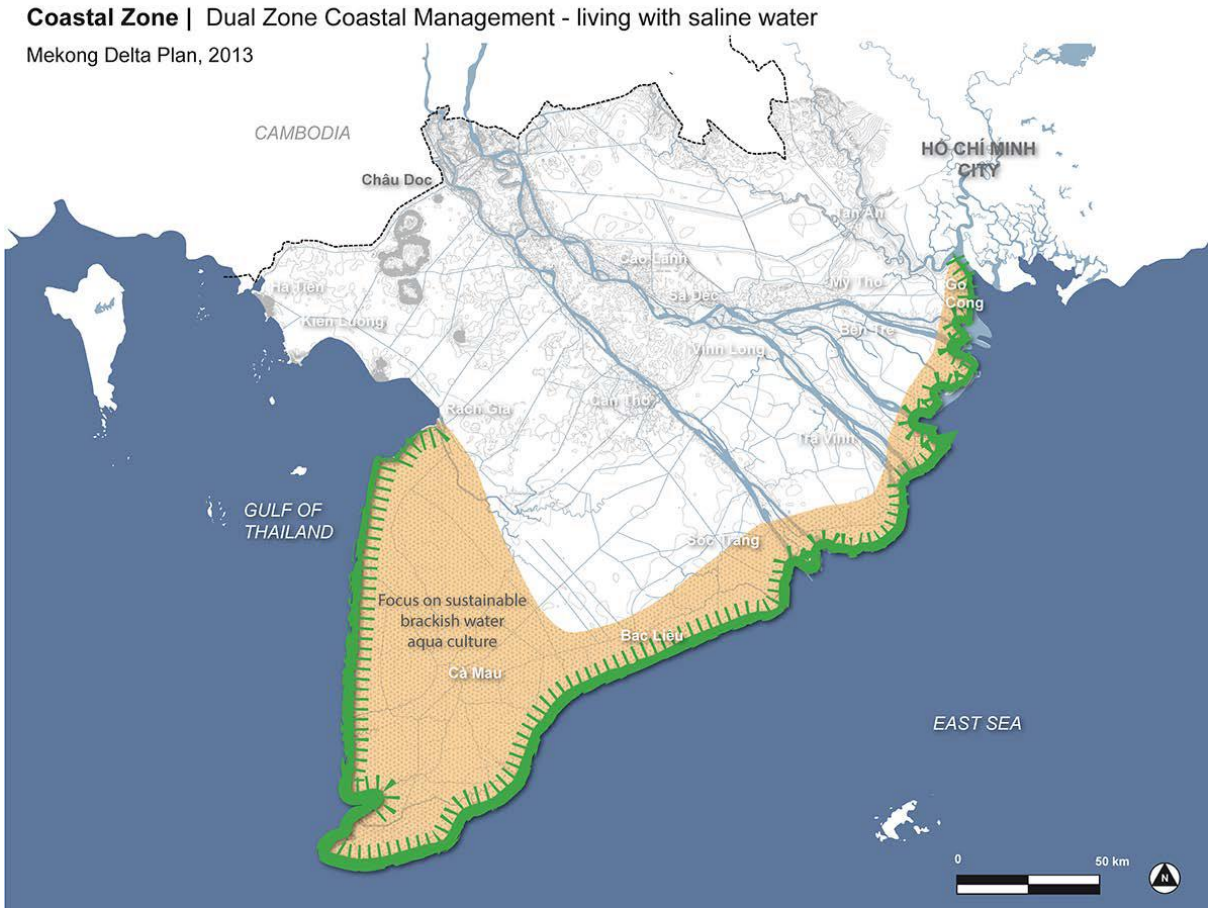


Figure 7 Schematic presentation of water resource management in the coastal zone of the Mekong Delta (Kingdom of the Netherlands and The Socialist Republic of Vietnam, 2013)

2.5. MOTA

There is a need to integrate climate change adaptation and future planning to adapt towards the adverse effects of socio-economic developments and climate change on delta areas. Strategic delta planning has emerged as an approach to support long-term (50-100 years) integrated planning in delta systems. The Mekong Delta Plan contains a strategic vision of the future and allows for a strategic framework to guide future actions. Such strategic planning is a result of decisions and negotiations at the operational level but often lacks implementation details.

To tackle these implementation gaps and to identify actions that are required to facilitate soft implementation actions, the MOTA-framework presented in Figure 8 has been developed by Phi et al (2015). While applying this framework of analysis, the interests, perceptions on risks and solutions, and the abilities for implementation of various local and regional actors who are expected to collaborate in delivering on-the-ground implementation can be better understood.

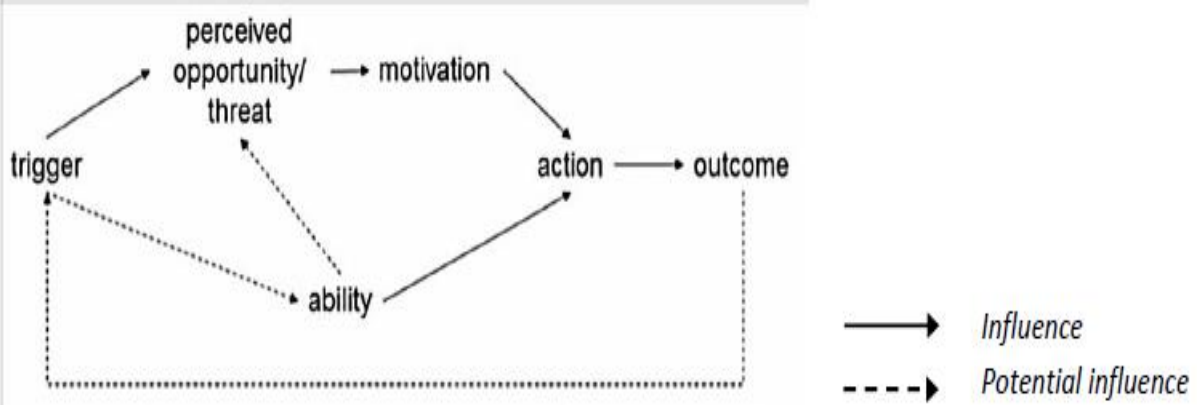


Figure 8 MOTA- Framework: from trigger to rational action (Phi et. al., 2015)

The framework focuses on the correlation between motivation, ability, and trigger to assess the (potential) outcomes of a plan/trigger. By indicating the interactions between the three components, potential influences that requires adjustment to narrow the gaps between the expected outcome and the estimated potential outcome can be addressed. Consequently, a MOTA-analysis proposes recommendations for planning objectives, a participatory planning process and/or (in)adequate resources/capital of stakeholders that might hinder plan implementation.

The relation between trigger and outcome during an assessment of a plan is often a regular subject and usually processed from top-down. MOTA is a community-based approach to study the integrated correlation of Trigger-Motivation-Ability. The outcome is conveyed in motivation and ability of stakeholders at different levels that co-exist in the planning processes. The influences of trigger to motivation is displayed through perception in terms of an opportunity or a threat because motivation is perceived as a negative or positive attitude and ranges from strong to weak intensity.

A trigger can be an official acceptance of a new strategic plan, but it could also be an external event, such as a natural disaster, a shift in markets, or an event or trend in the larger societal context. However, how actors are likely to take action is explained by how they perceive the triggers and are motivated by these perceptions. Therefore, understanding one actor's perception plays an important role to get insight into a collective action or feasibility of a plan. A trigger results in the perception of (actual and potential) opportunities and/or threats by actors at different levels. This perception is highly dependent on personal intuition, experience and emotions, and although perceptions are grounded in more 'factual' triggers, perception thus is not solely, and sometimes not even predominantly, based on facts. As a result, the same trigger may still result in a large diversion of

actors' perceptions. Motivation is the other precondition for action, next to ability. It is simply considered as threats and opportunities. A situation will present a certain opportunity on actors' perception, whereby the opportunity (positive or negative) represents the range of possible outcomes afforded by the situation. Ability and power of actors is linked to their access to, and control over resources. Abilities are recognized under three categories: financial, technical, and institutional.

- **Financial abilities**: simply refer to money, for instance budgets for investments, management and operation, even if the financial abilities are not necessarily linked to specific actors. Financial abilities also refer to similar resources that can be traded on the market.
- **Technical abilities:** refer to knowledge, expertise, skills and information, but also to the tools and materials needed to perform a certain task.
- **Institutional abilities:** derived from existing formal institutional arrangements. Institutions are here seen as rules, formal and informal, that structure interactions among groups of actors. In this way, they provide important coordination mechanisms, and they may help actors acquire certain technical and financial resources from other parties.

2.6. Research questions

2.6.1. Main question: *How does a changing hydrological regime interplays with farmers' land-use decisions based on a MOTA-analysis conducted in different hydrological regimes?*

2.6.2. Sub-questions:

What are the current hydrological regimes in Ben Tre and how have they been formed and influence land-use over time?

How are changes in hydrological regimes perceived amongst farmers operating in different hydrological regimes and how does it influence land-use decisions?

Which other factors determine land-use decisions of farmers in Ben Tre?

How does the access to, and control over resources influence motivation of farmers in terms of land-use decisions?

Chapter 3 Methodology

To gain insights in the land-use decisions of local farmers and the relation with changing hydrological regimes, data has been acquired by conducting semi-structured in-depth interviews. Beforehand, communes were selected based on the precondition that all the hydrological regimes and major cropping patterns were included. It is therefore that communes are selected with close proximity to the coast, the middle of Ben Tre and up north. The aim was to conduct as many interviews as needed until information became saturated. An interview guide, based in part on the principles of MOTA, discussions with professionals at WACC and Wageningen University with experience in fieldwork in Ben Tre was developed beforehand and is provided in Appendix II. The map of the visited communes is provided in Appendix III. The interview guide was used flexibly and sometimes served more as a checklist to see if all subjects were covered. In fact, the actual questions that were asked were based on the new insights obtained over time, and follow-up questions to gain deeper understanding or clarification. Furthermore, the order of questions remained flexible as experience has taught me that keeping farmers talking within their ''flow'' is important for the effectiveness and clearness of their response. Therefore, switching topics to discuss took place strategically and with collaborative advice from the translator to avoid farmers being confused feeling misunderstood. Furthermore, farmers were asked to show their actual farming practices by providing a small tour. This was done to gain insights in actual on-the-ground activities, to see if their answers matched reality and to ask for clarifications by means of actual examples. Furthermore, efforts were made to gain mutual trust and to create a friendly and informal atmosphere. This was done at the beginning of the interview with an introduction of both parties, explaining the aim of the research extensively and to clarify that the respondent' answers were used for research purposes only.

