

The Co-management Model in the Integrated Mangrove-aquaculture Farming in Ca Mau, the Vietnamese Mekong Delta



Dock with fishing boats surrounded by mangrove trees (Source: Anouk Starmans, 2023).

Anouk Starmans

Student number: 1990403

Supervisor: Mucahid Mustafa Bayrak

Second reader: Bishawjit Mallick



Acknowledgment

I would like to express my deepest gratitude to a variety of groups and institutions. Firstly, I am grateful to the staff of Kim Delta who assisted me with finding a research location and stakeholders in the area. Moreover, their support with translational work and their financial support has been valuable to me. My gratitude also goes to the staff of Minh Phu who helped find respondents and transported me around the commune. The spokesperson of Dat Mui also deserves my appreciation because he found time in his agenda for an interview. I also thank the 20 farmers in the commune and the three representatives because of their hospitality and openness towards me. I want to show appreciation towards my supervisor Mucahid Mustafa Bayrak for assisting me during my research in the field and for giving me constructive feedback. Lastly, I want to thank my family and partner for their support.

Abstract

In the coastal regions of the Mekong Delta in Vietnam, integrated mangrove-aquaculture farming has been gaining increasing popularity because of its apparent preservation-functioning of mangrove forests while also offering farmers the opportunity to gain an income from doing aquaculture. The Vietnamese government has regularly managed the ecosystem by using a co-management model in the form of land allocation. Farmers receive the right to do production on their piece of land but must adhere to forest-protection rules. This thesis aims to investigate what effect the co-management model has in the integrated mangrove-aquaculture sector on farmers, other stakeholders, and the natural environment of Ca Mau, the Southern province of the Mekong Delta, and how can it be explained using the criteria efficiency, equity, and sustainability. The use of these three criteria gives a more complete picture of the effects of the co-management model than only investigating the model from one lens. The commune of Vien An Dong (Viên An Đông), located in Ca Mau, is used as a case study research location to discover more in-depth and comprehensive knowledge about the subject. 20 interviews have been executed with farmers from the commune. Moreover, interviews with two experts have been performed as well as a focus group discussion with three representative farmers.

With the gathered data, the co-management model in this commune proves to have short-term positive effects on stakeholders and nature in integrated mangrove-aquaculture farming. It successfully preserves the mangrove forests and allows farmers to earn an income. However, in the long run, certain challenges may become difficult to resolve if changes do not occur. These challenges include farmers' increasing resistance to the forest ratio rule, the increased encroachment of pollution within the commune, the inequitable distribution of benefits, and unbalanced relations of power. Moreover, there is a disparity in opinions between the farmers and other stakeholders with higher authorities regarding the impact of the co-management model on the commune. The positive attitudes of governmental organs and independent companies and the negative viewpoints of farmers towards the co-management model need to become more balanced for the model to succeed in the future.

Keywords: Nature-based Solutions, integrated mangrove-aquaculture, co-management, efficiency, equity, sustainability

Table of contents

Introduction.....	6
1. Literature review and theoretical framework.....	10
1.1 Literature review	10
1.1.1 Nature-based solutions	10
1.1.2 Integrated mangrove-aquaculture systems	11
1.1.3 The co-management model	12
1.2 Theoretical framework.....	14
1.2.1 Ecosystem management	15
1.2.2 Efficiency	15
1.2.3 Equity.....	17
1.2.4 Sustainability	17
1.3 Conceptual framework.....	18
2. Methodology	20
2.1 Operationalization.....	20
2.2 Methods	22
2.3 Ethical considerations	23
2.4 Positionality.....	23
2.5 Limitations.....	23
3. Regional context: Co-management model in integrated mangrove-Aquaculture systems of Ca Mau 25	
3.1 Aquaculture farming in Ca Mau	25
3.2 Co-management in Ca Mau.....	27
4. Results and discussions	30
4.1 Introduction of the Vien An Dong commune	30
4.2 Stakeholder analysis.....	30
4.2.1 The farmers	31
4.2.2 Minh Phu	31
4.2.3 Department of Agriculture and Rural Development (DARD) Ca Mau	32
4.2.4 Dat Mui Protection Forest Management Board.....	32
4.3 Co-management and integrated mangrove-aquaculture farming in Vien An Dong.....	33
4.4. Efficiency, equity and sustainability	34
4.4.1 Efficiency	35
4.4.2 Equity.....	38
4.4.3 Sustainability	42
5. Conclusion	45

6. References..... 48
Appendix A 55
Appendix B 58
Appendix C..... 63
Appendix D 69
Appendix E..... 74

Introduction

Coastal areas in the world face many challenges in our contemporary times. First, the impact of climate change is becoming increasingly visible. Because of rising seawater and heavier weather conditions, flooding and intense winds occur more frequently (Toimil et al., 2020). Moreover, seawater is gradually intruding groundwater all around the world's coasts. These phenomena are caused by a combination of climate change and increased human activities (Agoubi, 2021). Coastal areas are particularly important zones in our global world because of their significance in the creation of natural and socio-economic resources. A huge part of the global population has settled somewhere around the coast (Nicholls & Lowe, 2004). The World Economic Forum warned that in 2100, up to 410 million people are risking their lives because of the rise of the ocean (World Economic Forum, 2022).

One of the best ways to counter these challenges in many parts of the world is the use of mangrove forests near the coastline. Because these trees grow at the intersection of land and sea, they form a natural protection layer against climate-related problems (Huxham, et al., 2018). Mangrove forests are important for the stability of coastal areas for multiple reasons. Mangrove trees are very efficient in weakening strong currents or waves. Together with the presence of other vegetation such as seagrass, mangrove forests can uphold short and long waves. Long waves can only reduce if the forests are healthy and stretched out to some extent. A short forest line would not do enough to stop the waves (Phan et al., 2015). Besides this, mangrove forests are good mechanisms for slowing down intense winds from storms. Researchers found that towns without the protection of mangrove forests are damaged more by intense winds than towns that did have this protection (Das and Crépin, 2013). Mangrove trees are also excellent mechanisms in the absorption of heavy metals. Surrounding water and soil remains healthier than without the presence of these trees (Sandilyan and Katherisan, 2014).

In the Mekong Delta of Vietnam, the amount of mangrove forests is decreasing all across the coast because of a combination of climate change such as salt intrusion and human-caused practices (Phan et al., 2015). According to Thu and Populus (2007), one of the main contributors to this decline is the aquaculture sector which has been growing in the region because of the Delta's ultimate natural conditions of brackish water. Between 1953 and 1995, over 160,000 hectares of mangrove forest in the Mekong Delta were removed by the Vietnamese population to make way for aquacultural farming (Lai et al., 2022). Ca Mau province has the leading role in the Mekong Delta regarding the cultivation of aquatic animals. This province, located in the southern part of Vietnam, produces one-third of the shrimp in the Mekong (McEwin & McNally, 2014). Because of this, 60.9% of the mangrove areas in the province have been transformed into aquaculture ponds in the period between 1979 and 2013 (Lai et al., 2022). The economic gains of intensive aquaculture farming are so high that many mangrove trees have been cleared for ponds. According to Thu and Populus, many farmers lack the knowledge to understand that the utilization of intensive farming and clearing of mangrove forests has negative effects in the long run (Thu and Populus, 2007).

Nevertheless, Ca Mau people also rely heavily on mangrove forests. The forests serve as protection for their coasts, support fishing activities, provide the raw materials for local houses, and meet a significant portion of the demand for firewood used in household heating (Clough et al., 2000). Therefore, an aquacultural production practice called integrated mangrove-aquaculture is increasingly introduced to farmers in Ca Mau which has the aim to be less harmful to the natural

environment. This is a practice that combines the cultivation of aquatic species such as shrimps and crabs with the preservation of mangrove trees (Alam et al., 2022). According to scholars such as Adam et al. (2022), this aquacultural practice is extensive and can realize higher economic returns than monoculture-produced shrimps can realize while conserving mangrove forests.

The main research question of this thesis is:

What effect does the co-management model have in the integrated mangrove-aquaculture sector on farmers, other stakeholders, and the natural environment of Ca Mau, and how can it be explained using the criteria efficiency, equity, and sustainability?

The research question is connected with some sub-questions:

- **How is the co-management model implemented in the integrated mangrove-aquaculture sector in Ca Mau and which stakeholders are involved in this implementation?**
- **How efficient is the co-management model in this locality?**
- **How equitable is the co-management model in this locality?**
- **How sustainable is the co-management model in this locality?**

Forestry laws regulate most integrated mangrove-aquaculture farms as they are typically situated in areas classified as protection or production forests (McEwin & McNally, 2014). Therefore, there was a necessity for some kind of integrated management of resources by local communities and state governments. This refers as a co-management approach which is the collaboration of resource management between local communities and governmental bodies. The implementation of the co-management approach can improve the management of resources in this sector. Local communities are partially in charge of resource management in their allocated land which according to scholars Thuy et al. (2021) works better in preserving the mangrove forests than if only the government is in charge of this. They add that the co-management model can give many advantages to ecosystem management when the state and other stakeholders also assist these communities when needed. Despite an increased propagation of co-management (Nguyen et al., 2022; Ha et al., 2012; Veettil et al., 2019), this approach is problematized because of the belief that governmental bodies and non-state companies still exercise too much control over mangrove forests in local areas, giving them greater authority in the local sphere (Ha et al., 2012). Even though co-management models also render positive claims in theoretical discussions, the practical implementation of co-management in ecosystem management is not running smoothly. Trung and Thuy (2020) give an example of a bad implementation of the co-management model. In their research, they argued that farmers in Ca Mau who are allocated a plot of land, must comply with all the demands made by the forest owners and therefore they often lack a sense of active participation in decision-making and management. As a result of this, they are not very aware of the preservation of the forest.

To the best scope of the author's knowledge, no research has been conducted yet that researched how well the co-management model operates for ecosystem management in an area of Ca Mau by using the three criteria efficiency, equity, and sustainability. Different authors have discussed these three criteria by different authors such as Van Wilgen et al. (1998) who discussed the efficiency, equity, and sustainability of ecosystem services in South Africa and Hein (2010) who, in his book "Economics and Ecosystems", used the framework of efficiency, equity and, sustainability to find out how well the ecosystem was managed in specific circumstances. Moreover, authors such as

Tenzing et al. (2021) and Young (2013) applied this framework in their studies to research how well the ecosystem has been managed. This research also makes use of the concepts of efficiency, equity and, sustainability to explain what effect the co-management model has in the integrated mangrove-aquaculture sector for farmers, other stakeholders, and the natural environment of Ca Mau. The use of these three criteria gives a comprehensive picture of the workings of the co-management model.

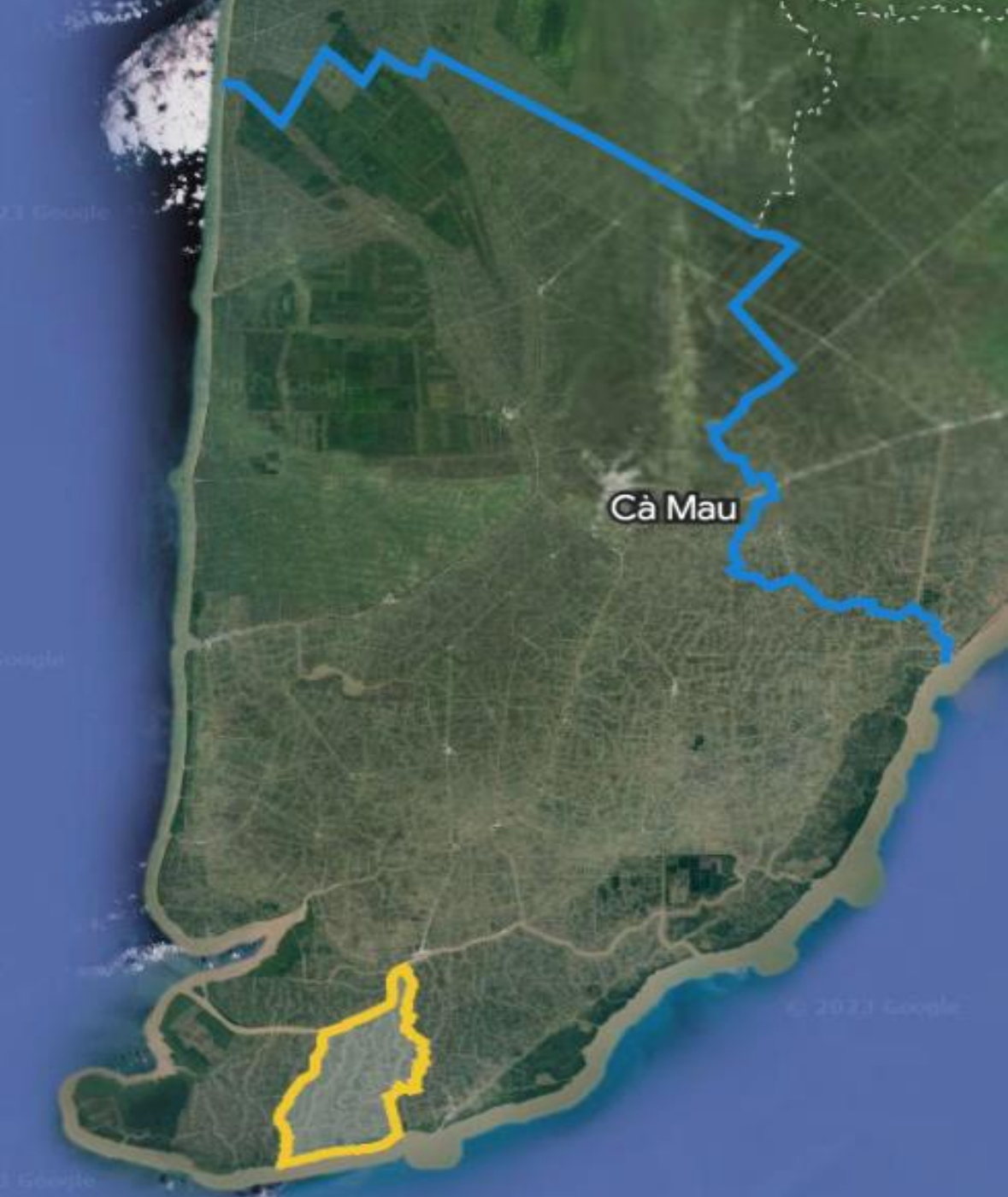


Figure 1: Map of Ca Mau with the commune Vien An Dong. (Source: Google Earth, 2023).