All interviews were recorded and transcribed afterwards. An anonymous file of these transcriptions can be requested by email. The names and telephone numbers of the interviewee's are known to the author and can be requested as well. Pictures were taken when permission was provided. An analysis of the transcriptions on commune-level has been conducted based on the components of the MOTA-framework and the result are presented in the order of communes operating in freshwater regimes, intermediate regimes, and brackish regimes. To nuance the interplay of land-use and the interplay with changing hydrological regimes overtime, a META-analysis on provincial level has been conducted. A META-analysis is an approach that combines the results of multiple studies, in this case the communes visited in Ben Tre, in an effort to increase validity over individual studies. This is done to produce a weighted average of the study results. Within this analysis, the historical land-use changes, the changes prior to the drought of 2016, and the land-use changes after the drought of 2016 are emphasized. Whereas the MOTA-analysis is focusing on the motives of farmers behind those land-use decisions.

Chapter 4 results

This chapter begins with an introduction on the various hydrological regimes of Ben Tre province. The results from the are also elaborated in this chapter and complimented by pictures and quotes obtained during the fieldtrip. Most data was gathered during the fieldtrip.

4.1 META-analysis on the hydrological regimes in Ben Tre

Historically, agricultural livelihoods in Ben Tre were based on a hydrological regime of approximately 6 months fresh water and 6 months of brackish/saline water. Many farmers operating in different locations in Ben Tre indicated that in the past they grew rice and were able to harvest only once per year. They complimented their livelihood by catching fish and shrimps in the canals and later on started to grow coconuts. Following the trends of agricultural intensification accompanied with the elaboration of infrastructural measures, the control over hydrological regimes in the late 90s increased resulting in large areas being converted to round-the-year freshwater regimes to cultivate triple harvest rice. Coastal areas form an exception as the global boom in aquaculture resulted in large mangrove areas being converted into shrimp farms and circumstances for a saline brackish hydrological regime were created. More recently, agriculture in Ben Tre has become more diversified with the introduction of the more profitable cultivation of tropical fruit trees and coconut. As presented in Figure 9, *coconut* and *aquaculture* have an increasing trend from 2010-2014 while the share of paddy is decreasing. (JICA, 2016) Not mentioned in the figure but worth noting is the increasingly important role of animal husbandry. Income generated from animal husbandry is increasing and associated with the change in diets of Vietnamese. (JICA, 2016)

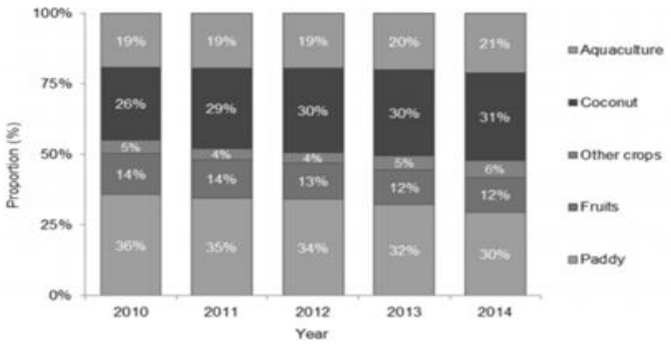


Figure 9 Land-use trends Ben Tre 2010-2014 (JICA, 2016)

The current water infrastructures provides a physical barrier between a 12-month saline/brackish zone, and a 12 months freshwater zone. However, due to the socio-economic developments and the effects of climate change, it has become increasingly difficult to keep areas in freshwater zones fresh. This has been displayed in various destructive droughts during dry-seasons. Ben Tre province has faced water shortages and saline intrusion more frequently and severely. Ben Tre recorded droughts in 1998, 2004-2005, 2010, 2013 and especially in 2016 when the worst drought in over 90 years occurred. (JICA, 2016) An estimated amount of 6.878 hectares of newly seeded rice died after salinity levels surpassed the tolerance level. Furthermore, the more upstream areas with relatively few experiences with saline water where affected as well. Given the predictions and developments, salinity will increasingly reach inland waters and therefore changing the hydrological regime further inland affecting livelihoods upstream. This has had major consequences for land-use depending on a freshwater regime. Measures to counteract saline intrusion are ineffective and result in a highly regulated water regime and waterflows being stagnated. In turn, this stagnated water causes significant pollution problems and is limiting the deposition of sedimentation. Thus, Ben Tre hosts an intermediate hydrological regime as well with roughly speaking 6-months of freshwater and 6-months of brackish water.

This latest intermediate hydrological regime differs from the historical intermediate regime as many efforts are made to regulate the regime in favour of freshwater land-use with fluctuating successes. It should be considered that this regime is highly dynamic as displayed in Figure 10 and it is influenced by a variety of factors. This saline-boundary fluctuates due to seasonal differences in freshwater runoff, precipitation, tidal forces, strong east winds, sea level rise and the completion and failure of

infrastructural measures. The actual impacts of such regime is spatially bound and depend on a variety of factors including land-use, freshwater availability and the ability of households to counteract these adverse effects. However, most areas are still zoned according to either a freshwater or a brackish/saline regime. Furthermore, this complex hydrological regime has exceptions within commune level. These are related to the actual position of farms with regards to the infrastructure and actions undertaken at farm-level. Farms positioned inside the dike-infrastructure can be designated to a different hydrological regime than farms found outside the dike-system. Even within the dike-system, there are examples of actions that farmers undertake on farm-level to have control over the complex hydraulics. These actions consist of measures or management practices including capturing and holding saline/brackish water and freshwater, building small dikes and/or sluice gates to protect crops from saline intrusion, the extraction of groundwater to control salinity levels and to irrigate crops, and collaboration between farmers to build collective small-scale dike-systems.

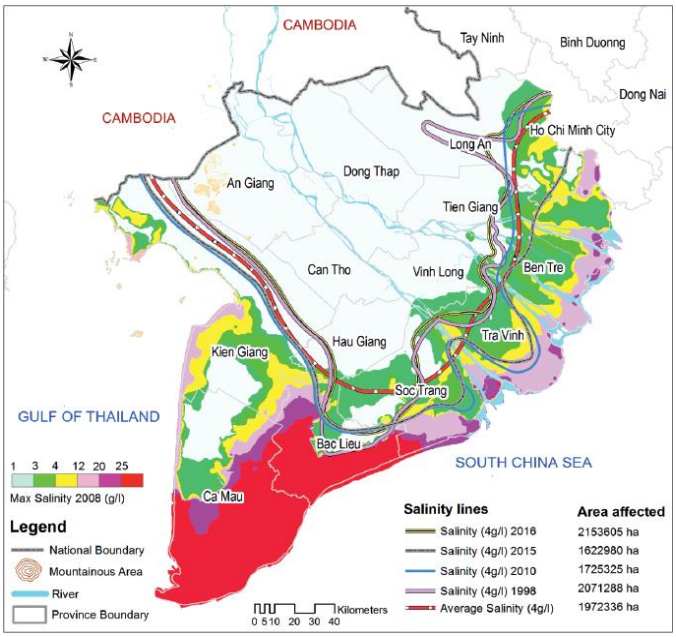


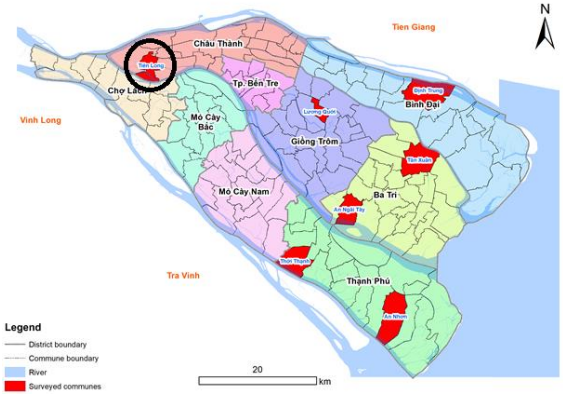
Figure 10 Coastal areas of the Vietnamese Mekong Delta affected by saltwater intrusion in the dry season of selected years (Duc Tran, 2018)

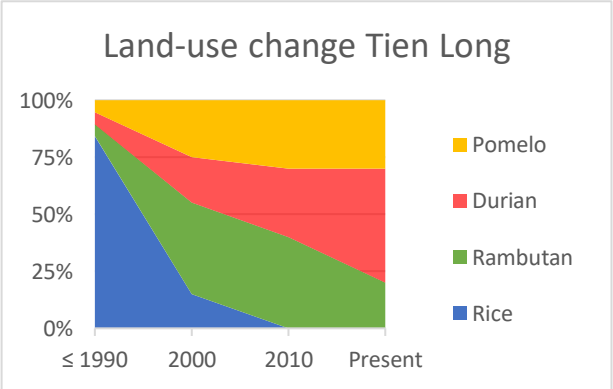
4.2 META-analysis on land-use change & MOTA-analysis on land-use decisions

This chapter elaborates on the data gathered during the field trip lasting from 4-22 March. All data, including the land-use change tables provided for each commune, is based on answers of the interviewed farmers. A total of 35 farmers were interviewed. Based on their response, a META-analysis was conducted. This analysis is followed by a MOTA-analysis according to its components. The MOTA-analysis follows a structure of threats and opportunities of farmers' current livelihoods, and abilities of farmers which are divided into financial, institutional and technical. The analysis ends with the motives of farmers to perform the livelihoods before and after the drought of 2016.

4.2.1 Tien Long commune

Tien Long is a commune operating in a freshwater regime close to Ben Tre city in which the cultivation of tropical fruits is the main livelihood. The area is well developed and good accessible due to its close proximity to the capital Ben Tre City. A total of five farmers were interviewed between ages 49 and 70 years old.





META

Before the human interventions increased the control over the hydrological regime, single harvest rice was cultivated in this area. As a product of an explicit governmental policy to ensure food security, most of the current flood- and salinization-control measures in the Mekong Delta were completed or upgraded during the 1990s. During the beginning of the 21th century, pomelo trees were introduced and became the dominant livelihood. Lately, farmers started to diversify their incomes by growing rambutan and more recently durian. The drought of 2016 significantly affected the livelihoods of local farmers and resulted in the uprooting of a vast number of trees.