This research is based on a case study of the commune Vien An Dong. The commune is located in the most Southerly situated area in the province of Ca Mau. In figure 1, the blue line shows the border of Ca Mau province and the yellow area is the Vien An Dong commune. The Department of Agriculture and Rural Development (DARD) in Ca Mau characterizes the commune as a buffer zone

which means that most farmers who live here obtained a green certification and are allowed to use 40 percent of the forestland for aquaculture while the rest of the land needs to be used for mangrove forests. The allocation of land, the manner of doing aquaculture and the policies to protect the mangrove forests in this commune are regulations that are made at provincial level (Thoai et al., 2019). The commune offers an excellent example of how land allocation plays a role in integrated mangrove-aquaculture. Moreover, the Ngoc Hien district is the district with the greatest expanse of mangrove forests in the province of Ca Mau (Nguyen et al., 2023); (Trang et al., 2016). It is interesting to understand how the co-management model influenced the preservation of the forest in this commune. The purpose of this case study is not to make generalizations about the results which could affect the whole province of Ca Mau. Instead, it gives a deep and comprehensive insight of the case to find new knowledge and understandings about the co-management model in Ca Mau.

This research is scientifically relevant because expanding knowledge about the operation of the co-management model helps the academic field to gain more insights into the implementations of co-management in real-time events. The research did profound research in the Vien An Dong commune and by researching the efficiency, equity, and sustainability of co-management, novel points of view are established that could add to the discussion of operation of the co-management model. This research could potentially consult stakeholders in the commune such as DARD and contributing companies when changes in the decision-making of the commune need to be made. Besides this, the thesis results are relevant because qualitative mixed methods have been used during the research. The results from the focus group discussion added significantly to the results of the in-depth interviews because only doing in-depth interviews gives fewer challenging viewpoints. Knowing more about the effects of the co-management model is also socially relevant in development because improving models also benefit the wealth and happiness of people that are affected by these models (Shaw & Elger, 2013). Moreover, little to no research has been done, to the author's knowledge, in the Vien An Dong commune which incorporated the voice of the inhabitants of that specific commune. Their complaints and ideas have been listened to and written down. During the interviews, several farmers expressed gratitude for having their voices acknowledged and felt empowered by the ability to articulate their opinions.

The thesis research is divided into 6 chapters. Chapter 1 is the literature review in which the integrated mangrove-aquaculture system and the co-management system are discussed. In the second chapter, the theoretical framework, used to analyze the co-management system in Vien An Dong, is explained. This part clarifies the measurements for the concept's efficiency, equity and, sustainability. The next chapter gives the regional context of the co-management model in the province of Ca Mau. This section includes the history of integrated mangrove-aquaculture, the beginning of land allocation to local farmers, and academics who support and oppose this type of resource management. After this contextual chapter, the results of the interviews and focus group discussion in Vien An Dong are examined and discussed in Chapter 4. This chapter is divided into a part in which general information about the workings of this commune is explained, a part in which the stakeholders who are involved are highlighted, and another part in which the results of efficiency, equity and, sustainability of the co-management model in Vien An Dong are presented. The results are discussed and compared to the ideas coming from the literature review and theoretical framework. In the last chapter, conclusions are made about the effects of the co-management model in the integrated mangrove-aquaculture sector for farmers, other stakeholders, and the natural environment of Ca Mau.

1. Literature review and theoretical framework

The literature review discusses multiple ideas and arguments relating to the concepts nature-based solutions, integrated mangrove-aquaculture systems, and co-management models. Previous studies that deal with these concepts are compared with each other and critically analyzed. This way, the literature review provides a structured context and necessary background information for the theoretical framework and the rest of the research in this thesis. Because both the concept co-management and integrated mangrove-aquaculture farming can have various interpretations, it is important to determine good definitions of these concepts as a foundation for the thesis.

1.1 Literature review

1.1.1 Nature-based solutions

In 2015, the United Nations introduced a set of seventeen goals they wanted to have achieved in the upcoming 15 years. These are called the Sustainable Development Goals (SDGs). These goals are aimed to eradicate economic, social and, environmental problems the world is facing nowadays (United Nations, n.d.). The goals promise interconnection with each other so that solutions can be found that affect all goals positively. However, many scholars argue that this interaction between the goals has not proven to be fulfilling yet and thus most problems will probably not be solved in 2030 (e.g. Seddon et al., 2020). Therefore, researchers have made efforts to find frameworks that do find solutions against the challenges of adaptation and mitigation to climate change, the protection of biodiversity, and the guarantee of human welfare. Nature-based solutions (NbS) have arisen as one of these frameworks (Cohen-Shacham et al., 2019).

Broadly speaking, Nature-based Solutions (NbS) entail collaborative actions that enhance natural systems to simultaneously deal with issues in society (Seddon et al., 2020). The IUCN French Committee (2019) has defined NbS as activities done for the protection, sustainable management, and restoration of ecosystems which are naturally occurring or human-made. The created solutions must be beneficial for biodiversity but also for the well-being of humans because challenges in society must also be addressed. Mace (2014) stated that with the growing interest in NbS, the focus shifted from conserving nature solely for nature's benefit to also conserving nature for the benefit of people. Instead of seeing people and nature apart from each other, NbS are interdisciplinary approaches that connect people and nature. This shift also involved a change from perceiving people as passive recipients of nature's benefits to active stewards of its preservation and restoration. Nesshöver et al. (2017) remark that this participation of many stakeholders and the transdisciplinary characteristic of the NbS is very necessary to conserve biodiversity and restore ecosystems. However, the scholars also believe that the concepts of NbS are still not universally understood which causes the full participation of societies becomes difficult to realize. Therefore, it is necessary to make all the concepts and principles transparent, understandable, and transferable. Only this way, there is a chance to make NbS inclusive and integrative.

NbS can differ in three crucial manners which influence how beneficial they can be for the ecosystem and the socio-economic system. Firstly, the NbS differ because of the wide variation of intervention methods. The protection or restoration of biodiversity by removing dams and making use of stream simulation to restore wetlands is one type of action plan. Another type of intervention strategy utilizes a hybrid-planning mechanism which combines natural with non-natural building mechanisms and infrastructure (Sutton-Grier et al., 2018). Secondly, NbS differ in the way in which local communities are included in implementation and decision-making. Some NbS are designed in a

way that reflects the interests of certain groups but then forgets the interests of other groups (Cohen-Shacham et al., 2019). Lastly, the level of support for biodiversity provided by NbS varies, impacting their ability to coop against natural challenges (Seddon et al., 2020).

1.1.2 Integrated mangrove-aquaculture farming systems

As a response to the intensive shrimp farming sector, integrated mangrove-aquaculture farming systems arose as an alternative, more natural way of cultivating aquatic animals. Alam et al. (2022) believe that integrated mangrove-aquaculture can serve as an NbS to revive coastal areas that have traditionally relied on intensive aquaculture as their main source of income. When farmers receive an economic incentive for protecting the forest, studies show that they are more willing to adhere to these protection regulations. Integrated mangrove-aquaculture farming systems are part of estuarine intertidal NbS. Estuarine intertidal areas are zones in which rivers transition to the sea. These areas are influenced by tides and brackish waters which can naturally be protected by mangrove forests (Dunlop et al. 2023). According to Bing et al. (1997), the inclusion of mangroves in aquaculture farming systems leads to higher economic returns for farmers compared to systems without mangroves. They argue that farms with 30 to 50 percent of mangrove cover yield the most significant returns for farmers. Even having 60 to 70 percent of mangrove cover on the farm is more beneficial than having no mangrove forest at all as claimed by the scholars. Vo et al. (2015) argue that a high forest cover of 70 percent or higher renders the most benefits for farmers even though the benefits seem not as significant for farmers as income from aquaculture in the short term. This is because timber needs to grow a substantial time before it can be logged. Furthermore, farmers are not sure how many costs they need to make with the harvest of mangroves. However, Vo et al. argue that benefits from mangrove forests go further than only logging profits. The forest brings a lot of advantages for aquaculture itself, the protection of the coast, and the extraction of carbon dioxide from the atmosphere. They argue that these benefits are undervalued as they exert a substantial influence on the livelihoods and overall well-being of communities.

Mangrove forests are beneficial for the natural environment according to some scholars. In a study on integrated-mangrove aquaculture in China, researchers Peng et al. (2009) concluded that mangrove forests improve the water quality of aquaculture ponds. The researchers observed that dissolved inorganic nitrogen and phosphate were occurring in smaller quantities in the mangrove-aquaculture ponds than in the ponds without mangrove trees. Furthermore, the PH value was better in the mangrove ponds as well as the amount of dissolved oxygen. This brings positive outcomes to aquaculture production. Venkatachalam et al. (2018) stated in their research that mangrove trees reduce the temperature of water and air. In a cooler environment, aquatic animals grow better and faster than in an environment that is warmer such as in an open aquaculture system. Moreover, a lower water temperature also causes the percentage of ammonia not to increase too much. When the concentration of ammonia becomes too high, it becomes toxic for the aquatic animals in the pond. According to Venkatachalam et al., the species in the pond survived 11 percent more in the ponds with mangroves than in the ponds without mangrove trees.

One of the most significant models that use a type of integrated mangrove-aquaculture system is the Community Mangrove Aqua-Silvi-Culture (CMAS) model which has been researched by Kabir and Baten (2019). In this model, a part of a swamp area is enclosed by dikes and within and on these dikes mangrove trees are growing while simultaneously fishes are being farmed in the surrounding waters. Because the ponds are self-sufficient, they are low in labor and maintenance costs. Kabir and

Baten have calculated that the costs of this model are equivalent to 7 percent of the gross economic return. Therefore, 93 percent of the gross economic return is the net income. Moreover, the ponds are less vulnerable to climate disasters than other types of aquafarming. However, with these types of ponds, the trees bring in a lot of shade and natural waste which decomposes in the ponds. This has the consequence that the ponds become less productive because of higher amounts of tannins and ammonia and lower amounts of oxygen (Rejeki et al., 2019). Alam et al. (2022) agree that, even though leaves also bring nutrients in the water, which is natural food for aquatic animals, it can also impact the quality of the water negatively. Therefore, they argue that economic production from aquaculture in the ponds must be equally important as the ecological impacts from the mangrove trees when developing the layout of the ponds.

1.1.3 The co-management model

Integrated mangrove-aquaculture farming systems often include the use of a co-management model (Alam et al. 2022). Co-management is a broadly used concept which according to Berkes et al. (1991) means the integrated organization of resources or ecosystems by cooperation between stakeholders such as local communities, state governments, and NGOs. Decision-making is done together and responsibilities are shared between the different parties involved. They argue that there is shared accountability and control over natural assets. Agreements that are made between two parties are often seen as fixed, but Beck argues that the process of decision-making is always evolving (Beck, 2000). Co-management is perceived as complex by many scholars, but this complexity has not been well captured according to Carlsson and Berkes (2005). In their research these scholars state, amongst others, that the state and communities are no homogenous entities, co-management is a naturally changing process, the collective legitimation of parties is difficult to realize and the response of the ecosystem to the use of resources is unforeseeable. Taking all this into account, they argue that the distribution of power is more the outcome than the beginning of the co-management process because the making of decisions is constantly developing.

One co-management strategy for organizing resources is the decentralization of government tasks to local communities. Pomeroy (2001) who wrote about co-management in the fishery industry, argues that there is a growing recognition of the direct involvement of fishers in the management of natural resources. Centralized management approaches are often failing because of insufficient involvement from the local communities. By allocating land rights to individuals or communities, these entities gain a greater feeling of responsibility. Giving fishers more rights and obligations increases the stimulation of investments which eventually leads to more efficient production. Because they gain the benefits of resource management as well as the costs, individuals or communities will be more encouraged to preserve the resources (Pomeroy, 2001). To make sure that the resources are managed effectively and to decide who is granted rights to property and who is not, the government creates some rules of operation.

Pomeroy (2001) also argues that there are various kinds of management strategies. Firstly, there is the basic co-management model which gives people rights to access the land without making them owners. The land is namely still the state's possession. The roles are divided in a way that the national government provides policies or regulations which authorize local communities to manage natural resources. Besides this model, there is also the community-based management model which gives ownership to an individual or community. Within this management model, the community has full control and responsibility over its commons. With their knowledge, skills, and capacities, they

take care and make decisions for their small-scale resources such as a part of a forest. State authorities are not hugely involved in this strategy (Korten, 1986). Tole (2010) believes that this approach can be greatly beneficial because it is low in cost and local people can feel more empowered by managing these resources. Finally, Pomeroy (2001) states that when community-based management is an internal part of a co-management model, this is then called the community-based co-management model. CBCM is still centered around the local community who owns the land to manage the natural resources, but the state plays some role in the process because it gives assistance to protect and conserve policies, spends money on infrastructure and needed services, improves education to build capabilities of people and supports communities at the institutional level (Pomeroy, 1998).

This research mostly focuses on land allocation using the co-management model and therefore this literature review concentrates on the opportunities and challenges of this model. Positive prospects of land allocation have been given by authors such as Singleton (1998). He argued that this type of governance over the commons helps combine the strength of both the government and communities while also mitigating their limitations. Moreover, Berkes et al. (1991) have stated that with the granting of access rights to a certain property, people can benefit more from the land. Berkes et al. (2008) also present a positive argument for the co-management model. In the book *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change* is stated that the incorporation of local knowledge on the natural environment coming from tribes or herders can add much useful information to preservation models of nature. Thus, when local people can implement their knowledge on a piece of property, this can enhance the functioning of the ecosystem management of that property. Alam et al. (2022) also argue for a co-management model because it makes the implementation of integrated mangrove-aquaculture systems more sustainable. The local communities are the crucial actors in making and preserving resources according to them, so they must be able to have an important contribution to decision-making processes on resource management. They say that state governments must support these communities with knowledge, finances, and policies and should not overrun the communities' expertise and experiences in maintaining resources. Supporting services must be given by not only national governments but also organizations that are working on these issues. This enduring assistance is significantly important for this method of management to be sustainable.

Brunckhorst and Trammell (2023) add that the co-management approach can work as a bridge between multiple institution levels. When different stakeholders are responsible for the management of natural resources, there is a need for knowledge transfer between the diverse parties so that the resources are coordinated better and a network of mutual trust is created. Both social and environmental challenges can be restored when resource management is coordinated rightly according to Brunckhorst and Trammell. Moreover, the approach leads to higher sustainability in the future than when there is a lack of cooperation between stakeholders because people are more capable of adaptability.

Nevertheless, scholars such as Cronkleton et al. (2012) do not believe that the co-management model in its current stage brings the most benefits to people. According to these scholars, co-management theories, which aim to utilize the full potential of multiple actors within a system to satisfy the needs of all stakeholders, do not always align with what happens in practice. In their research, they investigated how the governments of Bolivia, the Philippines, India, and

Guatemala had partially decentralized the control over forest resource management to communities. They argued that many individuals in the communities did not gain beneficial outcomes from this forest allocation because they were excluded from managing tasks. Others who were allowed to participate could also not fully enjoy the benefits because of the stringent regulations of the state. Castro and Nielsen (2001) also remarked that co-management often is not as beneficial in real life as many theorists may think because of the limited participation of the local communities when decisions need to be made about resource management. They portrayed an example of co-management in a joint forest. Here, the local inhabitants did not share the same power as the forest officers concerning the management of the forest. Moreover, the officers were able to end a contract of land allocation when they observed that the rules were not obeyed properly. On the contrary of this lack of participation and representation, Castro and Nielsen believe that co-management can cause excessive participation with a lot of different opinions when too many stakeholders are involved in the making of decisions. This can cause local communities to be placed in a marginal position. Another issue that arose in research in Malawi according to Njaya (2007) is that informally in some countries, chiefs often have the biggest authority in a community. When a formal co-management structure then is implemented in such an area, conflicts of power can increase. Njaya (2007) for example observed in her research that chiefs often allow fishing which is prohibited according to the rules created in the co-management model. Traditional power structures have to be clarified when making decisions about natural resources. Otherwise, the decentralized co-management model will not work properly.

Schmitt (2009) proposes that it is necessary to create a deeper kind of co-management model that gives local communities more responsibilities and power over their land. He argues for 4 principles that need to be applied within the model which are consultation and organization, negotiation and agreement, implementation, and monitoring and evaluation. The first principle proposes that communities need to gain more awareness and capacity to make the operations of this model work well. The second principle implies that all stakeholders need to negotiate about the implementations of this model and every stakeholder needs to agree on the processes and the regulations before they are implemented. In stage 3, the implementations of the rules are done according to the agreement. Finally, stage 4 entails that farmers have the chance to monitor and evaluate their land. The regulations for monitoring and evaluation are also agreed upon by all stakeholders. Besides this, he also proposes that farmers need to financially profit from protecting the forest so that they have another incentive to genuinely participate in this model.

This chapter discussed integrated mangrove-aquaculture farming systems as being nature-based solutions. A possibility to manage these systems is by using a co-management model with which local communities make decisions and share responsibilities with higher organs such as the government or organizations.

1.2 Theoretical framework

This chapter proposes a theoretical framework which is necessary for examining what effect the co-management model has on the ecosystem. It also introduces the three criteria efficiency, equity, and sustainability which are used in the research to conclude if the co-management model has a good effect on the ecosystem.

1.2.1 Ecosystem management

The proper way to manage the ecosystem is an immensely debatable subject. According to Cortner et al. (1998), ecosystem management is the need to reestablish and protect a part of or the whole ecosystem by making comprehensive decisions that also keep in mind societal desires. At the end of the last century, most scholars agreed that a balance must exist between the economic, social, and environmental aspects of ecosystem management (also called people-profit-planet). The definition of ecosystem management is the adaptation and calculated management of the economy, society, and the natural environment in such a way that the ecosystem can be properly produced, restored, or maintained in the long run (Overbay, 1992). However, this perfect balance is not realistic because there are worldviews that are more biocentric and thus believe that humankind is subordinated to the preservation of nature and worldviews exist that are more anthropocentric and believe that humans are necessary beings to improve nature (Stanley, 1995). Vogt et al. (1996) believe that human values always hinder the management-functioning of the natural system. They thus argue that the management of the ecosystem foremostly starts with a social approach.

Different scholars have researched how well the ecosystem has been managed by using the three criteria efficiency, equity, and sustainability. Research by Van Wilgen et al. (1998), the functioning of Water Programs in South Africa has been taken under the loop. According to the authors, the programs need to be ecologically sustainable, efficient, and socially equitable to be functioning well as an ecosystem service. In the book "Economics and Ecosystems" Hein (2010) also searched how the ecosystem can be managed best. He described three criteria, namely efficiency, equity, and sustainability which are important to examine to find out if a certain ecosystem management system is functioning well. Hein (2010) also acknowledged that it is possible to include more criteria into this balance but that the three previously mentioned criteria are the most significant ones. Other scholars have also used these three criteria to find out how well the ecosystem is managed. Tenzing et al. (2021) researched in their study how efficient, equitable, and sustainable property rights are for management in the rangelands of Bhutan. In another study from Young (2013), environmental governance, which is the activities and decisions of humans on the ecosystem and natural resources, is evaluated using efficiency, equity, and sustainability. The study weights the quality of governance based on these factors. The following part of the theoretical framework delves deeper into these three factors.

1.2.2 Efficiency

The efficiency criteria, defined by Hein (2010), states that an allocation of resources is considered optimal if it results in the maximum net benefit from the utilization of those resources. Efficiency is usually connected with the Pareto criterion. An allocation of a resource is estimated to be Pareto optimal if it is not possible to make any individual better off without making someone else worse off. Tietenberg and Lewis (2018) make a distinction between static and dynamic efficiency. According to them, static efficiency is used to explore situations where the allocation of a type of resource is not influenced by time. This means that the choice for allocation of a resource does not influence how another resource is allocated the year after. Dynamic efficiency, on the other hand, can be used in situations where time is critical to include in decisions for resource allocation. Here, successive decisions for resources depend on decisions that have been made earlier.

Another way to observe efficiency is to look at inefficiencies in ecosystem management leading to possible market failure. Three inefficiencies are discussed further in this section. Firstly,

the absence or shortage of property rights can lead to management problems. Property rights are rights over material and non-material possessions that are legally given to individuals or entities. These rights establish individuals as owners and provide the authority to exclude others from accessing or asserting ownership over their possessions. According to Scott (2000), property rights have multiple distinct features which differentiate them from one another. These characteristics include the ability and security to hold on to the property, the amount of authority and control people have over their property, the time period people have the rights over their property, and the capacity people have to transfer the rights to others. An absence or lack of property rights can have negative consequences on the management of resources. Galiani and Schargrodsky (2011) argue that people will not invest enough time and money if they do not have proper land rights. Mäler (2000) and Tietenberg and Lewis (2018) add that people have fewer incentives to utilize sustainable resources when they are denied property rights because they do not have the assurance that benefits of the ecosystem from investments will also benefit them.

Secondly, environmental externalities can lead to market failures. Externalities in the broadest meaning are unintended effects of decision-making or actions in the economic sector on other individuals or entities who are not immediately engaged in this decision-making or actions. Externalities can be positive and negative. Positive externalities follow when the actions and decisions of an individual or entity benefit other individuals or entities without being compensated for it. An example of this is a progression in skills, knowledge, and motivation related to emerging technologies. These aspects are good for economic growth in society (Steward and Ghani, 1991). Whenever externalities are negative, the actions and decisions of one actor cause damage or additional costs to other actors. Environmental externalities arise when one person who uses an environmental resource influences the ability for another person to utilize this resource in an unintentional manner. This can lead to market inefficiency (Mäler, 2000); (Tietenberg and Lewis, 2018). The emission of greenhouse gases such as CO₂ is an example of such as negative environmental externality because the augmentation of gases in the atmosphere also increases the temperature which in turn causes natural disasters to become more frequent (Rezai et al., 2012). Most ecosystem services, which are the diversity of advantages that are supplied by the ecosystem, are considered public goods which can cause a free-rider dilemma. This can also lead to negative externalities because the possibility for individuals to not pay for these services increases. Other people then have to pay more to compensate for this person's non-cooperation (Mäler, 2000); (Tietenberg and Lewis, 2018).

A lack of knowledge can be a consequence of incomplete information which is the final inefficiency discussed in this thesis. The concept of incomplete information was first discussed in game theory in which multiple actors make decisions that may result in different outcomes. Game theory is based on Neumann's work on zero-sum games in which the advantage of one player results in the disadvantage of another (Von Neumann & Morgenstern, 1945). Players with incomplete information in game theory do not have the availability to particular characteristics of the game which makes it more difficult to make the most beneficial choice (Peters, 2008). According to Harsanyi, incomplete information comes in many forms such as the lack of strategic outcomes or the non-availability of strategies and information other people obtain. The Game Theory is used to analyze how to make rational choices in a specific context of everyday economic, social, and political life (Harsanyi, 1995). Rarely do all actors in a market receive complete information about the immediate and external effects of their money spend on ecosystem management. Often people do

not understand the workings of the ecosystem or the way that the ecosystem can create economic value (Mäler, 2000); (Tietenberg and Lewis, 2018).

1.2.3 Equity

The second criterion is equity which describes how fair and just certain circumstances are. Equity is different from equality in that equality-based theories consider everyone to have the same rights and needs. On the other hand, equity-based theories recognize that people are not totally like each other and need different essentials that have to be fairly distributed (Espinoza, 2008).

To research equity, we can observe the distribution of benefits in a certain society. With the Theory of Access, Ribot and Peluso (2003) have offered a way of thinking that looks at individual preferences for benefits and access distributed by society. For individuals, there are certain agent-level factors that can influence the distribution of benefits such as ownership, location, and ethnicity. Access from society is influenced by structural factors like social exclusion and class. The agent-level and structural level can negotiate what the actual access to benefits will be. When looking at how well the benefits provided by the ecosystem are distributed amongst the local inhabitants, we look at access to natural resources. Stakeholders rarely profit similarly from ecosystem services. There always are some people who benefit more from them than others. Alteration in the ecosystem can impact people differently because they are not dependent on the ecosystem in the same way. Moreover, people often have different accessibility rights to ecosystem services. Lastly, the history of people regarding the utilization of a resource can also differ (Hein et al., 2006).