MOTA

Threats & opportunities current livelihood

All farmers indicated that salinity forms a major threat for their livelihood. Farmers in Tien Long have had little experience with salinization and the salinization in 2016 came as a surprise. Many trees had to be uprooted when salinity levels surpassed the tolerance level. The trees that survived produced up to 60% less and are still not reaching production levels prior 2016. The adverse effects of climate change including increasing temperatures and changing rainfall patterns are mentioned as a threat and is often directly linked with salinization. Other major threats are unstable out-put prices. The export markets, often referred to by farmers as China and Russia are unstable. Furthermore, unknown diseases are affecting the fruits of the trees. More recently, it has become difficult to access freshwater. Groundwater often has low value of PH due to the release of acid-sulphate. The out-migration of people caused labour costs to rise. Opportunities consist of relatively high technical

abilities of farmers to cope with many of threats such as treating the affected groundwater. Furthermore, farmers mentioned the access to all kind of input products as an opportunity. The fact that tropical fruits are relatively high value crops also motivates farmers to continue their land-use practices.

Abilities

Farmers in Tien long are in general in a better *financial* situation than the other visited communes. Tropical fruit has been a profitable livelihood and farmers frame pomelo, durian, and rambutan as products with a high economic value. The fact that there are farmers able to invest in purification and modern irrigation systems distinguish this commune from the other ones visited. Furthermore, previous investments in optimal designs of their orchards are paying off and farmers are financially able to frequently switch to other fruit trees. *Institutional* support from middlemen is limited. Local authorities are strongly encouraging cooperative farming. However, farmers are mentioning that they have difficulties meeting the standards. For example, the Vietnamese Good Agricultural Practices, VietGAP does not allow farmers to grow animals on their land. Something that is considered by many farmers as important for own supply. Land-use planning limits crop choice to freshwater based land-use. Good access to input-markets enables farmers to buy all the input they need to improve their farm. The *technical* abilities of the farmers spoken with are high. Farmers are able to influence the production cycles of their trees by carefully design their gardens and applying fertilizers. Furthermore, farmers were able to recover to some extend the roots of the trees affected by salinity and made improvements to their sluice and dike systems. Their high technical ability convinced farmers that they were able to prevent problems with salinization in the future.

Pre 2016

Before the human intervention increased control over the hydrological regime, farmers were limited to grow single harvest rice. After the completion, farmers changed to the cultivation of triple harvest rice. The introduction of the more profitable pomelo tree caused a change in land-use. The higher obtained prices motivated farmers to switch from rice to pomelo.

Post 2016

The drought of 2016 had devastating effects on agricultural productivity in this commune. Many trees were so severally damaged that they either had to be uprooted or are still recovering to previous production levels. The motivation to choose for certain crops differed among the farmers. Some farmers switched crops but chose for crops that are familiar to this commune such as rambutan, pomelo, and durian. The motivation to base crops on market prices is displayed in an increase in the production of durian. Whereas required labour motivated old farmers to decrease rambutan production and choose for the less labour-intensive coconut. Many invested in dredging their canals to improve fresh water storage abilities and improved their dike and sluice systems. Furthermore, farmers invested in PH and salinity measuring equipment, purification and irrigation systems. It is noticeable that salinity is considered as a major threat, but this is not reflected in their crop choice. Their actions however, show efforts to increase freshwater availability to continue with their freshwater based livelihoods and no thoughts are given yet to grow crops with a higher tolerance towards salinity.

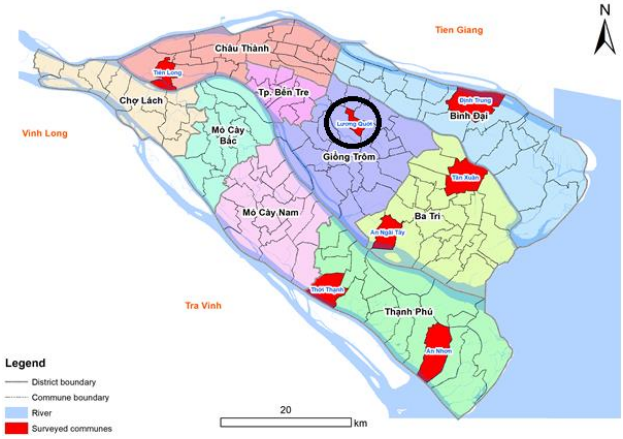
Interviewee 32 walking through his garden: ''*We are all very scared and afraid of the saline water. I have never thought about growing more saline tolerant crops. This area is a fresh-zone, so we cannot grow any saline tolerant crops here such as in the brackish/saline areas. People around here have cut down more than 60% of their rambutan and replaced them with durian and pomelo.*''

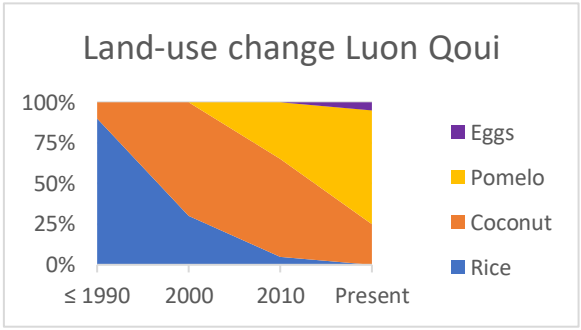
Interviewee 33 in his garden: ''*It is very difficult for farmers to follow the standards required for a stamp on their products. For example, they have to follow a certain schedule of when they should apply fertilizer to the plants and when they should irrigate the plants. If you want to follow the standards of VietGAP, then you cannot grow any chickens or ducks or any kind of animals which most farmers are doing now to provide food for their families.*''

Interviewee 34 showing his well-organized durian garden: ''*The technical aspects of farming here are developing. We have access to all sources of information and the market can provide everything we need. The thing is, you have to be a smart farmer to choose the best ones from the best companies. I am more concerned about the output markets for our products. We are facing difficulties because we still don't have trade agreements with countries such as China.''*

4.2.2 Luon Qoui

Luon Qoui is a freshwater commune operating in an intermediate regime in which fruits, mainly pomelo is the main livelihood. Farmers often compliment their livelihood by growing coconut, citrus trees and animals such as small birds of which they sell the eggs. A total of 5 farmers were interviewed aged between 55 and 61 years old.





META

Coconuts are considered as the traditional livelihood. However, around 10 years ago pomelo trees were introduced by the local government. Rapid expansion followed and people referred to Luon Qoui as a pomelo forest. Farmers have access to a variety of markets to modernize their farms and to buy seeds to grow many types of ornamental plants. The drought of 2016 had devastating impacts. It does not happen often that salinity reaches this commune and it came for many farmers as a surprise. The result was agricultural chaos and many fruits trees were damaged to such extend that they had to be uprooted. The other trees struggled to survive and provided up to 70% less yield the year after. While recovering from the drought, farmers did not choose for more saline tolerant crops species and mainly continued growing similar crops. Their actions however, such as investments in irrigation and purification systems show efforts to increase freshwater availability to continue with their freshwater based livelihoods. Furthermore, it was noticeable that bird-egg production became more popular.

MOTA

Threats & opportunities current livelihood

Since 2014, many pomelo trees suffer from an unknown disease. Leaves of trees turn brown and fruits are affected. The fruits grow slower, look different and are therefore harder to sell. The salinization of 2016 affected many trees, and more than half had to be uprooted. It is therefore that salinization is mentioned as the most severe threat. The effects are still felt, and farmers find it increasingly difficult to find freshwater sources. More recently, it has become difficult to access freshwater. Groundwater often has low values of PH due to the release of acid-sulphate whereas surface-water is often too polluted by animal manure to use. The good access to the market offers a variety of opportunities when it comes to input materials. Farmers indicated that they are able to import everything they want ranging from seeds and fertilizers to water-purification systems.

Abilities

One farmer received *financial* support after the drought of 2016 by the local government. The government was willing to temporarily finance 50% of the cost for drip irrigation. The farmers would pay it back later when his financial situation has improved. Furthermore, some farmers are able to invest in expensive drip-irrigation and purification systems. Whereas other farmers were more pessimistic and are in debt as a result of the drought. Other farmers showed distrust in the *institutional* bodies and questioned the support they were provided with. It was considered as unfair as loans had to be repaid before farmers were able to obtain any income from newly planted fruit trees. The few remaining rice-farmers got supported after the drought by means of free seeds. However, the scale of damage done were beyond the capacities of the local governments to cover. Other farmers indicated that they had difficulties recently to reach certain yield-quantities for the middlemen to come and buy their harvest. *Technical* abilities are high as farmers have good access to the market. In theory, farmers can import all they need to modernize and improve their farm. Farmers are using purification and drip-irrigation systems and are able to measure PH- and salinity-values in the canals and groundwater.

Pre 2016

Before the human intervention increased control over the hydrological regime, farmers were limited to grow single harvest rice. After the completion, farmers changed to the cultivation of triple harvest rice. The introduction of pomelo trees 10 years ago brought a lot of benefits for this commune and many farmers started to adopt this tree-specie in their farming practice. Even though pomelos are difficult to grow as it requires a lot of attention and work, farmers are motivated to grow pomelo trees as it is considered as a high-value crop.

Post 2016

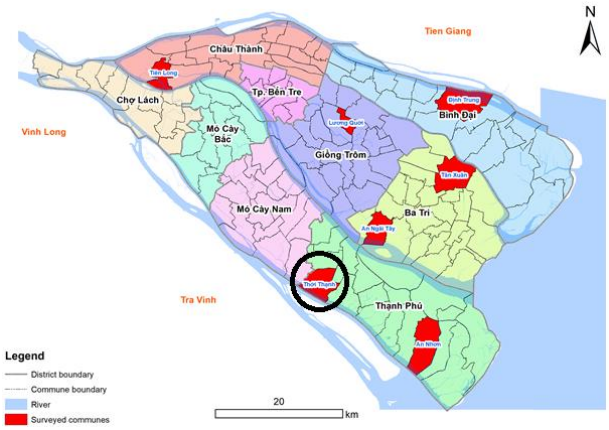
The devastating effects of the drought of 2016 left many farmers with no other choice than to uproot most of their affected pomelo trees. Farmers with enough financial capacity were able to replant the same trees or decided to grow others such as avocado, jackfruits and banana. However, most decided to continue growing pomelo with exception of one who decided to grow coconut as he became too afraid of salinity intrusion. Investments are made in drip-irrigation and purification system in order be secured of freshwater supply. Water from the canals would be used after it has been treated by the purification system. Also, one farmer started to grow ornamental plants and applied the principals of permaculture in his land-use. This land-use change went along with many technical investments and the farmer was highly motivated to continue his land-use practice.