The criteria equity also measures the level that inhabitants can be involved and represented in making decisions about the management of the ecosystem. The management decision of an individual stakeholder or a small alliance of stakeholders can have a significant influence on the quantity and quality of ecosystem services to the rest of the stakeholders involved. Therefore, it is more practical to make management strategies that all stakeholders then have to follow. A problem that can arise with this is that some people are better represented in decision-making than others. It can especially give negative consequences for people when there is a hierarchical structure in which the most powerful make decisions for the people with less power. Hein argues that in general terms it is preferable to implement and design management policies for the ecosystem with all stakeholders participating. Enforcing policies on the ecosystem can become a challenge if local interests do not support this (Hein, 2010). To find out how certain strategies within ecosystem management are represented, it is possible to research how policies are reflecting the interests of all the stakeholders involved. However, scholars such as Soma and Vatn (2009) also state that there are some risks associated with the integration of all voices in policymaking. The interests of the stakeholders in the gatherings can be more contradictory than the interests of the overall people living in the area, the environment, and the generations of the future.

1.2.4 Sustainability

Lastly, the criteria sustainability measures what the probabilities are that ecosystem management is still working well in the future. This criterium can be interpreted in multiple ways because of its broad meaning. A definition of the concept of sustainable development was first introduced by the World Commission on Environment and Development (in the Brundtland report of 1987) and was described as: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). Hein took this definition into account and defined sustainable ecosystem management as a type of

management that ensures the ability of the ecosystem to deliver a comparable quantity and quality of ecosystem services to future generations as it does today. Scholars Barbier and Markandya (1990) describe that management choices can be evaluated on their sustainability level by studying their effects on the ecosystem in the future. They also argue that management of the environment is done less sustainably when preliminary levels of environmental quality are low in a specific area. The reason behind this is that in present times the costs of achieving a clean environment are high and unsustainable economic growth has much more benefits for people. Degradation of the environment mostly occurs in future times and is less on people's minds than income loss in contemporary times. Tietenberg and Lewis (2018) connect the concept of sustainability with that of static and dynamic efficiency. Static efficiency takes less in mind the sustainability of a resource because the current choices that are made do not consider the consequences of these choices in the future. Dynamic efficiency is more sustainable because this concept considers that the use of the resource should generate the greatest possible benefit over time, taking into account the exhaustible character of the resource and the impact of its use on future generations.

To define sustainability, it is also possible to make a distinction between weak and strong sustainability. In 1974, Solow proposed in his research "Intergenerational equity and exhaustible resources" that it is possible to let the economy grow endlessly even if natural capital is scarce. He said that natural resources can be extracted as long as other capitals are replacing them. Neumayer (2003) however stated that this situation can be seen as weak sustainability. Here, human and natural systems can be considered independent compartments without restrictions. The various kinds of capital (economic, social, and environmental) need to be constant when they are summed up. If economic and social capital grows, it does not matter whether natural resources are running out. In a system of weak sustainability, capital can be substituted for one another. On the other hand, Neumayer (2003) argued that with strong sustainability, human systems are part of the natural system. This means that economic and social capital cannot exceed the boundaries of the natural environment. Natural and human capital are complementary, not interchangeable. To secure economic welfare in the long run, both reserves must be protected. Ott (2003) also argued that human capital can be limited by natural capital when this becomes scarce. That is why the author argues that societies need to do more investments in natural capital. This limitation of human capital, however, does not make living conditions for people unbearable because strong sustainability still allows the production of human capital to some extent.

1.3 Conceptual framework

Figure 2 presents the conceptual framework. This framework shows how the theories are connected with the literature and the research questions. It is first important to know how the specific co-management model and the integrated mangrove-aquaculture system in Vien An Dong are implemented. Moreover, the stakeholders that are contributing intensely in the commune, need to be highlighted. When the big picture is clear, the question of how efficient, equitable, and sustainable the co-management model is, can be answered. Based on the theoretical framework the three broad concepts are divided into different criteria to make the measurement process more straightforward. With the criteria of efficiency, the research looks at the absence of property rights, environmental externalities, and incomplete information. The factor equity is measured by researching the distribution of benefits and representation and participation. Lastly, to measure sustainability, the research observes strong and weak sustainability. With this information, the main question is answered which is:

What effect does the co-management model have in the integrated mangrove-aquaculture sector on farmers, other stakeholders, and the natural environment of Ca Mau, and how can it be explained using the criteria efficiency, equity, and sustainability?

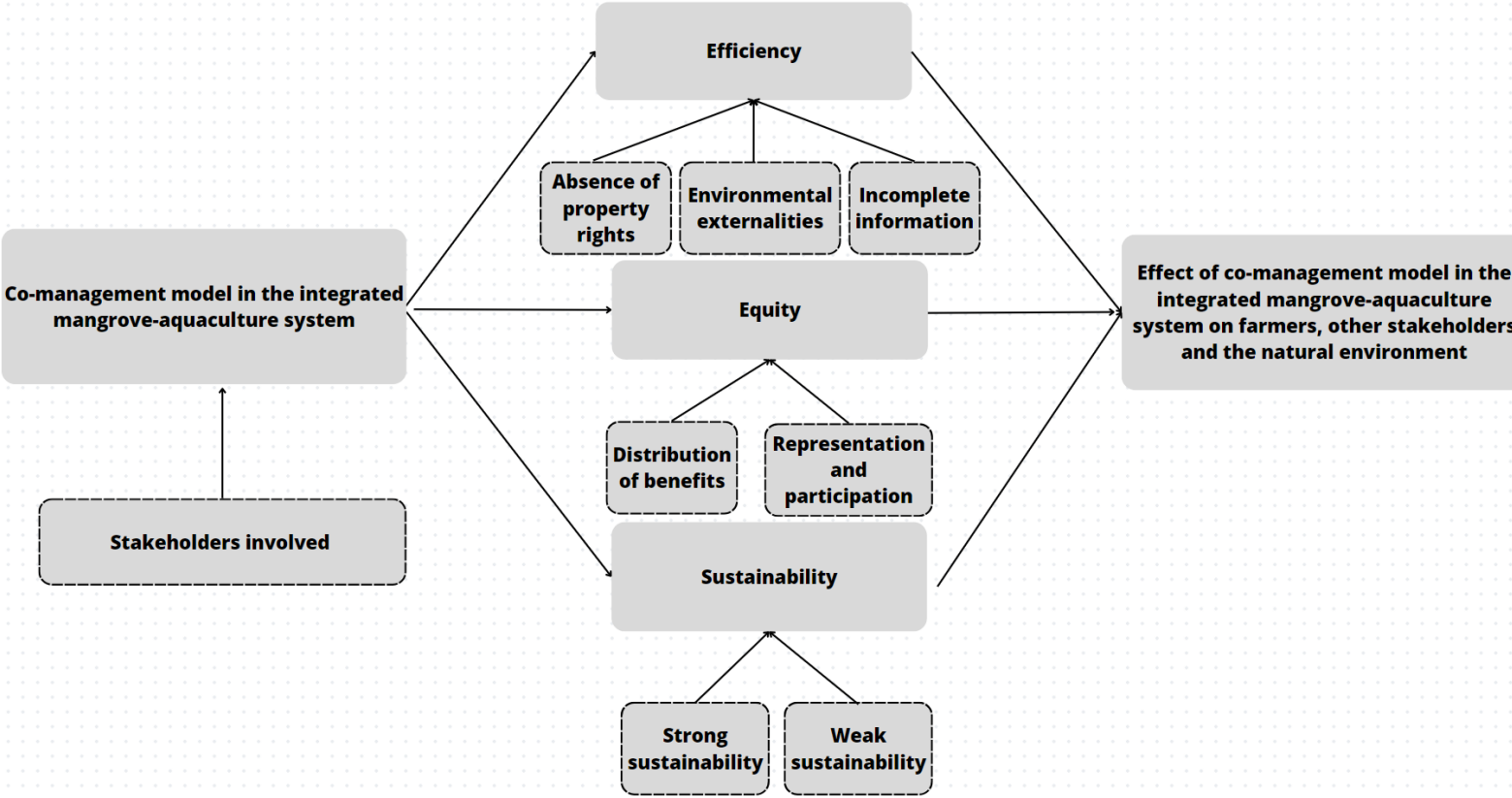


Figure 2: Conceptual framework (Source: Anouk Starmans, 2023).

2. Methodology

Before this thesis discusses the regional context of integrated mangrove-aquaculture and the co-management model in the province of Ca Mau, the methodology chapter explains how the research is executed. First, the abstract theories and literature are operationalized to make the researched concepts more measurable. Then the different sorts of methods used to conduct the research are clarified and the sampling strategy is given. Lastly, the research makes some limitations related to the research visible.

2.1 Operationalization

This research focuses on the effects of the co-management model in the integrated mangrove-aquaculture farming system for farmers, other stakeholders, and the natural environment of Ca Mau. It investigates the particular implementation of the co-management model and the functioning of the integrated mangrove-aquaculture farming in Ca Mau by making use of results found in the commune of Vien An Dong. Moreover, it gives an overview of the most important stakeholders in this area. To answer the question of how efficient, equitable, and sustainable the co-management model in the integrated mangrove-aquaculture farming system is, operationalization of the three concepts is necessary in this thesis. The concepts of efficiency, equity, and sustainability were not used in the interview guidelines for farmers, the focus group discussion, the spokesperson of Dat Mui (a Forest Management Board), and the vice-director of Minh Phu (a shrimp company) because the staff of Kim Delta advised that the people of the commune would perhaps not understand these concepts. Therefore, the guidelines were organized into five parts, namely: opening questions, economic, social, and environmental sections, and lastly a few closing questions. Dat Mui did have an extra section with questions about the functioning of policies in the commune because of their governmental role. The questionnaires of the individual farmers and the focus group discussion are found in Appendix A, B, C, and D.

With the criterion efficiency, the thesis operationalizes the three inefficiencies lack of property rights, environmental externalities, and incomplete information. To find out if the commune lacks property rights, farmers were asked social questions related to the rights on their lands and their opinions towards the amount of control over their lands. Economic questions about the change or continuation of farmers' production, income, and everyday spending were also asked. The research questioned these sets of questions to find out if a correlation exists between the level of production and income of farmers on the one hand and the farmers' control over their land on the other hand. In the environmental section, questions were posed to explore the potential presence of environmental externalities. Farmers provided responses regarding the presence of pollution on their lands and, if they acknowledged this, they were further asked about the source of this pollution. Lastly, the thesis researched the level of incomplete information by asking farmers if they were able to attend meetings and workshops in the social section. This way, the research found out if higher authorities shared practical and ideational information with farmers.

The thesis researched the criteria equity by operationalizing the distribution of benefits and representation and participation. To identify the distribution of benefits, the research needed answers on the combination of social questions relating to the opinions towards control of the land, economic questions about the level of income and production and some opening questions such as the size of the farmer's land. In so doing, it is possible to identify if smaller farmers gain fewer benefits in the commune than big farmers. This research defines small farmers as owning less than 5 hectares of land and big farmers as owning more than 5 hectares of land. The amount of representation and participation of farmers was detected by looking at farmers' responses in the

social section. They were questioned if they had attended meetings and if, in these meetings, they could participate in regulation-making about the commune.

The thesis uses the concepts of strong and weak sustainability to research the sustainability of the co-management model. To discover the strongness or weakness of sustainability, farmers were asked environmental questions about their opinion towards forest conservation, the current residence of animals in the commune, and the change or continuation of forest cover on their land. The economic questions regarding the production and income level of farmers were also used here because economic prosperity is also important for sustainability. The future prospect of the co-management model and the commune is discussed with the answers to these questions.

Appendix E includes a code tree that provides all the inductive codes found before the research conducted the interviews with the stakeholders and the deductive codes which were discovered after the research conducted the interviews. This tree gives additional clarity about the operationalization of the three criteria because it shows the connections between the criteria efficiency, equity, and sustainability and the codes which fall under these criteria.

No	Date of interview	Gender	Age	Experience	Total family members	Education	Size of farm (in hectares)
Farmer 1	28-02-2023	Male	45	40	4	Secondary school	6
Farmer 2	28-02-2023	Female	46	30	4	Primary school	12
Farmer 3	28-02-2023	Male	59	36	6	Secondary school	10
Farmer 4	28-02-2023	Male	52	25	4	High school	8.5
Farmer 5	28-02-2023	Male	60	34	7	Secondary school	4
Farmer 6	01-03-2023	Male	36	10	4	Secondary school	2.5
Farmer 7	01-03-2023	Male	56	33	7	Secondary school	3.6
Farmer 8	01-03-2023	Male	60	22	5	Secondary school	2.6
Farmer 9	01-03-2023	Female	48	24	4	Secondary school	2.2
Farmer 10	01-03-2023	Male	55	25	5	High school	12
Farmer 11	01-03-2023	Male	52	25	6	Secondary school	10
Farmer 12	01-03-2023	Male	61	40	2	Primary school	3.4
Farmer 13	02-03-2023	Male	52	18	4	Primary school	4.8
Farmer 14	02-03-2023	Female	45	20	5	Primary school	4
Farmer 15	02-03-2023	Male	57	32	3	High school	6.7
Farmer 16	02-03-2023	Female	42	18	5	Secondary school	3.1
Farmer 17	02-03-2023	Male	56	35	6	High school	2.7
Farmer 18	03-03-2023	Male	71	32	3	Secondary school	5.2
Farmer 19	03-03-2023	Male	81	20	2	Primary school	5
Farmer 20	03-03-2023	Male	69	30	2	Primary school	4.4
Representative 1	07-04-2023	Male					
Representative 2	07-04-2023	Male					
Representative 3	07-04-2023	Male					
Spokesperson Dat Mui	07-04-2023	Male					
Vice-director Minh Phu	15-06-2023	Male					

Table 1: Codebook of all the stakeholders with some basic characteristics (Source: Anouk Starmans, 2023).

2.2 Methods

The method section explains the different kinds of methods together with the sampling techniques. Firstly, 20 in-depth interviews have been conducted in Vien An Dong with farmers of the commune. Individuals may have different views and experiences on the extent to which they think this model has been working well for them and for the environment. All these 20 interviewed farmers were allocated a piece of land by the Forest Management Board Dat Mui of which they can use 40 percent for aquaculture while the rest of the land (60 percent) must be covered by forest. This research made use of purposive sampling which is a nonprobability sampling technique. The thesis choose certain criteria such as a balance between men and women participants, as well as a diversification of income levels, ages, locations, and land sizes. With this sampling technique, the goal is not to generalize over a population but to find rich and comprehensive information in the commune (Etikan et al., 2016). To have a multitude of stories, it was preferable that the participants had diverse characteristics. These criteria were submitted to Minh Phu which is a big shrimp production company with a great deal of influence in the commune. Minh Phu gave assistance to find these farmers because the company has a good relationship with many farmers. They collect and process shrimp for good price thus the shrimp company could more easily reach out to them than when outsiders would have.

Table 1 highlights the characteristics of the stakeholders and each farmer has a code to give the result and discussion section a better structure. The interviews were finally conducted with more men than women, namely 4 women and 16 men. Moreover, the average age of all the farmers was relatively high. Nevertheless, the farmers' ages ranged from 36 to 81 years old. Aspects in which diversity among the farmers was visible were the availability of participants with small and big farm sizes. Income diversification was also present and the farmers' experience in mangrove aquaculture varied between 10 and 40 years. With regard to education, four farmers completed primary school, ten farmers completed secondary school, and four farmers completed high school. Finally, the farmers' households varied between 2 members and 7 members.

As the map in Figure 3 shows, the chosen farmers are widely spread across the northern part of the commune. Some farmers are living close to each other but others live in more remote places of the commune.

Besides interviews with farmers, one focus group discussion took place with 3 representative farmers of the commune. They are numbered from 1 to 3 and all represent a group of around 35 farmers in the Vien An Dong commune. Farmer 1 is the representative of 37 farmers, farmers 2 spoke on behalf of 40 farmers and farmer 3 represents 32 farmers. All three of them have

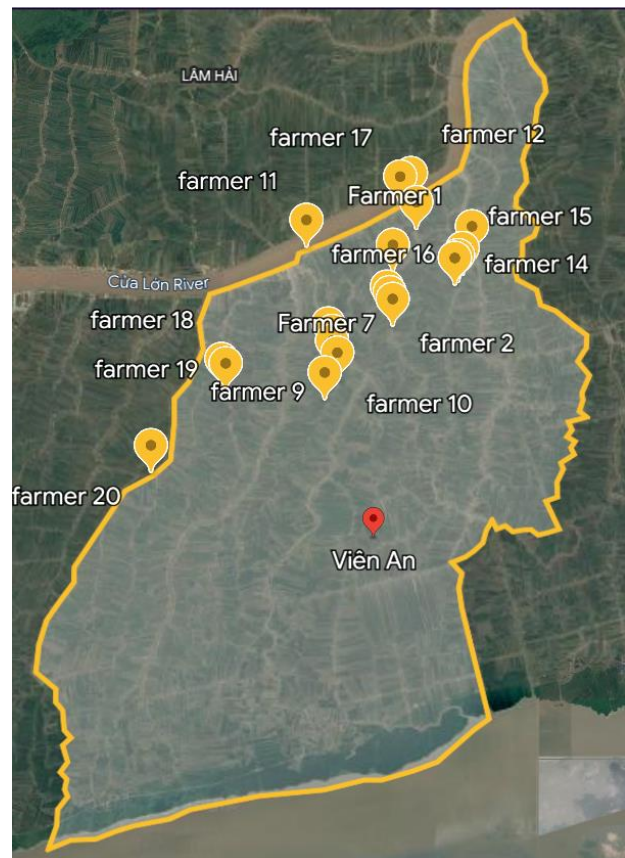


Figure 3: Map of farmers' locations in the Vien An Dong commune (Source: Google Earth, 2023).

lived in the commune for over 30 years and have a lot of experience in mangrove-aquaculture farming. The shrimp company Minh Phu also found these three men. The research placed the representatives in a focus group to discuss the similarities and differences in income levels of the farmers they represent, general opinions about the 60/40 ratio, general opinions about land rights, and views about the cooperation between farmers in the commune. Some interesting resemblances between the representative farmers were found here but also some contrasting opinions became known.

In addition to the research done with farmers, the stakeholders Dat Mui and Minh Phu were interviewed. Dat Mui, an essential part of DARD, is the Forest Management Board which allocates land to farmers in the commune. The interview with Dat Mui was not extensive but questions around policies in Vien An Dong were discussed. Moreover, the employee explained what the role of Dat Mui was in the commune. The vice director of Minh Phu participated in an online interview. Minh Phu is a direct actor in the vertical production chain and therefore they know a lot about the production process of aquaculture farming. They were asked, among other things, whether they think that farmers who implement this model have the chance of a good income and whether farmers can get by with their income. They are also socially and environmentally involved so their view on the status of pollution, biodiversity and forest cover in the commune was asked. Moreover, their opinion about the farmer's level of rights, responsibilities, and participation was questioned.

2.3 Ethical considerations

All stakeholders gained knowledge of the research through an informed consent form which was communicated to them in Vietnamese before the interviews started. This consent form described the voluntary participation of the respondents as well as their anonymity in the research and the minimal risk of harm from their participation. The transcribed interviews are confidentially held by the researcher and will not be shared. Because of the participant's anonymous cooperation, the data cannot be connected with the individuals who have participated.

2.4 Positionality

The author's background is that of a woman from a Western cultural context. During the research, the researcher reflected on this positionality by attempting not to make too many presumptions and by adapting to the Vietnamese culture as much as possible. One way in which positionality could have affected the collection of data is that the researcher has close and informal connections with Kim Delta. Kim Delta is a company located in Can Tho (the Mekong Delta) that trains and consults industries in the fishery, aquaculture, and agricultural sector on possible efficient solutions for the future. The organization has knowledge of value chain management of agrifood and how to create an efficient business plan (Kim Delta, n.d.). The organization helped find the location for the research and was an intermediary with relevant stakeholders. The objectivity of finding the research area, stakeholders, and translator could have been affected by the personal bond with them.

2.5 Limitations

Some other limitations became visible during the research. Firstly, the use of a case study within a research brings limitations because external validation is difficult to realize (Bryman & Bell, 2007). The one case of Vien An Dong cannot give general results for the whole province of Ca Mau. The study of Vien An Dong must be used in its specific context to add knowledge to the larger context. Secondly, even though Minh Phu's contribution to finding the respondents was helpful, the company is also a stakeholder who has significant interests in the commune. Therefore, it cannot be ruled out that Minh Phu chose farmers for its own convenience. Thirdly, none of the stakeholders could speak

English which made it necessary to communicate through a Vietnamese translator. The interviews were fully transcribed and translated afterward but cross-cultural communication barriers during the interviews could not have been avoided which occasionally led to misunderstandings. The translator sometimes had difficulties communicating with respondents because of a disparity in accents between her and the respondents.

Besides practical limitations, some boundaries have to be mentioned regarding the use of theories in this research. The choice to only research three inefficiencies in the efficiency part is a limitation in this thesis because multiple problems were analyzed during the interviews which cannot only be divided into lack of property rights, environmental externalities, and incomplete information. The criteria efficiency is therefore not as comprehensively researched as could have been possible. The same problem is found in the equity and sustainability section. Equity, namely, is not fully researched when only observing the distribution of benefits and representation and participation. Similarly, sustainability is not completely defined as strong or weak sustainability. In future research, other criteria can be researched to give additional or contradictory information on what has been found.

3. Regional context: Co-management model in integrated mangrove-Aquaculture systems of Ca Mau

In this chapter, the province of Ca Mau is taken under the loop since it is the province in which the Vien An Dong commune is located. First, this chapter discusses a brief history of aquaculture farming in the province, followed by an explanation of the working of integrated mangrove-aquaculture farming and the implementation of co-management models in the form of land allocation.

3.1 Aquaculture farming in Ca Mau

As mentioned before, Ca Mau is located in the most Southern part of Vietnam. The province first belonged to the province which was called Minh Hai. In 1996, Minh Hai was separated into two provinces Bac Lieu and Ca Mau (Thong Thai, 2021). Because of its delta characteristics, the topography of the province is even. A significant portion of the province lies within the intertidal zone with a range between one meter below sea level and one meter above sea level (Clough et al., 2000).

Rice farming has always been an integral part of the Mekong Delta's culture and history. It has provided food and livelihoods for generations of farmers and was very important in determining the landscape and ecosystem of the region. In Ca Mau, this high dependence on rice production was also present. However, in the beginning of the 1980s, Ca Mau began with shrimp farming. The Vietnamese government encouraged farmers to convert brackish rice fields located on the coast to shrimp ponds because this would make the country prosper. International organizations also supported this transformation because of the prospected reduction in poverty and the creation of work and income. Farmers also felt stimulated by the thought of a higher income because they were told that one hectare of shrimp could increase their revenue 160 times compared to one hectare of rice (Binh et al., 2005).

During that time, the way of farming was still very extensive which means that shrimp fry came from the wild and feeding was not supplemented. Farmers just relied on the natural production of ponds with low densities of aquatic animals. Regardless of this, shrimp production went from 3000 hectares in 1980 to 40.000 hectares in 1987. Around the beginning of the 1990s, post-larvae were cultivated in hatcheries and farmers started to supplement feed for the shrimps. In 1992 the produced shrimps had increased to 60.000 hectares (de Graaf & Xuan, 1998). In the early 2000s, a more intensive way of shrimp cultivation was introduced in the province. This meant that more shrimps were put in a smaller pond and artificial feeding took the upper hand. Because of this method, shrimp production went up drastically to around 600.000 hectares a year (Ha, 2012). In contrast, rice production declined immensely during that same period. Between 2000 and 2005, rice production during the summer season went down with 50.000 hectares and during the winter season it, even decreased with 150.000 hectares (Nhung et al., 2019).

This conversion of rise in shrimp production also initiated the transformation of 68,000 ha of mangrove forests into shrimp ponds in the period between 1979 and 2013 (Lai et al., 2022). Besides the clearance of mangrove forests, other damaging consequences have paved their way into the province due to the popularity of intensive shrimp farming. One of these negative consequences is that intensive shrimp farming has a much higher risk of disease outbreaks. This can be destructive for the farmers of these intensive ponds but the disease also has the possibility of spreading to more extensive shrimp producers. Intensive shrimp farming also harms the biodiversity of the province.

Because of an incline in chemical use, which is used to eradicate other varieties of fish that otherwise eat the shrimp feed, the biodiversity in the ecosystem of Ca Mau faced some losses (Nair, 2015). The use of pesticides for better productivity by intensive shrimp farmers which causes negative consequences on the environment and extensive farmers is defined as an environmental externality according to Xuan and Sandorf (2020).



Figure 4: Map of Ca Mau province with districts. (Source: Viipip, n.d.)

Despite the increase in intensive farming, this method is not the predominant shrimp farming system in the province because of the province’s natural mangrove ecosystem. In Ca Mau, much more extensive farming is used than in other provinces of the Mekong Delta. In the Nam Can and Ngoc Hien districts, which are the 2 most Southern districts in Ca Mau shown in Figure 4, integrated mangrove-aquacultural farming is the conventional way of cultivating shrimps and other aquatic animals. In 2009, integrated mangrove-aquaculture farming attributed to 15% of total shrimp

farming in the province. In contrast, intensive shrimp farming has only attributed to 0.5% of the total farming (Ha, 2012). Because of this less significant reliance on intensive shrimp farming, the province also experienced fewer losses in biodiversity and smaller outbreaks of diseases than neighboring provinces (Nair, 2015).