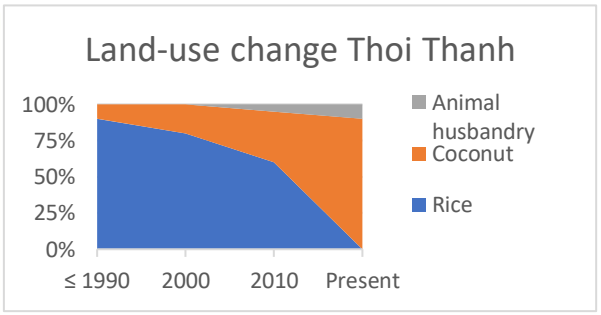
Interviewee 29 showing his garden: ''*I choose a new approach here. I follow a livelihood with high levels of technology. I learn a lot from Israel and Japan. I had to adapt their knowledge and technology a bit to our local circumstances. In this area, I am the only one applying this. I would like to expand it because I already have difficulties reaching the demand for the market of decorative plants and flowers especially during big events in the Vietnamese society. I am able to filter my water and I grow plants that are able to store water in their root-system. I put buckets with plants on all my available land. This keeps the moist in the soil. Challenges for up-scaling are the corporation with other farmers, climate change and water supply, perception and suspicion of famers, initial investment, and the willingness of youth to work in agriculture.*''

Interviewee 27 in front of his house: ''*Salinization in my opinion is the most important factor that affect our livelihood here. If it happens every year, it won't only affect us here but everyone in Ben Tre province. It just happened once, and my productivity reduced with 50%. We really need to find alternative livelihoods to cope with it.*''

4.2.3 Thoi Thanh commune

Thoi Than is a remote commune operating in the intermediate regime where coconut and cattle form the main livelihood. A total of 3 farmers were interviewed aged between 36 and 54. The capability of farmers to proper express themselves differed and therefore data is limited. Furthermore, one farmer started farming just 5 years ago.





META

Until 10 years ago, rice was the dominant livelihood of this commune. Nowadays this commune is almost fully covered with coconut trees. To compliment livelihoods, animals such as goats, chickens, and cows are raised. The drought of 2016 impacted the daily life of farmers and providing cattle with drinking water became very difficult. Coconut trees suffered but not significantly.

MOTA

Threats and opportunities current livelihood

Farmers are facing difficulties regarding water supply for their cattle and coconut trees. Pollution as a result of direct animal manure dumped into the canals is mentioned as a serious problem. The water in the canals has become too polluted to use for drinking water for animals and daily use for farmers. Furthermore, the increasing effects of salinity intrusion is mentioned as a threat as it limits the ability to flush out pollution and refresh the canals. People fled the area when freshwater was not available anymore. Groundwater is often not suitable to use for animals. The groundwater became too saline and contains low PH values due to release of acid-sulphate. The recent decrease in prices for coconut and fluctuating prices for cattle causes financial instability. Higher temperatures, cold nights and fluctuating rainfall patterns are factors affecting coconut production and daily life.

Abilities

One farmer indicated that he had a good relationship with his middleman and was able to obtain *financial* support. He got provided with stable in- and output prices. The other farmers indicated that they had a bad relationship with the middleman and little financial means for operating their farms. When it comes to *institutional* abilities, farmers indicated that they receive support from the farmer union and the local government in terms of trainings and workshops. Also, the middleman provided technical support in terms of how to grow chickens. Farmers are *technical* able to store freshwater for daily use, drinking water for their cattle, and to irrigate their crops for approximately 2-3 months. However, during the drought of 2016 this proved to be not enough.

Pre 2016

Low prices for rice and increasing prices for coconuts resulted in major land-use changes in Thoi Thanh commune. More than 10 years ago, the dominant livelihood consisted of rice. The benefits of growing rice were so low that many farmers decided to replace their rice fields with coconut trees. Nowadays the dominants livelihoods consist of coconuts complimented with cattle which is getting increasingly popular lately as prices for meat increase. Farmers that decided to keep on growing rice had to switch to coconuts as well due to the fact that mice and other animals from their neighbouring coconut farms ate their crops.

Post 2016

Even though the drought of 2016 had serious consequences, no significant changes in land-use decisions took place. To mitigate the effects of future droughts, farmers increased their storage capacity by building more water tanks, dredge their canals and build water canvas storage facilities. Farmers continued with the same farming practices after the drought of 2016. High prices for cattle motivate farmers to expand their livestock and grow more grass in between their coconut trees to provide food for the animals.

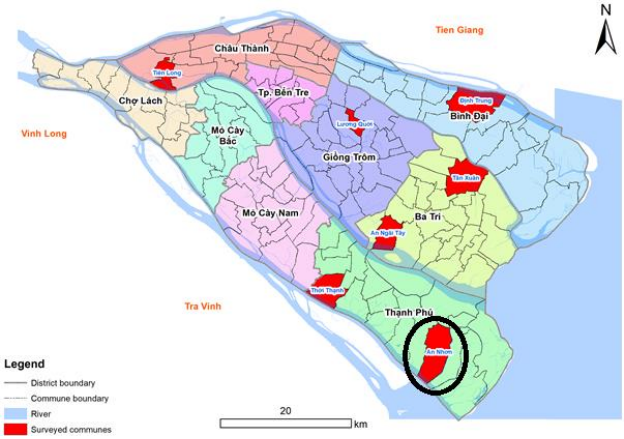
Interviewee 4 showing his coconut garden: *''More than 10 years ago, this land was lower. So, we grew rice in this area. My neighbours also grew rice. Around 10 years ago most of them decided to grow coconut because the rice did not bring them enough benefits. Only me left growing rice. Then the animals and mice eat my rice. I did not have enough benefit and made my land higher to grow coconut.''*

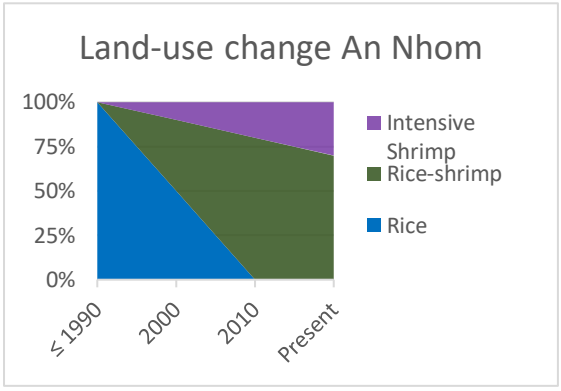
Interviewee 5 showing his rainwater storage facilities: *"I don't really know what to do if the salinity last for too long. For now, I will store more rainwater when we have a lot of rain here. I will store the water in around 10 tanks that I have and store more in my pond. We can last several months but if the salinity last longer, then I don't know what to do."*

Interviewee 6 showing his goat stable: *"The price of the output for animals can go up and suddenly reduce. During the past 4-5 years I had to deal with fluctuating prices 3-4 times."*

4.2.4 An Nhom

An nhom is a remote commune operating within a saline regime. Three farmers aged between 49 and 72 years old were interviewed. All farmers applied a livelihood consisting of extensive shrimp during the dry season and organic single harvest rice during the wet season.





META

An Nhom used to be a remote and sparsely populated commune with one season of rice during the wet season as main livelihood. During the 90s, aquaculture developed rapidly when the first successful attempts of farming shrimps were conducted. This trend in land-use change was accompanied by large scale deforestation of mangrove forests. Farmers indicated that they followed the trend in land-use change and had little influence on the decision-making process. Nowadays the rice-shrimp model has become the main livelihood in An Nhom. The drought of 2016 had devastating effects and all yields were lost. However, this did not lead to land-use changes afterwards. Farmers continued with their rice-shrimp livelihood.

MOTA

Threats & opportunities current livelihood

There are several factors that cause a threat for the shrimp-rice livelihoods. These relate to water quality, water supply, quality of input-larvae, preparation and operation of the shrimp pond, higher temperatures, fluctuating rainfall patterns, and fluctuating in- and output prices. All farmers indicated that the water in the canals is polluted and often contains diseases that easily spread around in shrimp ponds. Preparation of ponds for the next shrimp-season is considered as expensive and difficult. Opportunities of this livelihood consists of possibilities to obtain high benefits with shrimps and the ability to grow rice for own supply. Farmers indicated that whenever shrimp harvest fails, they always could eat the rice as they are able to store it for later usage.

Abilities

When it comes to *financial* abilities, farmers indicated that if needed they could be provided with a loan from local governments. Furthermore, the middleman sometimes supports farmers with a discount on the larvae. However, when farmers sell their shrimp to this middleman, they receive a lower price as interest for the loan is calculated within the price they receive. Via the farmers union, farmers receive a higher price when they fulfil the requirements of organic farming practices. Farmers also receive *technical* support by means of workshops and trainings from the farmers-union. Even with these trainings, it becomes increasingly more difficult to prevent diseases in their extensive shrimp ponds. Farmers are limited in their use of pesticides and chemicals since they are growing shrimps

extensively. To tackle the impacts of rising temperatures on their shrimps, farmers raise the water levels in their ponds. However, concerns are raised as their water supply is unstable and is decreasing over time. Furthermore, maintaining water levels in a pond is difficult due to seepage from their borders. The *institutional* capacities of farmers are defined by the middleman, the farmers union and the local authorities. The farmers union provides farmers with training and more stable in- and output prices when they are able to raise shrimps according to their standards. Furthermore, one farmer mentioned that the local authorities supported him by checking the quality of the larvae and frequently provide trainings and workshops. These workshops however do not always improve their abilities. When it comes to actual land-use decisions, farmers are limited to the governmental strategy which limits them to apply the rice-shrimp model. Farmers who aren't a member of the union are assigned to the middleman to sell their products. They have no influence on the price and often maintain a bad relationship with the middleman.

Pre 2016

Before the 90s, there were no suitable conditions to grow rice and therefore farmers were limited to harvest only once per year. The introduction of shrimp farming in this region resulted in a massive change from a traditional single harvest rice livelihood towards the much more profitable shrimp-rice livelihood. The choices to grow shrimp were mainly driven by the high prices that farmers received for their shrimp. Whereas farmers that wanted to continue growing rice were unable to continue due to conflicts in water demand. Farming shrimp requires brackish water whereas farming rice requires freshwater.