3.2 Co-management in Ca Mau

Besides the already existing nature of mangrove-shrimp farming in the province, the issue of mangrove loss in Vietnam was further addressed by the government which implemented a replantation program for mangroves. Until the mid-1980s, forests were protected and managed by the national government and thus state property. State Forest Enterprises (SFEs) were in control over management and replanting programs. However, a lot of forests still disappeared and the state decided to decentralize the forests in 1986 and give more tenure ship to the Vietnamese inhabitants who then acted as protectors of the forests. This would hopefully stimulate socio-economic development while improving the maintenance of the forests (Ha et al. 2014). In Ca Mau, this decentralization strategy also increased in use. As part of the program, farmers were incentivized to replant mangroves in areas that belonged to the government. Moreover, the farmers were hired to preserve and oversee the management of the mangrove forests. In exchange for these efforts, they were allowed to harvest some parts of the mangrove forests. Additionally, the farmers were given the right to utilize a part of their land for aquaculture farming (Binh et al., 1997).

In the 90s, these decentralization practices even went further. In 1993, the Land Law was established which gave official rights of land property to people for a longer time by means of a certificate. Two types of certificates were offered. With the green certificate (also called the green book), farmers obtain a contract that gives them the right to use the land for 20 years. These contracts can be re-established when these 20 years are finished. With a red certificate (also called red book) farmers are owners of the land for 50 years. Farmers with a red book have more authority over their lands than farmers who own a green book. However, both certifications give farmers the right to collect the benefits made on the land (Ha et al. 2014).

The coastal areas in Ca Mau exist of three zones. People with a red book are placed in a zone, furthest away from the coast, called the Economic Zone (EZ). Here, almost no mangrove trees are existing anymore so there is no need for much protection and conservation. People with a green book are mostly placed in a Buffer Zone (BZ). In these zones, 50 to 70% of the land must be covered with mangroves while the residual 30 to 50% can be utilized for constructing ponds, dikes, and houses. Buffer Zones are situated along the coast, right behind the full protection zone (FPZ). In this last zone, any type of living and farming is prohibited. Before 2009, mangrove trees were allowed to be harvested every 14 to 20 years by farmers in the Buffer Zone. The collected wood could be sold and farmers obtained most of the profit (up to 95 percent). From the income they received, costs for planting investments needed to be subtracted. Figure 5 shows how farmers are replanting mangrove trees on their lands. However, farmers with smaller-sized lands did not profit that much from the harvest. Therefore, Forest Management Boards in some communes lowered the growing period before harvesting to 10-12 years (Ha et al., 2013).

In the province of Ca Mau, 13,600 hectares of mangroves were replanted because of these programs in the period between 2003 and 2013 (Lai et al., 2022). Many scholars agree that this land



Figure 5: Farmer plants mangroves in their pond in Vietnam's Ca Mau Province (Source: GreaterMekongSubregion, n.d.)

allocation model can help with the organization of integrated mangrove-aquacultural farming. Christensen et al. (2008) did research on a co-management project in the Ca Mau province. 7 mangrove forest enterprises are located here which include fully-protected forests and zones where 40 percent of the surface can be used by humans in a sustainable manner. Besides the use of these forests for aquaculture, local people are also allowed to collect wood. The researchers believe that this

integrated coastal management gives excellent social, economic, and ecologic outcomes. Other scholars who argue that co-management can become very beneficial for integrated mangrove-aquaculture systems are Nguyen et al. (2022). They argue that without the institutionalization of coastal zone management with rules and structures between all the actors involved, integrated mangrove-aquaculture systems will become less successfully implemented. It is important to build a trustful network between the local farmers and local governments.

Some authors such as Ha et al. (2012) and Veettil et al. (2019) also agree that such a more decentralized approach is beneficial in coastal areas with mangrove lands such as Ca Mau because it empowers local people. The people must feel that they can be co-owners of the mangrove forest because this would encourage them to act as protectors and actors of reforestation while using the area for fishery, eco-tourism, and other purposes. So, besides the safeguarding of mangroves, the model also promotes communities in a social-economic way. However, Ha et al. (2012) also argue that it is questionable to give full property rights to the communities in communes of Ca Mau, as they found in their research that nearly half of the farmers would use more than 40 percent of their land for aquaculture ponds and decrease the portion allocated for mangrove forests. Therefore, they believe that full private forest management in Vietnam has not and will not take place and that the government always remains involved in the management of the mangrove forests in one way or another.

In research from Ha et al. (2014), some hesitations were also expressed about the working of the co-management model in Ca Mau. They are in doubt about the working of land certifications for farmer's empowerment. Even though, decentralization from the state to farmers increased in the last decades, this decentralized system faced numerous institutional and political-economic challenges, resulting in limited progress. Forest Management Boards have not done much effort to deepen the connections between them and the farmers because the distribution of obligations and profits remains low for the farmers. Moreover, inequality is still high in the communes because of the existence of farmers with more privilege who receive more benefits. They do think that the profits generated from aquaculture will become less important for farmers if farmers get compensation for conserving mangroves as an environmental service. Consequently, farmers might decide to prioritize the conservation of the forest. Ha et al. (2013) also discovered that although changes have been made in mangrove harvesting, the Forest Management Boards still obtain more benefits than the

farmers in the Mekong Delta provinces of Bac Lieu and Ca Mau. They state that the conservation of mangroves would be more interesting for farmers if the time between planting and harvesting became even shorter. This way, farmers would obtain income from harvests more frequently. Besides this, the authors think that farmers would feel more responsible for the preservation of mangroves if they had more independence regarding the management of the trees. Lastly, transparency and fairness about benefit- and cost-sharing amongst the farmers and the Forest Management Boards would help with elevating farmers' interests in the two provinces of the Mekong Delta.

Trung and Thuy (2020) also believe that the national government and non-state companies still have too much authority over the mangrove forests in the local sphere. They argue that mangrove forests in most current locations of the Mekong Delta are still mostly managed and regulated by the Forest Management Boards. Local farmers are assigned a piece of land but must almost follow everything that has been demanded by the forest owners. They do not feel as if they can really participate in decision-making and management and do not feel much aware of forest protection. Trung and Thuy propose a community-based co-management model across all the coastal areas of the Mekong Delta because this can establish a contract of ownership between local governments and communities. This would local people make more responsible as co-owners of the mangrove forests. This again, would help with the goal of reforestation and protection of the forests. They state that CBCM models can be efficient because farmers can achieve higher incomes, they can be equitable due to the increase in rights and responsibilities for local communities, and they can be more sustainable because of a more long-term development strategy.

4. Results and discussions

This chapter gives answers to the sub-questions of this thesis by using the results from the interviews and the focus group discussion in the Vien An Dong commune. The chapter is divided into four sub-chapters of which the first one gives a small introduction of the commune. The second part discusses the main stakeholders that have appeared in the research. The third sub-chapter explains how the co-management model is implemented exactly in the commune and how the integrated mangrove-aquaculture farming system is organized here. Finally, the last part shows the results related to the question of how efficient, equitable, and sustainable the co-management model is in Vien An Dong.

4.1 Introduction of the Vien An Dong commune

From 1979, the commune of Vien An Dong was established and initially it was included in a larger region known as the Vien An commune for a period of five years. In 1984, Vien An was divided into three smaller communes, namely: Vien An Dong, Vien An Thay and Dat Mui. The surface of Vien An Dong is around 135.67 km². The commune can only be accessed by going through the entrance in Figure 6. It is not a place with a lot of difference in altitude because the region stays between minus 1 meter and plus 1 meter of the sea level. The area is divided into various parts of land because of the river and its attached canals. This area, like other communes in the Ngoc Hien district, experiences the impact of tide regimes which are uneven and local. Half of the year the area is affected by high tides because of the wet season and the other half of the year the dry season comes to play which is characterized by its lower tides (Thong Thai, 2021).

Because of these specific circumstances, a wide range of mangrove species are observed here. Besides some small populations of other mangrove species, two types of mangrove varieties are found here which form the majority in the commune. These trees are called the *Avicennia* and *Rhizophora* trees but the *Avicennia* is most resistant against higher tides or higher concentrations of salinity in the water. That is why this tree variety is mostly planted in this coastal area (Trang et al., 2016). In their academic research, scholars Thoai et al. (2019) published results that Vien An Dong has faced erosion because of its coastal location. Between the period 1990 and 2010, 693 hectares of land eroded in the river and sea. People also illegally cut down 350 hectares of mangrove forests in the same period. In a survey executed by Nguyen et al. (2022), the scholars researched that mangrove-aquaculture systems (MAS) cover 44 percent of the total area in the commune and 1219 farmers are engaged in the mangrove-shrimp business. On average the size of their farms is 4.3 hectares.

4.2 Stakeholder analysis

Before the thesis discusses how land allocation in the integrated mangrove-aquaculture farming system is facilitated in the commune, this sub-chapter introduces the stakeholders that play an important part in the commune, according to the found data.



Figure 3: Entrance of the Vien An Dong commune (Source: Anouk Starmans, 2023).

4.2.1 The farmers

The commune of Vien An Dong contains mostly fishermen who are occupied with integrated mangrove-aquaculture farming systems and are living in houses next to a water source such as a river or canal which is seen in Figure 7. In 2021, the population of Vien An Dong existed of 10.011 people and the density of people per square kilometer was 74 (Thong Thai, 2021). The three farmers from the focus group discussion stated that most of the farmers they represent were already located close to the area and lived on indigenous shrimps such as silver shrimps and crabs before the co-management system was implemented here. 16 of all



Figure 4: House of a farmer in Vien An Dong next to a small river (Source: Anouk Starmans, 2023).

the respondents from the individual interviews also said that they had worked in the rice fields, as a hired worker, or as a seller of aquatic animals somewhere else near the commune area before they were allocated land in the commune. Then, the state decided to allocate land where farmers could cultivate and sell aquatic animals with which they could generate more income. The most important reason for them to move to the commune was that the income generated from mangrove aquaculture was larger and more stable than what they received from their previous jobs. Farmer 6 said he moved to Vien An Dong: "In the past, I didn't have enough money when working for others, so I wanted to start my own business to make my life more stable."

4.2.2 Minh Phu

Minh Phu is a Vietnamese company that sells shrimp products since. Their website states that Minh Phu is the corporation with the highest export value among all the Vietnamese seafood exporters. They aim to deliver these goods over the entire world while integrating the responsible vertical value chain (Minh Phu, n.d.). All the stages that are included in the process, from the production of the shrimp seed to the final product for customers, are in the control of the company. They argue that this production strategy improves the quality of the shrimp and seeds and makes the whole production process more sustainable (IDH, n.d.). With a responsible value chain, they aim to guarantee safe and hygienic food, protect the environment, keep a balance with the benefits of all people connected in this value chain, and take care of the welfare of animals (Minh Phu, n.d.).

Minh Phu has introduced several projects in the province of Ca Mau which aimed to certify organic shrimp farmers who cultivate their shrimps in mangrove forests. Their goals with these projects are to become more socially responsible, enhance the capability to track and trace a product within the supply chain, and grow people's responsiveness towards the protection of the environment (Vietnam Business Form, 2022). The vice director of Minh Phu indicated in the interview that they have been present in Vien An Dong since 2013. He also stated that farmers need to obey to multiple criteria to obtain a certification for organic shrimp farming from Minh Phu such as compliance with local laws, appropriate waste treatment, the protection of biodiversity, and the maintenance of the forest ratio rule.

4.2.3 Department of Agriculture and Rural Development (DARD) Ca Mau

The Ministry of Agriculture and Rural Development (MARD) is a ministry of the Vietnamese government that lays responsibility for the development of rural areas and for governing, promoting, and sustaining the agricultural industry in the country. The MARD is mainly occupied in the sectors of forestry, irrigation, aquaculture, the salt industry, water management, and flood control. In the whole country, the MARD has 64 departments in each province which are called the Department of Agriculture and Rural Development (DARD) (Devex, n.d.). The ministry's history goes back to 1987. In this year, the Ministry of Agriculture and the Ministry of Food were combined to form the Ministry of Agriculture and Food Industry. 8 years later, in 1995, the Ministry of Forestry and the Ministry of Irrigation were also added which eventually led to the establishment of the MARD. In 2007, the Ministry of Fishery also merged into this ministry (MARD, n.d.).

Forest management and protection is one of the ministry's biggest responsibilities. The MARD must adhere to the laws created by the national government and must ensure that policies and rules are implemented well. They also need to identify the structure of the flora and fauna in forests and with this information they advise the government on how to best set up plans and projects to achieve the most optimal forest protection, management, and exploitation. The MARD is also obligated to organize and guide the way that forest protection and management is executed. Lastly, they also need to coordinate with people who inspect if protection and management rules are followed well (MARD, n.d.).