Post 2016

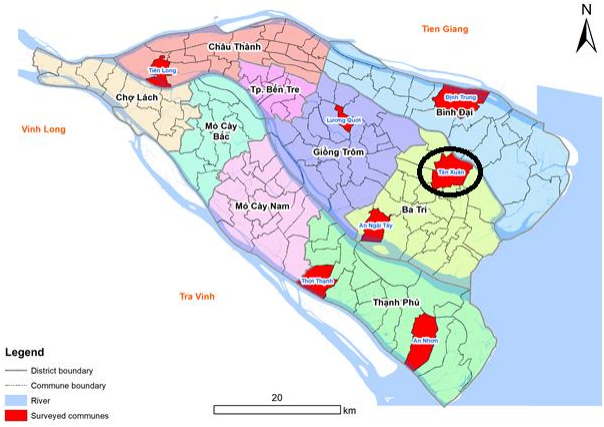
The impact of the drought of 2016 was devastating for this commune. All farmers indicated that they lost everything due to salinity levels outranging the tolerance of their shrimps. Even though the drought had a destructive impact and salinization is considered as a major threat, few noticeable changes of land-use or management were noticed. The possibility of obtaining high benefits and the ability to store rice are factors that motivates farmers to conduct this livelihood. Changing land-use is not a possibility when it does not fit within the strategy of the local government. It is therefore that their institutional capacity is determining for a great extend their land-use decisions.

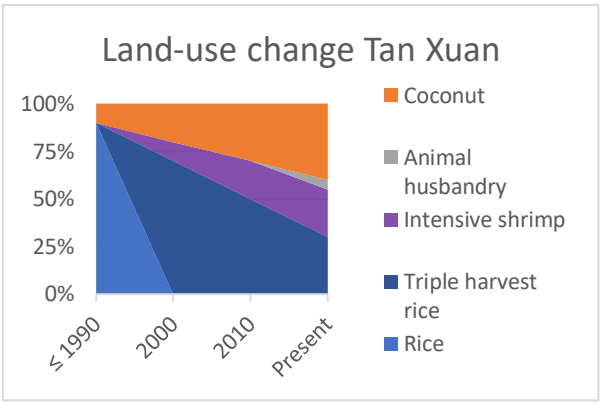
Interviewee 3, showing is extensive shrimp pond: ''*When I was born in this area, I saw many mangroves. Now I don't see them anymore. Mangroves provide shadow against heat and their roots provide a suitable habitat for fish species, I have some in my pond.''*

Interviewee 1: ''*I will have to continue with this livelihood because I do not have any other plans. We have to follow governmental strategy to decide on what kind of animal and plants we can grow here. Cultivating other crops is not an option.''*

4.2.5 March Tan Xaun commune

A total of 9 farmers aged between 39 and 67 years old were interview in Tan Xuan commune. Farmers operate in an intermediate regime and a brackish/saline water regime. Land-use in this commune is based on a freshwater regime and a brackish regime.





META

Tan Xuan commune used to have an intermediate regime until the completion of the Ba Lai sluice gate changed the hydrological regime. Farmers inside the dike-system are operating in a freshwater regime whereas farmers located outside the dike system still operate under an intermediate regime and practice brackish shrimp farming. Inside the dike-system, triple harvest rice became the dominant livelihood often combined with coconut and more recently an increasing amount of cattle. The drought of 2016 had major consequences for this commune. All rice harvest was lost and freshwater for daily life and animals became scarce resulting in a massive out-migration. Prices for renting farmland reduced with 70% and labour costs significantly increased. Approximately 10 years ago, many farmers increased their amount of coconut production. This trend continued after the drought of 2016.

MOTA

Threat & opportunities current livelihood

The current dominant livelihood inside the dike-system consists of double or triple harvest rice complemented by coconuts and cattle. The effects of climate change, insufficient freshwater supply, the increasing salinization, labour costs, and fluctuating prices are mentioned as the main threats of the current livelihoods. The high prices for cattle offers several farmers an opportunity to complement their livelihood. Farmers outside the dike-system raising shrimp are threatened by low quality of input-larvae, fluctuating prices, raising temperatures and fluctuating rainfall patterns. Salinization seemed to have little effect on their harvest as they were able to harvest earlier and to select larvae based on saline tolerance.

Abilities

Farmers indicated that they received *financial* support from the government after the drought of 2016 and initial investment support to start raising cattle. Also, farmers could pay for fertilizer from local companies after they sold their harvest. Given the out-migration after the drought of 2016, cost for labour almost tripled. This lowers profits and formed a limitation of farmers to change their livelihood. Several farmers were willing to switch from rice to coconut but were not able to pay for the labour

costs. Furthermore, as a result of the drought, farmers had not enough savings to sustain the 3-4 years the trees needed to develop before being able to harvest fruits. Farmers receive support from several *institutional* bodies including the middleman, local authorities and organizations. Farmers obtained advice from local authorities to optimize feeding of cattle, advice on when to start seeding rice and which variety is most suitable and provided water-storage tanks for poor farmers. The support from middlemen was limited and the relationship with farmers is often negative. Fewer middlemen are willing to buy rice and farmers have little influence on the price they receive for their products. Farmers use several *techniques* to improve their irrigation. For instance, the usage of pump-systems to irrigate elevated areas and building small dikes and sluice-gates to prevent saline water from intruding. Furthermore, some farmers are able to store rice and sell it later when prices have increased.

Pre 2016

Before the completion of the Ba Lai sluice-gate and several dikes and embankments, most farmers practiced single rice harvest rice complimented with the production of coconuts. Following the national policy of intensification for national food security, triple harvest rice became the dominant livelihood. The abundance of freshwater as a result of the completed infrastructure provided rice farmers with a stable livelihood. Overtime salinity intrusion occurred more often threatening crop production during the dry-season. This resulted in a slowly decrease in rice-paddies and an increase in coconut production. Increasing prices for cattle motivated farmers to grow animals often fed by the leftover straws from the rice-production.

Post 2016

After the drought of 2016 many farmers decided to not grow 3 seasons of rice anymore. Many changed to grow coconuts instead or decided to grow 2 seasons of rice. Farmers showed motivation to substitute the third rice crop by more saline tolerant water melons or egg-plants. However, conflicting land-uses of their neighbours and rapidly increased labour prices formed limitations to change their land-used. Also, different varieties of rice are grown, and more grass is planted to feed cows. However, the different levels of elevation and soil types including acid sulphate are seen as a limitation of farmers in terms of land-use decisions.

Interviewee 17 showing his new variety of rice: *''This is a new type of rice I received from local authorities. They said this type will have less insects and diseases, so we don't have to use as much pesticides as we did before. I bought the new seeds with a bit higher price than the previous rice. Like 50k per kg instead of 8k per kg. This rice is acid sulphate tolerant. So far, it developed really well. I hope to sell it for 7k per kg.''*

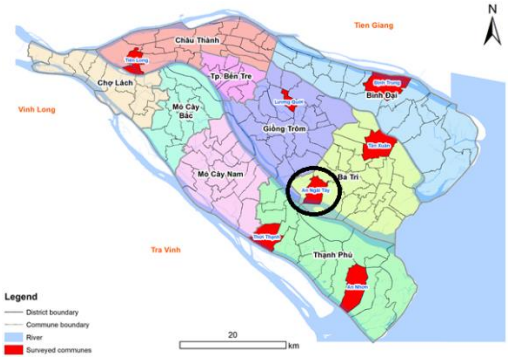
Interviewee 16 inside his house: ''*In 2016, we did not have enough water for our daily life. The local government supported us with water tanks to store freshwater for drinking and cooking. Also, they want us to grow coconut and borrow us money to switch to alternative livelihoods such as cows. We pay a little bit of interest, 0.5-0.6% and pay it back within 3 years. If the salinity comes again, I don't think I am able to live here anymore.''*

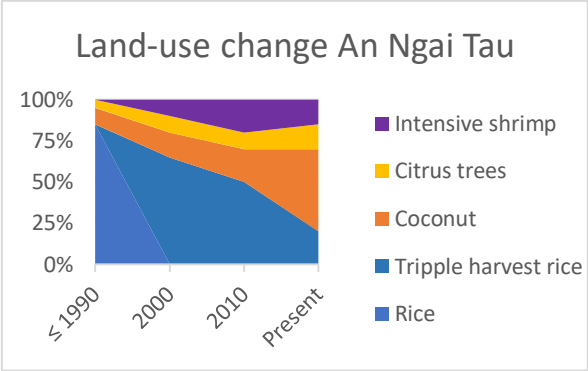
Interviewee 15 showing her water storage facilities: ‘’*Me and my animals need freshwater to drink. As you can see, we have a lot of tanks to store rainwater. However, sometimes we have to pay for freshwater to people living in an area very near with fresh groundwater to fill our tanks. Everything here suffers from salinity because we are located close to the river. On the news we heard that salinity is coming. Animals already die in other provinces.*’’

Interviewee 13 standing next to her rice-field: ''*If the salinization continues in the future, I will have to transform to other kinds of livelihoods. For example, before we could do triple harvest rice and now, we do double. So, in the dry-season we can grow vegetables, such as some kind of melon or egg plant which is more saline tolerant. I want to do this, but I can't. It has to be done on a large-scale. If you do it on a small-scale, and your neighbours are still growing rice, the pesticides your neighbour uses will get into your field and kill your crops. I am thinking about collaborating. But my neighbour will not listen to me and neither would I to him. Therefore, we need the government to explain it to them at a gathering or something.*''

4.2.6 An Ngai Tau

A total of 5 farmers aged between 56 and 62 years old were interviewed. An Ngai Tau has a variety of livelihoods and operates in an intermediate regime. livelihoods are base on a freshwater and a brackish hydrological regime.





META

Historically, single harvest rice farming has been the dominant livelihood under the intermediate regime. Nowadays this commune operates in an intermediate hydrological regime again, but land-use is based on a freshwater and brackish/saline hydrological regime. This results in a current variety of livelihoods consisting of shrimp farming, triple harvest rice, double harvest rice, coconuts, cattle and citrus trees. This commune has a variety of soil types, including acid sulphate soils.

MOTA

Threats & opportunities current livelihood

Shrimp farming is described as profitable but at the same time very risky. The adverse impacts of climate change such as higher temperatures and fluctuating rainfall patterns, salinization, proper pond preparation, diseases, quality of larvae and unstable prices are considered as threats for this livelihood. Rice farmers indicated that salinization is their biggest threat. Farmers that were not able to treat their soils mentioned acid sulphate as their biggest threat. Furthermore, snails and insects are affecting crops. Too little owned land is limiting farmers in their land-use possibilities as well. Coconut trees still had to grow before providing fruits to sell. The current low prices for coconut is considered as a threat. However, farmers still choose for coconuts instead of rice.