In Ca Mau, the Department of Agriculture and Rural Development Ca Mau (DARD Ca Mau) is making sure that the national regulations are followed in the province. This department works under the People's Committee of the province which can be seen as the provincial government body. The DARD has to adhere to the laws set up by the Committee and organizes plans and programs that follow the regulations of the Committee. Simultaneously, the department needs to advise the Committee on how to alter or improve the existing regulations (DARD, 2019).

4.2.4 Dat Mui Protection Forest Management Board

In the commune of Vien An Dong, most farmers are assigned land by Dat Mui Protection Forest Management Board. This board is part of the DARD. The responsibility of Dat Mui is to manage, protect, develop, and utilize forests within its designated authority in accordance with the law. They aim to create a management structure of forestland that combines forestry, aquaculture, and agriculture. To combat deforestation the Board assigns households and individuals to live and work on the land while conserving the forest. By communicating the law to the farmers, Dat Mui hopes that the rules are acknowledged and followed so that mangrove forests are not excessively cut down and animals are not hunted. The board also works with NGOs and businesses which can assist in providing the services the community needs to properly implement the law (DARD, 2019).

Diagram 1 shows the roles of the different stakeholders in the implementation of the co-management model in the commune. Dat Mui and the farmers are both internal stakeholders

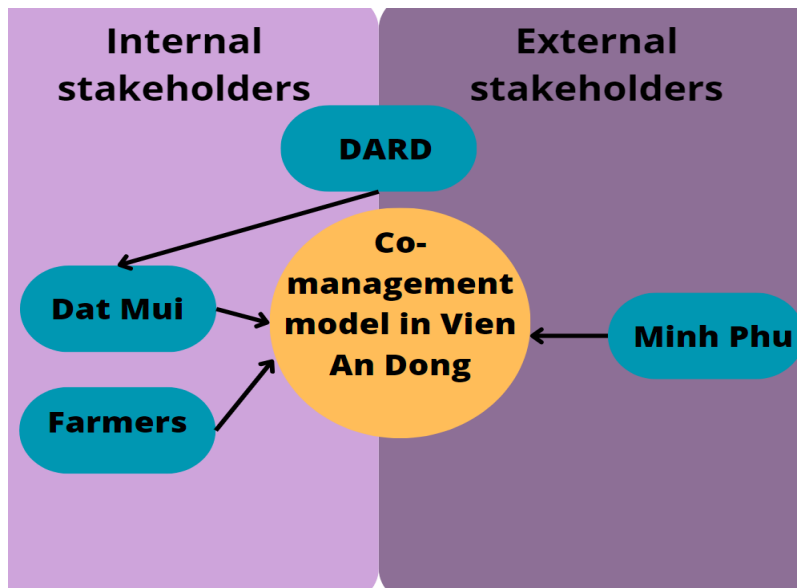


Diagram 1: Visual image of internal and external stakeholders of the model. (Source: Anouk Starmans, 2023)

because they are directly involved in the model. Dat Mui is responsible for the execution of the regulations of DARD. The farmers are immediately influenced by these rules. DARD is also directly involved because the Department's rules are implemented in the commune but they are also external stakeholders because they are not involved in the execution. Minh Phu is an external stakeholder because they are not involved in decision-making processes and do not influence the regulations.

4.3 Co-management and integrated mangrove-aquaculture farming in Vien An Dong

This sub-part explains how specifically the co-management model is implemented in the integrated mangrove-aquaculture farming system of Vien An Dong. In Vien An Dong, farmers live off the land that is allocated by the Dat Mui Forest Management Board. All the respondents of the research said that they had received a green certification when they received land which made them owners of this land for 20 years. 6 farmers are second-generation landowners which means that they were not directly allocated land by the Forest Management Board but received the land rights of the farm from their parents or other farmers. The land however still officially belongs to Dat Mui.

The two main income sources of the farmers interviewed are generated from aquaculture and wood logging. From these two income sources, aquaculture is the most important source of income for all respondents. Because of the land-allocation model, farmers have a chance to do production and earn a stable income in a remote area. According to all the farmers, no taxes are paid to Dat Mui anymore for doing aquaculture because this aquaculture tax was abolished 7 years ago. Therefore, the farmers do not have to share the profits and gain 100 percent of the revenue they make. Moreover, Minh Phu supports the farmers every year by handing out 500.000 VND worth of fingerlings per hectare that a farmer possesses. Farmer 15 also said that Minh Phu pays more per kilogram of shrimp than other collectors even though they sell the shrimp in the market for around the same price as other shrimp companies. This higher price for shrimp was however not confirmed by Minh Phu who said that they paid the same as the market price. The vice director of Minh Phu did say that farmers with a certification for organic shrimp farming were able to receive higher prices for their products from Minh Phu.

Farmers mostly cultivate shrimp and crabs in the ponds on their land. Three-quarters of the farmers also said to catch natural fish in these same ponds which are species of fish that are not cultivated and come in the ponds from the adjacent rivers with the tides. In the past, the shrimps also came from the natural environment but farmers declared that these yields went down because of environmental deterioration. In the focus group discussion, the representative farmers argued that the poor water quality and the unpredictable weather caused the shells of crabs to become

softer and shrimps to turn red. Both characteristics indicate that the quality of the animals decreased. This is why all farmers begin with the stocking of fingerlings of species such as the black tiger shrimp. Twice a month, collectors come to the houses of the farmers to buy their products. The price farmers receive for their yields depends on the size and species of the specific product. Once the collectors obtain the products, they proceed to sell them to businesses such as Minh Phu. Besides shrimps, crabs, and natural fishes, three farmers are raising additional aquatic animals such as clams or oysters because the revenues for these aquatic animals are high. Three other farmers also have the aspiration to cultivate these animals but have not dared to do it because it is a risky business. From the results, it turns out that clams and oysters are not very resilient against diseases. According to farmer 18, there have been attempts by certain households to cultivate clams on a trial basis, but they did not yield satisfactory results. Additionally, farmer 13 has declared that: "If you raise many crabs, you will not dare to release the clams because the crabs will eat them all."

Besides the cultivation of aquatic animals, farmers also may log a part of the mangrove trees in their forest. According to farmers, the logging regulations are that farmers may harvest the mangrove trees after 12 years when the density of the forest is low. When the part of the forest has a high density, the trees will grow slower and therefore farmers need to wait around 15 years. Forests may be thinned out in the meantime if they receive approval from Dat Mui. Figure 8 shows the cycle of mangrove harvest: on the left, the trees are small and just replanted, in the middle image the trees are full-grown and on the right, the trees are just harvested. If too many trees are exploited or thinned out, farmers will be fined. Another rule which was repeated by many farmers was that they have to replant the same number of trees they had harvested so that the ratio of 60/40 would be preserved. Farmers do have to pay taxes to Dat Mui on their profits per harvest session, namely 5 to 10 percent. Furthermore, the farmers are required to log the forest within a certain period. This period is set from July to August.



Figure 5: Harvesting cycle of mangrove trees (Source: Anouk Starmans, 2023).

4.4. Efficiency, equity, and sustainability

This section will provide insights into the efficiency, equity, and sustainability of the co-management model for the ecosystem in Vien An Dong. Initially, the results for each criterion are written down in, followed by a subsequent discussion.

4.4.1 Efficiency

Property rights

Obtaining rights to a piece of land is perceived as positive by farmers because they can, to a certain extent, make their own decisions. Dat Mui does not have the capacity to protect the whole region by itself so they give the community the chance to help with this by giving them the right to be an owner of a piece of forestland for 20 years where they can do production. They receive a contract in which all the rules and rights are written down. The allocation of land and the right to produce on this land is seen as positive by farmers because they do not have a superior who makes decisions for them about everything. Farmer 2 explained: "The Forest Enterprise assigns me to keep the forest, but everything else is decided by myself, I think that is also convenient." Farmer 4 also acknowledged that the rules in the commune were necessary because many farmers would cut down the forest if they are not obligated to follow rules anymore. He said that a neighboring integrated mangrove-aquaculture commune had extensively decreased its forest cover in size because they did not strictly obey the rules. This eventually had the consequence that there was almost no forest left in the commune. Therefore, they had to switch to an intensive type of farming. Farmers thus see the necessity of some regulations in their commune.

Nevertheless, many farmers are not satisfied with the number of rights they have on their lands. Farmers are especially displeased about the rules related to the ratio of forest cover because they cannot choose the forest cover they prefer. 10 farmers declare that the high tree density, caused by the high forest ratio, results in a significant number of leaves that cast shade over the water face in the ponds. The farmers attribute the insufficient oxygen, sunlight, and wind for the species in the pond to the dense tree cover, which in turn reduces production. In addition, the leaves that fall into the ponds may serve as natural fertilizers and food, but as too many leaves decay, they can also contaminate and pollute the water. Farmers think that nature is put above human interest. They say that the current obligated forest cover is too extensive, resulting in a negative impact on aquaculture and thus on income. Nearly all farmers from the individual interviews say that a balance between the protection of the environment and the production of aquaculture needs to be improved. Only farmer 1 is satisfied with the forest-land ratio determined by the DARD. The other farmers rather want to decrease the forest cover.

When the spokesperson from Dat Mui was asked why the ratio is set to 60/40, he replied that the ratio follows the national laws. These laws are based on a significant amount of research and therefore they cannot be changed that easily in the region. The farmers' struggles were also mentioned to the vice director of Minh Phu, who answered that the shrimp company is satisfied with the forest ratio and that farmers must not be able to decrease the forest because it will not make production more efficient. He acknowledged that a lack of sunlight could become a problem for production. However, instead of decreasing the forest ratio, Minh Phu's plan is to replace the forest in such a way that ponds are less covered with shade and receive more sunlight.

Another element respondents want more control over is the harvesting of wood. Even though the harvest of wood is presented by Dat Mui as a manner to earn extra income, the income created by logging is often inadequate for many farmers because it takes such a long time for the trees to be big enough for harvest. It often feels useless for farmers to begin the logging process because it does not bring them profit. Of the 15 farmers who said to have harvested wood in the past, 10 of them only cut down trees once during their life because the rules impose them to wait for the harvest. Farmer 12 even replied that he just harvested for the first time even though he was already living there for 40 years and farmer 4 said: "It is not the age to exploit the mangroves. Not yet, because according to the regulations, they have to be 15 years old, but the trees we planted are

only 10 years old.” So far, this farmer has only thinned out his trees because they came too close to the shore. One of the representative farmers proposed in the group discussion that Dat Mui should give a higher price for harvested wood to farmers which the other two representatives seemed to agree on. However, it was also said by farmers that luckily some of the regulations that Dat Mui had implied regarding harvest were not always regulated strictly by the Forest Management Board. Farmer 1 declared that the replanting of the trees that were harvested does not have to be done all at once: “Planting everything at once is hard for people. Therefore, people can be flexible. For example, if 4 hectares of forest is harvested, the first year, five thousand square meters is planted. In the next year, two or three thousand square meters more will be planted. As long as there is enough area replanted eventually.”

Besides the reduction of the forest ratio and harvesting rules, some smaller criticisms about regulations were spoken out. The liberty to renovate and clean the ponds for aquaculture at their discretion is also an often-heard complaint. Farmers have to empty and clean their ponds within a certain period and they need to ask permission from Dat Mui when they want to renovate their ponds. These strict rules give, according to 4 farmers, difficulties for them to improve their ways of doing aquaculture because they cannot decide for themselves how to handle the ponds. More desires for change in regulations mentioned were to higher the embankments of the ponds to have the ability to grow vegetables and fruits, to higher workers more easily, and to experiment with other aquaculture models such as intensive shrimp farming. Farmer 7 declared that the lack of rights was caused by the farmers’ attainment of the green book: “If the State allocates land and forests to people for cultivation, it must give people freedom to produce, just like issuing a red book to people. However, the current contract “green” book is not good for people. This green book makes it difficult for people to do what they want to do.” Only if the Forest Company enlarged the rights linked to the green book or gives them a red book, he would desire to stay in the commune.

Environmental externalities

The most significant environmental externality according to the farmers is the entrance of polluted water that originates from the intensive aquaculture farming areas and the industrial zones near the commune. Farmers say that these intensive aquaculture areas and industrial zones are producing in a non-sustainable way. Industrial waste and waste from intensive shrimp farming is discharged into the river water. This polluted water is then transported to the commune and leaks into the water resources of the farmers. Farmer 17 speculated that the contaminated water from the industrial zones and high-intensity farming areas could potentially flow into the ponds of the commune during floods. 17 out of 20 farmers thought the environment is more polluted nowadays than the year they were allocated the land. In total, 13 farmers stated that the leaking of this polluted water was one of the reasons that their production and income had reduced since the period they started farming in the commune. A consequence of this pollution was according to farmer 3 that the capture of shrimps from the natural environment had almost disappeared. In the past, he could capture 40 to 50 kilograms of wild shrimps with every harvest moment but that is almost reduced to zero kilograms in present times. Another negative consequence of polluted water coming into the ponds is according to farmer 8 that aquatic animals are more at risk of getting diseases.