Ability

When it comes to *financial* abilities, the middleman, the local government and the governmental bank play a central role. Due to the decrease in rice livelihoods, one farmer indicated that there are not so many middlemen left to choose to sell the rice to. This resulted in lower prices for his products. Whereas another farmer has a good relationship with his middleman since it is his relative. He receives support regarding in- and output for his farm and gifts during Tet-holiday, the biggest national festivity. The local government and governmental banks are able to support farmers with loans when needed. Farmers who own a lot of land are able to rent big machines to treat their acid sulphate soils. Their *technical* abilities are much higher than the abilities of smallholders. To adapt towards salinity, many farmers indicated that they close their sluice-gates when the salinity is noticed on time. Furthermore, farmers collaborate by building small dikes during the dry-season. However, the drought of 2016 was so severe that saline water infiltrated from upstream the river, bypassing all the infrastructures. Training and workshops are provided throughout *institutional* organizations such as the local government farmer unions and middlemen.

Pre 2016

Before the drought of 2016, the suitable circumstances for cultivating rice resulted in large amount of land dedicated towards triple harvest rice. Farmers gained benefits especially for the winter-spring crop, the rice cultivated in the dry season. High prices for coconut and cattle have led to an increase in coconut production and the amount of cattle raised on farms. Shrimp farming is considered profitable but comes with high risks. The drought of 2016 had devastating impacts on this commune. According to local officials, farmers barely had access to freshwater and many fled the area. All rice harvest was lost, and daily life was difficult. One official estimated that after 2016, 70% of rice farmers switched from rice towards the more saline tolerant coconut.

Post 2016

The drought had devastating impacts for this commune. Local authorities received help from the national government and freshwater had to be imported with trucks. Many farmers made direct land-use changes and switched from rice towards the more saline tolerant coconut trees. Furthermore, collaboration among farmers to build dikes occurred and investment were made in freshwater storage. One farmer indicated that he lowered the scale of his farming practices to lower risks. Aquaculture remained the same as profits obtained in the past motivates farmers to continue this livelihood. To be able to keep on raising cattle, farmers increased their freshwater storage capacity.

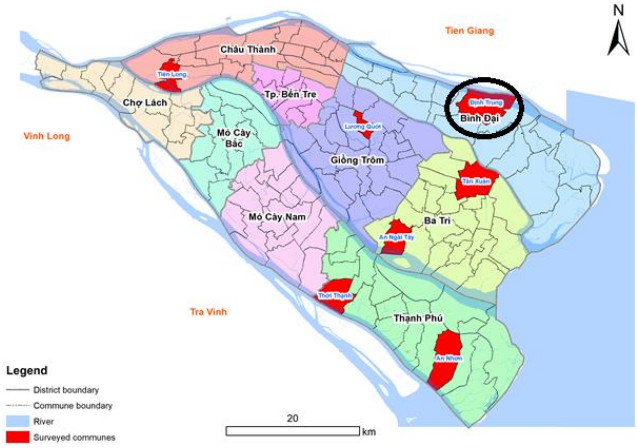
Interviewee 11 showing his affected young cacao tree: ''A*fter the drought, several neighbours decided to grow citrus trees, but it is going not well. When their roots are still in the shallow level of the soils then it is ok, but when they develop overtime and the roots touches the deeper levels of the soil if touches the saline water and they die.''*

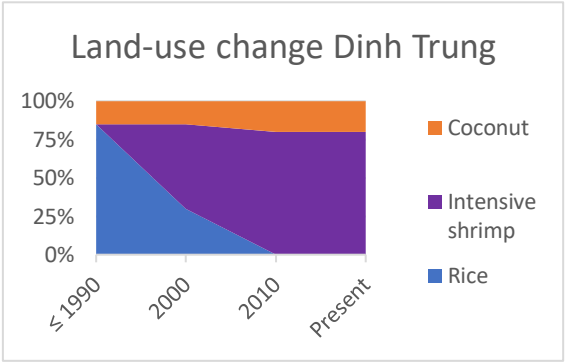
Interviewee 10 showing his canals: ''*We mostly avoid salinization using dikes build by the government. When it is closed, the situation is good for most of the time. However, even though the dikes are closed, the salinization follows the river flow and enters this area upstream from the upper parts of this area. From there it continues into the canals and smaller rivers into our area. Another reason is that we have salt groundwater during the dry season. When a lot of water evaporates, that is when we experience higher concentrations than normal. In order to prevent saline water from entering our farms, several farmers work together to build small dikes. I did the same thing. It is effective to some extent. The canal here for example, when the dry-season came we made the small dike to prevent saline water from entering. After the dry-season we*

Interviewee 8 showing his neighbours agricultural activity: ''*The farm with shrimp that you see over there belongs to a different zone from the governmental planning. That is a brackish and salty zone. But my farm is in a fresh zone and we cannot grow shrimp here. In this zone we only can grow freshwater based livelihoods. Before there were 2 seasons here, 6 months dry (brackish/saline) and 6 months for wet (fresh). Then the government made a dike and we only had freshwater. But now we are experiencing salinization again. It is very difficult to have permission to grow shrimp here because the government does not allow us to do. But in case the government allows us to do it, it will be very difficult for me to switch because I have little land.''*

4.2.7 Dinh Trung commune

A total 6 farmers aging between 43 and 71 years old were interviewed in Dinh Trung commune. The commune Dinh Trung operates within a brackish/saline hydrological regime. Brackish shrimp aquaculture is the current dominant livelihood often combined with some coconut trees.





META

After completion of the Ba Lai sluice-gate and several embankments at the beginning of the 21st century, the hydrological regime changed from and intermediate to saline for the whole year. Dinh Trung used to be a remote and poorly developed commune. Agricultural livelihoods were limited to single-harvest rice due to the temporarily availability of freshwater and the absence of fast-growing rice varieties. Some farmers indicated that they could catch fish and shrimps from the canals to complement their livelihood. During the 90s, following the trend of the global boom in aquaculture, successful attempts of farming shrimps in the dry-season were conducted. The high benefits obtained resulted in a boost of local aquaculture and general development of this commune. After the completion of the Ba Lai sluice gate, the hydrological regime changed from intermediate to saline.

MOTA

Threats and opportunities current livelihood

Shrimp farming is described as profitable but at the same time very risky. The adverse impacts of climate change such as higher temperatures and fluctuating rainfall patterns, salinization, proper pond preparation, diseases, quality of larvae and unstable prices are considered as threats for this livelihood. Rice farmers indicated that salinization is their biggest threat. Farmers that were not able to treat their soils mention acid sulphate as their biggest threat. Furthermore, snails and insects are affecting crops. Too little owned land is limiting farmers in their land-use possibilities as well.

Abilities

Farmers depend on several external parties to determine their *institutional* capacity. One farmer indicated that he tried cultivating other fish species but was not able to sell it to a middleman as he was not interested in buying them. Farmers received training from local authorities in recognizing diseases in shrimp ponds and received chemicals to treat diseases. Attempts for cooperative farming are made but remain in an initial phase as there is a general lack of trust among participants. The *financial* capacity differs among farmers. Most farmers indicate that shrimp farming is gambling, sometimes you lose and sometimes you win. Whereas others are satisfied with their livelihood. Farmers receive discount when they pay for all their input at once or only have to pay for feed input for the first month and paying-off the rest later. The high initial investment needed to change their

land-use was mentioned as a limitation. *Technical* capacities often refer to the ability to treat diseases and prepare the ponds. Farmers treat diseases by adding chlorine to their ponds. A more environmentally friendly measure consists of adding tilapia fish larvae as soon as sick shrimps are floating among the surface waters. By applying this method, some farmers are able to safe 70% of the shrimp from dying while others are struggling to maintain the added tilapia population limited. One famer was not able to prevent seepage from entering his pond and decided to change land-use to growing coconut. Preventing acid sulphate from reaching pond waters is done by applying calcium as part of preparing ponds. Whereas other farmers wait for the rain to flush out the acid sulphate from their ponds.

Pre 2016

Most farmers indicated that at the beginning of the 21st century, they switched from farming rice and coconuts towards intensive shrimp farming often combined with coconuts. Maintaining freshwater based livelihoods became increasingly difficult when more rice farms converted to shrimp. Both livelihoods have conflicting water demand. Rice requires freshwater while shrimp requires brackish/saline water. Farmers indicated that they had to follow the trend and were limited in terms of making their own decisions. Whereas other followed the trend because they were motivated by the high prices of shrimps. Coconuts are grown for own consumption and to a little extent to compliment the main shrimp farming livelihood.

Post 2016

The drought in 2016 had little effects the land-use in Dinh Trung. Brackish water livelihoods were already dominant. Some farmers made a loss but for most farmers, the drought occurred during the time they were preparing their ponds for the next season. Farmers indicate that it is difficult to grow other crops than coconuts because the high level of salinity in soils forms a limitation.

Interviewee 21: ''*The profitability of our livelihoods differs each year and depends on the amounts of shrimp ponds you use. For instance, if you cultivate shrimps in 10 ponds, 3-5 ponds will provide you with benefits.''*

Interviewee 23:*''It's unclear for us now about any directions for the future. Shrimp farming can give you very high benefits, but it is also very risky. The best way for my children now is to study and find a suitable job later. Traditionally, children would stay and do the rice farming after their parents cannot do it anymore. But now, the youth don't like that anymore. Dredging canals for instance is hard work and my children don't want to do it. I am old now but still do it.''*

4.3 Comparative analysis of the case studies

Ben Tre province is host to three hydrological regimes consisting of a freshwater, an intermediate, and a brackish/saline regime. The communes that have been visited were selected based on the pre-condition that all these regimes were covered. There are several general conclusions that can be drawn. Changing hydrological regimes by means of infrastructural measures have resulted in large-scale land-use changes in Ben Tre province. Although land-use change occurs in a graduate process, several events can be distinguished as major drivers for change. These drivers for change include a rapid expansion of infrastructure measures during the 90s in effort to increase control over the hydrological regime, a boom in coastal aquaculture, crop diversification to make optimal use of bio-physical environments, and the more recent response towards the increasing effects of salinization. The response in terms of land-use change towards these changes are dynamic and triggered by a variety of factors. Moreover, these responses are often spatially bound. Coastal area where the historical hydrological regime limited rice production to single harvest rice transformed rapidly into rice-shrimp and shrimp farms. This was accompanied by mangrove deforestation. Conflicts in water demand between rice and shrimp farmers accelerated this trend of land-use change. Areas with relative secure freshwater supply adopted the rice-shrimp rotating system whereas areas with limited freshwater supply are practicing extensive and intensive brackish shrimp farming. These farming practices are found land-inwards in areas operating outside saline control boundaries as well. More inland in the intermediate regime, the expansion of water control measures during the 90s, transferred large areas into permanent freshwater zones. Triple harvest rice livelihoods replaced single harvest livelihoods and became the dominant crop. Overtime when salinity intrusion became increasingly severe, rice livelihoods gradually transferred into the more saline tolerant coconut livelihood. Areas with a more secure supply of freshwater diversified their livelihoods with raising animals, tropical fruit and citrus trees. Responding to the increasing effects of salinization, coconut livelihoods increased, and triple harvest livelihoods often replace the winter spring rice crops with a more saline tolerant livelihood such as grass for cattle. Upstream areas in the freshwater regime underwent a rapid expansion of tropical fruit livelihoods accompanied by the water control infrastructural measures replacing single-harvest rice livelihoods. However, whilst zooming in on commune-level there are many exceptions found.

Whilst visiting the communes, the actual farming practices on the ground differed from what was expected. For instance, in An Ngai Tau which operates behind large dikes, freshwater based livelihoods were expected to encounter. Instead, aquaculture is practiced adjacent to freshwater based livelihoods. This indicates that despites the efforts on provincial level to manipulate the hydrological regime and to zone an area as freshwater based, different land-use practices according to different regimes are found. Zoning appeared to be less strict in this commune and farmers deviated their land-use from the provincial zoning. Whereas in other communes, such as An Nhom this seemed to be impossible as farmers had to follow the strategies from the local authorities more strictly. The commune of An Nhom which operates in near the coast in front of the large dikes was expected to be permanent brackish. However, the farmers spoken with all grew rice in the wet season. In Tan Xuan, farmers operate under two hydrological regimes, a freshwater and an intermediate regime divided by a dyke. Farmers inside the dyke system were affected by the drought of 2016 and performed actions to prevent saline water from entering. Whereas farmers operating outside the dyke system were not much affected by the drought. Furthermore, land-use changed after the drought of 2016 appeared to be much more dynamic in this commune compared with others. Since there are so many varieties found on ground, it is difficult for planners to draw exact boundaries and steer zoning towards more sustainable land-use practices.

While applying the MOTA-framework of analysis, a variety of insights were gained on factors that influence land-use decisions of farmers operating in different hydrological regimes in Ben Tre. In general, farmers described the opportunities of their current livelihoods as limited. Shrimp farmers mentioned the possibility of obtaining high profits as an opportunity. However, these high profits are accompanied with high economic risks. Whereas farmers operating upstream describe market access as an opportunity. Farmers operating upstream close to urbanization and major infrastructure have relatively good access to markets for their input materials and receive high prices for their products. The cultivation of profitable tropical fruit causes their financial and technical abilities to be higher than those of communes more downstream. They experienced the drought of 2016 as a major threat but believed in a technological fix. This is reflected in their actions such as investing in drip- and purification systems. Threats are more common and frequently mentioned. Most farmers frame water supply, both in quantity and quality, as their major threats towards their current livelihoods. Limited freshwater supply also has a major impact on the daily life of farmers. Other threats consist of fluctuating in and output prices, diseases, changes in climate, labour costs, age, market access, quality of input larvae and pond preparation. The fluctuating in and output prices makes changing land-use risky as it is difficult for farmers to predict how prices will develop. Whereas the sudden increase in labour cost is limiting farmers to choose for labour intensive livelihoods because the costs for labour has become too high. Relatively old farmers tend to choose for less labour-intensive land use such as coconuts despite the current low prices. The fact that coconuts are more saline tolerant plays a role as well. Farmers operating in the intermediate zone more downstream have lower financial and technical abilities. These farmers who seemed to be less well-off tend to make the switch towards more saline tolerant crops such as coconuts or stick to their traditional tropical fruit livelihoods without major adjustments. Institutional ability in terms of institutional support differed among the visited communes. Some farmers received technical and financial support from the middleman and the local authorities whilst others maintain a bad relationship with the middleman. In remote communes such as Thoi Thanh, the access to the market is determined by the middleman and the local authorities. The responses in this commune towards a changing hydrological regime remained limited to increasing freshwater storage and no changes in crops choices or patterns occurred.

Chapter 5 Discussion & conclusion

5.1. Discussion

Circumstances for interviewing farmers in Ben Tre were difficult. The time consumed for gaining permission from authorities to conduct interviews differed from a whole day to just one hour of discussion the purposes of this research. Farmers were most of the time selected beforehand and during the interviews local officials and police were joining. They took notes of all questions asked, responses of farmers and sometimes interrupted interviews. Most farmers were limited in expressing themselves probably and keeping control of the direction of the interview is difficult as it is considered rude to interrupt a farmer's flow of speaking. These factors greatly influence the extent to which complete interviews and therefore MOTA-analysis could be conducted. Furthermore, the fact that the interviews were all recorded for transcription purposes was sometimes received with suspicion. Conducting an interview for a MOTA-analysis on an individual basis proved to be time consuming and not all farmers and/or officials were willing and/or able to spend such amount of time. Even though the translator who accompanied me during this fieldwork has a high capability of expressing herself in English, some responds were difficult to translate or could have different meanings once translated. This language barrier resulted in a tendency of interviews becoming superficial. All these mentioned factors are reflected in different data-sets per commune and therefore influence the validity. The communes of An Nhom and Thoi Thanh are represented by a data-set of 6 farmers in total. Whereas in Tan Xuan a total of 9 farmers represent this commune by itself. It is therefore likely that if circumstances were more stable during the fieldtrip, a different set of data would have been obtained. It is important for the reader to bear this in mind.

Due to drought of 2016, governmental resolution 120 and implementation of the Mekong Delta Plan foreseen in 2020, it was expected beforehand to find many examples of land-use change according to the changing hydrological regime. This change in policy appeared to be still in an initial phase and a translation towards the provincial, district and commune levels of the Vietnamese government was therefore not noticeable. It was expected that response in terms of land-use change would differ among each of the hydrological regimes. This proved to be partly true. The actual boundaries of the identified regimes appeared to be dynamic with exceptions found on several locations. The response was indeed different and can be clarified by a variety of factors but directly linking this to the hydrological regime in which these responses occurred cannot be done. The factors that influence land-use decisions are partly based on how a drought is defined by an individual, spatially bound and depending on the livelihood activities conducted by each individual. These findings support the work of Kristjanson et al. (2017) which state different perceptions of climate change result in different exposure to climate shocks. This exposure relates to the abilities of each individual to cope with shocks which in turn relates to livelihood activities carried out by individuals. Furthermore, a study conducted by Ziaul Haider and Zaber Hossain (2013), regarding the impact of salinity on livelihood strategies for farmers also found out that there is no significant pattern in farmers' response towards saline intrusion. Furthermore, this research had similar findings regarding response of farmers who frequently experience saline water intrusion and those who less frequently experience saline intrusion. The believe in the technical fix of the problem was higher among farmers operating in areas with less experience with saline intrusion than in areas with more experience in both studies.

The MOTA-analysis is able to trace back this limitation in land-use decisions to some extend towards the defined abilities. Gaining actual insights in the financial abilities of farmers was not possible. Questions asked regarding finances and number were often received as unappropriated and disturbed the flow of the interview. It was therefore decided in an early stage of the fieldtrip to ask more descriptive questions about financial abilities which in turn resulted in more descriptive answers. This study is unable to encompass the entire motivation of farmers to change their land-use in relation with changing hydrological regimes in the past. This was partly due to the fact that not all farmers were operating in the communes during those changes. Also, those changes occurred a long time ago and farmers often expressed that it was difficult for them to remember what motivated them in the past to change.

An interesting new finding of this research is that there are farmers that invest in PH and salinity measurement systems. These developments bring into question why this task seemed to be not carried out by authorities on provincial level. This data is important in terms of the selection of suitable livelihoods as variations in this data-set are likely to be spatially bound. To draw any conclusions on this, it is recommended to conduct further research regarding this topic. Given my current knowledge on conducting fieldwork in Ben Tre I would recommend having a more flexible planning during the fieldtrip. The conditions to conduct interviews for a MOTA-analysis differed to such an extend that it is wise to spend more time in communes with more suitable circumstances that in communes in which it was more difficult.

5.2. Conclusion

One of the research objectives of this research was to gain understanding of the different hydrological regimes present in Ben Tre in order to explore the influence on land-use changes. Historically, Ben Tre hosted an intermediate regime and farmers were limited to grow single harvest rice. During the 90s, massive infrastructural measures were implemented to increase control over the hydrological regime. Land-use changed occurred according to the new permanent freshwater regime which is reflected in new rice cropping patterns, including triple harvest, which resulted into a large increase in production. The brackish coastal zone is an exception where rice fields and mangroves areas turned into shrimp farms under a brackish water regime. The decision to maintain a brackish/saline regime in the coastal areas can be explained due to the massive boom in aquaculture following the high prices that could be obtained from farming shrimp. Due to socio-economic developments and the effects of climate change, the freshwater regime gradually changed towards an intermediate regime. As a response, large amounts of sluice-gates were implemented at the beginning of 21st century to regulate the intermediate regime for the protection of freshwater based land-use. Simultaneously, Land-use have changed according to this heavily regulated hydrological regime which is displayed in the decrease in rice production which requires a stable and constant freshwater supply. Roughly speaking, farmers in Ben Tre operate within a brackish/saline regime, an intermediate regime and a freshwater regime. The boundaries of the intermediate regime are constantly evolving due to the fact that the extent in which salinity intrudes land-inwards and the concentration of salinity levels are depending on a variety of factors. This changing hydrological regime has led to a decrease in overall rice production in Ben Tre. Rice affected by salinization has been replaced by tropical fruit trees, aquaculture, coconuts and ornament plants which from the current major crops in Ben Tre.

The interests, perceptions on risks and solutions, and the financial, institutional and technical abilities of farmers were analysed using the principles of the MOTA-framework. According to the MOTA-analysis, almost all the interviewed farmers are experiencing the changing hydrological regime as a major threat for their current land-use and are anxious for the continuity of their livelihood. There are many farmers willing to change their livelihood according to those changes and there are farmers still convinced that they can adapt towards the changing hydrological regime and continue their current farming practices. This perception of being able to apply land-use change that are adaptive towards these changes and continue with previous land-use practices are influenced by their high technical and financial abilities. This was most explicit in the communes of Tien Long and Luong Qoui operating in the freshwater regime where farmers still saw opportunities for their current farming practices. Due to their close proximity to urban areas and good accessibility due to better developed road infrastructure, these farmers distinguished themselves with high technical abilities from farmers operating more downstream. Despite the fact that determining financial capacity proved to be difficult it is likely that tropical fruit farmers operating in Tien Long and Luon Goui have higher financial capacities than farmers operating more downstream. The cultivation of tropical fruit is considered as a profitable livelihood and farmers are able to invest in expensive machinery such as drip and purification systems. Farmers operating more downstream mentioned significantly less opportunities to continue their current livelihood practices and are more motivated to change their land-use. However, the other factors that determine land-use decisions play a more significant role in the intermediate regime.

Fluctuating in and output prices due to an unstable market is causing financial instability of farmers. The middleman decides for a great extend upon the price farmers receive for their crops which affects their financial abilities. Furthermore, farmers are limited in terms of achieving input material for their farm. Most depend on local authorities or the middleman for their input material. Especially farmers operating in remote areas are affected by this. Another factor is the amount of labour required for a certain land-use. Most farmers are relatively old, and costs of labour are rapidly increasing due to an out-migration of youth that seeks fortune in cities instead of agriculture. This motivates farmers to choose for land-use that require low amounts of labour such as growing coconuts. Furthermore, farmers in Ben Tre are typical smallholder farmers. The amount of land farmers owned is limiting their land-use options. There are examples of farmers willing to change their land-use towards aquaculture, but their small amount of owned land is limiting them from doing so. This large amount of smallholder farmers are irrigating their crops by using water from the canals and discharge their waste water in these canals that are shared with riparian farmers. Therefore, land-use practices of neighbouring farms are limiting land-use decisions as well. Farmers who grow rice use pesticides and fertilizers. Neighbouring farmer are likely to receive input water affected by this which forms a limitation to grow crops such as certain vegetables that are unable to tolerate this. Many farmers operating in the intermediate regime indicated that they base their livelihoods on positive experience of their neighbours. These decisions also relates to the limited abilities of farmers. Insights in market trends and prices are often limited to the information provided by the middleman and local authorities. Seeing someone performing a new land-use successfully is therefore triggering farmers to change their land-use. Local authorities have a strong grip on land-use in Ben Tre since they are often the source that provides farmers with input materials and are responsible for the zoning of areas. Therefore, they are a determining factor that influence land-use decisions. Farmers that are operating in zones that are administered as a fresh zone are not allowed to grow other crops than freshwater based. Farmers have to base their land-use decisions according to the strategy of local authorities and have therefore low institutional abilities. However, the strictness of zoning differed among the visited communes which is displayed in brackish aquaculture practices found more land inwards.

These factors that limit land-use decisions are displayed in the action farmers undertake. These actions greatly depend on their technical and financial abilities and range from building small dikes, improve sluice-gates, redesign orchards, and investing in water storage facilities to facility freshwater supply for household usage and to a limited extent towards irrigating crops.

The motivation of farmers conducting aquaculture in the intermediate and brackish regime differed from the freshwater based livelihoods found more upstream. The fact that the canals are interconnected and shared, causes shrimp farming to be vulnerable to diseases. The shared water easily spread diseases. Shrimp farmers indicated that this widespread of diseases is linked to the input water they receive, fluctuating rainfall patterns and temperature which makes it difficult to control salinity levels in their ponds, and fluctuating in and output prices as major threats. The discharge of untreated waste water, low PH-values due to the release of acid-sulphate, and chemical pollution causes a widespread of diseases among shrimp ponds. This causes massive economical damage due to yield lost. Shrimp farmers are often left with no choice but to borrow money to continue their shrimp farming practices in an effort to pay off debts despite the major risks involved. The land-use practices of their neighbouring environment and their low financial ability to pay for physical adjustments to their land to perform land-use other than aquaculture is limiting land-use options. Growing other fish-species is considered not economically attractive and are therefore not raised on commercial scale.

It can be concluded that there is a noticeable interplay between changing hydrological regimes and land-use decisions of farmers in Ben Tre. This interplay is spatially bound and the motivation to change accordingly is most noticeable among farmers with limited abilities. This interplay is most of the time not reflected in crop-choice due to a variety of other factors influencing land-use decisions. However, it is reflected in actions and measures that farmers undertake to adapt towards this changing hydrological regime. Difficult challenges have to be overcome in order to grow towards the desired agricultural state of Ben Tre and motivating farmers is one of them. Until then, future periods of prolonged and severe droughts will put the effectiveness of the measures implemented on farm-scale to the test.

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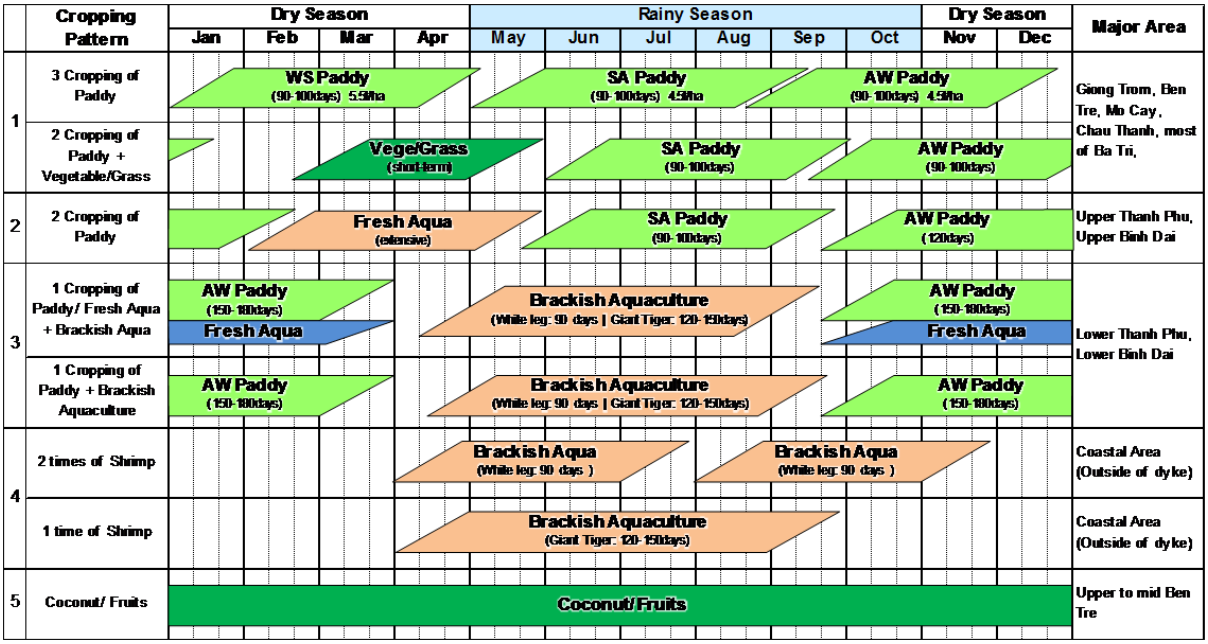
Chapter 7 Appendix

Appendix I Cropping patterns of major crops in Ben Tre



* For SA paddy, acid tolerance is preferred as it is cultivated at the beginning of rainy season when acidity tends to be slightly high.
* For AW paddy, occurrence of warm is not severer than SA paddy; however, it is cloudy, thus, about same level of yield as SA paddy is expected.
* The crop yield is based on dried paddy (15% in moisture)
* For repeated cultivation of shrimp, at least one month of furrow period should be made.
* Fresh water aquaculture can be managed with local variety of paddy, as it does not require so much application of fertilizer and pesticide.
* Fresh water aquaculture can be managed even during dry season when saline concentration is high if enough amount of fresh water can be secured during rainy season.
* Nowadays, two times of shrimp culture is gaining more popularity (roughly 80% of extensive brackish aquaculture).
* In terms of brackish shrimp culture alone, 10,700 ha are intensive and semi-intensive (30%), 25,000 ha is extensive (70%) in 2015. (JICA, 2016)

Appendix II Semi-structured interview

Semi-structured interview

Name:	Level of education:
Age:	Family size (persons):
Gender:	Number of employees:
Phone number:	Housing: ①permanent ②semi-permanent ③temporary
Facilities: ① Scooters/ manual motorbike, ② Automatic motorbike, ③ Flush toilets (septic tank included) in the house, ④ Fridge, ⑤ TV, ⑥ Air conditioning, ⑦ Washing machine, ⑧ Car, ⑨ Electrical generator	Large mechanized engines for production purpose (tractors, harvesters, tillers …): ① Yes ② No Total area of owned land:……. m2 Total are of rented land:……. m2 Total area of cultivated land: ……. m2

Current livelihood Mota

1) Intro/background of the farmer

1. What kind of crops do you cultivate?
2. For how long have you been doing this?
3. Which aspects of your current farming practice are going well?
4. Which aspects of your current farming practice are going not so well?
5. Why are you doing this kind of farming practices?
6. Did you farther also do this kind of farming practice?
7. What kind of role does your family members play in the farm?
8. Besides farming, what kind of livelihood activities are carried out to generate income?
9. Would you be so kind to give me a short tour around your farm and explain me about the system?

During/after tour

2.) Mota on current livelihood

10. Can you tell me something about the most considerable internal and external changes you encountered during your career as a farmer?
11. How did or do you adapt towards this?
12. How did it influence your livelihood?
13. What do you perceive as threats/risks for your current livelihood? / What are the current constrains?
14. What kind of consequences does this have/had for your livelihood?
15. How did/do you respond towards this?
16. How does/did it influence your credit line/ financial situation?
17. How do you think your financial situation will develop when you maintain this livelihood?
18. How do you bring your crops to the market?
19. Have you tried cultivating other crops? If yes, how did it go?
20. If the drought of 2016 becomes the new normal, how would this effect your livelihood? How would you deal with it?

Proposed livelihood Mota

Explain farmers about the future predictions of salinity, explain the desired future situation of the MDP, explain resolution 120 (go through the proposed livelihoods)

1. Do you think one of these livelihoods addresses your current constrains? (refer to it) How does or doesn't it?
2. What kind of physical adjustment are required for your farm?
3. What kind of opportunities would this new livelihood bring you?
4. What kind of threats do you foresee?
5. How well are your current abilities to imply this livelihood?
6. What is needed to improve your abilities to adapt towards this livelihood?
7. Does this livelihood fit within your future thoughts of farming in Ben Tre?
8. Are you motivated to transform your livelihood towards this propagated livelihood?
9. Do you have any suggestions that could improve your motivation to adapt towards this livelihood?
10. What kind of future perspective do you for see for your children? Where would they work?
11. How realistic you think that perspective is?
12. Is there a farming career for your children in agriculture?
13. What kind of agriculture would provide a good life for your children?
14. What do you think is needed to change for your children to have a career in agriculture?

Appendix III Map of surveyed communes