Farmer 3 said that the government had established regulations to treat the wastewater from factories but that the leaking of non-treated water continues regardless. In the interview with a spokesperson from Dat Mui was also argued by the spokesperson that there are national laws that require factories to treat wastewater before rejecting it into the environment. However, the spokesperson confessed that this has not been executed properly in the region. Concerning the polluted water coming in from intensive shrimp farms, farmer 5 made an argument that pollution

would be less spread if the ponds of these intensive farms would be closed off from the water reservoirs outside the ponds. Therefore, it would be necessary to not throw wastewater from shrimps into the rivers. According to 2 farmers, the Vien An Dong commune's survival hinges on the improvement of water quality in the future, which can only be done if less polluted water can come in from these polluting industries.

Incomplete information

Based on the gathered data, most farmers do not obtain full information about production and the environment from higher authorities. Only a few farmers mentioned that they did receive information on how to improve their farms. Two farmers reported attending workshops on improving aquaculture skills, which aided in maintaining high levels of production and income. Farmer 10 declared that he learned a technique with which he could control the quality of the water before letting water out of the pond. This allowed him to gain knowledge about his pond and adjust better to cope with issues such as pollution. He also declared that all farmers could join these trainings but if too many wanted to attend, only the representatives would go and pass on the knowledge they acquired to the others. Farmer 16 also followed a workshop on how to replant trees which he thought to be very useful. The respondents from Dat Mui and Minh Phu were also positive about the amount of guidance and information they shared with the farmers. The spokesperson from Dat Mui argued that the government has given technical guidance to farmers on how to productively work in and with the forest and the vice director of Minh Phu stated that farmers are trained by the company when they want to receive a certification for organic farming.

Nevertheless, except for the two farmers earlier mentioned, the rest of the farmers did not mention the existence of workshops or their attendance at one. Some stated that they lack the skills and knowledge to manage pollution and unstable weather conditions to improve their production. An example given here is that they notice a decrease in production and believe pollution to be a cause of this but they cannot say this with certainty. Another case that also shows farmers' lack of complete information is that they use the concepts of weather and climate interchangeably. Farmers often do not know certainly if the unregular weather conditions such as hotter weather and increased rainfall during the dry season are due to climate change or not. Farmer 17 stated that he and others speculate about the consequences of climate change but they do not know what climate change exactly is and what it does for production because they had never heard from the government or NGOs what the exact consequences are. Because of these knowledge gaps, farmer 8 proposed that more effective production could be achieved by offering improved guidance and information to farmers from the state.

Discussion

The three inefficiency criteria examined in the commune gave multiple results on how efficient the co-management model in Vien An Dong is in real life. Most farmers in the commune argue that an absence of enough control on their farms is one of the most important reasons leading to inefficient production. Incomplete information, on the other hand, was mentioned by fewer farmers to be a cause of poor efficiency. The three inefficiencies are discussed here.

As has been said, property rights are lacking in the commune. Even though farmers gained property rights for their piece of land in the commune with the co-management model, most farmers interviewed believe that they are denied sufficient authority over their lands. Especially the lack of rights about the forest-cover ratio led to disagreements from the farmers. Moreover, corresponding to the argument of Ha et al. (2013), farmers are not satisfied with the regulations for the harvest of trees on their farms, especially not with the long period between planting and harvesting. Many farmers are less stimulated to log wood because of this rule. The farmers thus argue that there is no

balance between the protection of the forest and the production of farmers and therefore, they plead for more individual rights and responsibilities to choose the ratio that works best on their land. On the one hand, this request could increase the incentive for farmers to improve sustainable practices on farms because they feel more accountable as has been said by scholars such as Pomeroy (2001) and Galiani and Schargrodsy (2011). On the other hand, granting farmers full choice of forest ratio could, as Ha et al. (2012) mentioned, have the consequence that farmers harvest too much forest to make room for ponds. In the worst scenario, an existential decrease in the forest would also cause the Vien An Dong commune to transform into an intensive aquaculture farm as has happened with the neighboring commune. Still, this thesis research believes that farmers should obtain some additional rights to their land to control the forest cover because their cooperation in this co-management model is essential. They need to feel some entitlement to their ground to make their farm productive and the environment protected.

Negative consequences from environmental externalities caused by intensive aquaculture farming and industrial factories are visible to farmers in the commune and are a big problem for production. The existence of this environmental externality coming from the intensive farming industry in Ca Mau was already mentioned earlier by Xuan and Sandorf (2020). Nevertheless, this research found that industrial factories are also responsible for environmental externalities which have negative effects in the Vien An Dong commune. The decisions and actions from the external parties to get rid of wastewater without treating it first has the consequence that water resources in ponds in the Vien An Dong commune are more polluted. The pollution in turn leads to a decrease in production which makes the model of land allocation less efficient. The environmental quality of the commune is being compromised because of the production activities of other industries. This issue is also part of the free-rider dilemma, cited by Mäler (2000) and Tietenberg and Lewis (2018), because the industrial factories did not invest in wastewater treatment even though this is required by national laws. Therefore, farmers in the commune and the government need to invest more money into dikes and filters to prevent wastewater from coming into the ponds. Despite the devoted investment of time, money, and effort by both individuals and entities, the problem stays unresolved thus far.

Even though, farmers rarely explicitly argued incomplete information to be a problem in the commune, the absence of education and workshops in Vien An Dong caused efficiency to decrease. Lessons and knowledge exchange from Dat Mui and other organizations on how to use new techniques to improve production have only been given to a few farmers. The majority of farmers seem to lack knowledge, skills, and means when trying to improve production on their farms. Many farmers also argued that they do not receive complete information from Dat Mui because they do not know how and in which capacity climate change influences their production. When connecting this case with the Game Theory from Von Neumann & Morgenstern (1945), this incomplete information makes the decision of a rational strategy or choice more difficult because farmers do not know how to use their farm and do production in the best way possible. The information would be more complete if farmers would receive workshops and if farmers with more knowledge and skills would share their expertise with others.

4.4.2 Equity

Distribution of benefits

Regarding the distribution of benefits, the results have shown that farmers with a small piece of land face more difficulties in the commune than large landowners. They are left with fewer advantages, such as smaller residences as can be seen in Figure 10, than the farmers who obtain bigger areas and bigger residences, as can be seen in Figure 9, because of two reasons which this section will explain.



Figure 6: Example of a farmer with a smaller-sized house (Source: Anouk Starmans, 2023)

farmers with a land size between 2.1 and 5 hectares produced just enough but had no savings left or did not produce a sufficient income and thus had to work additionally to continue their lives in the commune. This observation was confirmed by farmer 4 with about 8.5 hectares of land who said: "In my case, it is enough, but some other households with a smaller area, like my brother who cultivates 2 hectares, have to find another job to have more income." Unfortunately, for farmer 16 with a small area of 3.1 hectares, the lack of income made it too difficult for her to stay in the commune. She said that her family was planning to relocate to a different city in pursuit of a more lucrative income.

Smaller-land farmer 17 affirmed that sometimes his income was sufficient and sometimes it was not. For instance, when the pond needs to be renovated, he frequently faces a shortage of funds so his daughters send additional financial support from Ho Chi Minh City. However, in harvest season his income is sufficient most of the time. This farmer came up with the idea of a flexible forest cover ratio: "depending on the area that is allocated, for example, 7:3, 6:4, 5:5, even if the land is too small, it may not be necessary to plant forests." Representative 3 had a similar idea and argued that it would be a better idea to give farmers with an area size of less than 5 hectares the opportunity to decrease the forest ratio to 40 percent. He also said that Dat Mui, on some occasions, already turned a blind eye or made an exception when small owners had a lower forest cover because they need the income which can be achieved with a bigger pond size.



Figure 7: Example of a farmer with a bigger-sized house (Source: Anouk Starmans, 2023)

Secondly, farmers with a smaller area often find harvesting wood less profitable than farmers with a more extensive area of land because less wood can be logged and replanting costs are high. Smaller farmers do not see the additional value of harvesting and often only trim their trees so that the forest cover does not become too dense or come too close to the shore. The farmers who harvested more than once had a bigger size of land on average (8.3 hectares) than the farmers who never harvested or only once (4.9 hectares). Farmer 8 said that with his small land of 2.6 hectares "logging is not significant because, after harvesting, it takes 10-15 years to renovate, which is not

profitable.” According to the gathered information, replanting costs are sometimes almost equal to the benefits that small landowners receive from harvesting. Therefore, arrangements are made on occasions which give small owners more benefits from the harvested wood. A small farmer (12) with 3.4 hectares, for example, exploited 3000 square meters of wood and did not have to pay any tax on the obtained profits because companies who bought the wood from him paid a tax of 10 percent to Dat Mui. That way, this farmer is said to have received all the benefits from harvesting and thus had more incentives to begin the logging process. Not all small farmers did however mention this arrangement.

Representation and participation

In the case of farmers being able to participate in decision-making or being represented in the commune, a division of arguments can be seen based on the results. On the one hand, meetings are present in the commune and some farmers are able to participate and give their opinion. The respondents were asked if they have been invited by the local government or Dat Mui to meetings when there is a change in policies or a new implementation of plans. More than half of the farmers responded that they are sometimes invited to these meetings. Farmer 1 also mentioned the existence of representatives who then would take part in a meeting on behalf of each hamlet within the commune and afterward would pass on the information to the rest of the farmers. He preferred this because he did not desire to go to meetings himself. If he had a personal issue, he would meet the local government to discuss this and not share this in a meeting. 5 farmers also said that the local government listens to them and gives useful feedback and guidance. Moreover, the local government passes on the opinions and complaints of farmers to the provincial committee which then sometimes transmits them to the top level if they find these opinions and complaints reasonable to research further. When this top level then decides, it will inform the lower-level authorities. Several individuals had observed alterations in policies after meetings where farmers had voiced their views. Farmer 9 for example expressed that the period in which logging is allowed was broadened from July till August to April till August. He also mentioned that after asking permission from Dat Mui, the community is now allowed to create a schedule to work on the renovation of the pond together. Besides sharing opinions in meetings, the vice director of Minh Phu also stated that groups of farmers can communicate their complaints and ideas to Minh Phu using their smartphones.

Although half of the farmers did get invited to meetings, a quarter of the farmers rarely were invited to meetings anymore and the other quarter indicated that they had received invitations in the past but had not been informed about meetings lately. All these farmers, except for one, wanted to be invited more so that they could participate, give their opinions, and get guidance from the local government. Two farmers believed that they were not invited anymore because Dat Mui did not see it to be necessary anymore. In the past, the forest was in a worse condition than now according to Dat Mui and that is why the company gathered farmers to give guidance on how to improve the forest. However, recently, Dat Mui did not see the urge anymore to invite farmers because the forest cover had improved. Besides the absence of many farmers, another problem was that farmers often felt that they were not being heard. 8 of the farmers did not perceive that the companies or authorities listened to what they had to say or had made any changes resulting from these meetings. They for example did not change the forest ratio yet even though almost all farmers have proclaimed this to be a problem.

The representative farmers from the group discussion have also made several recommendations to the People’s Committee which according to them have not been listened to. Representative 1 had proposed to plant one mangrove tree every two meters instead of every one

meter. In a pilot test of 2000 square meters which was executed with trees standing further apart from each other, the farmer claims that the trees in this area grew faster and more straight up than the trees with narrower space between them. Furthermore, young trees in this pilot died less quickly than mangrove trees in more dense forests. Eventually, the trees from the pilot caught up with the other mangrove forests at the age of 12 years old so the pilot trees could be harvested when the other mangrove trees of 15 years old were being harvested. He showed his results to the provincial authorities but no one has responded back to him. Representatives 2 and 3 agreed that this plan could work well but they would also be satisfied if their suggestion to the committee on thinning the trees with only 1-meter distance more regularly, would be accepted. However, representative 1, who suggested the pilot test, did not think that thinning would be good enough to elevate farmers' income. A difference in opinions was visible here.

Discussion

The equity section, found interesting results which can add new arguments to the research field. During the interviews, farmers commented that circumstances sometimes were inequitable in the commune amongst farmers but also between farmers and Dat Mui. Both concepts are further elaborated on in the sections underneath.

According to many of the farmers, benefits provided by the ecosystem are not equally shared amongst all farmers. Corresponding to what Ha et al. (2014) said, some farmers are gaining more benefits from their production on the land than others. When investigating the challenges with the forest ratio and wood harvest, the results show that farmers who have a bigger size of land can enjoy the advantages of integrated mangrove-aquaculture farming more than farmers with a smaller land area. The idea of a flexible forest ratio has been suggested by a farmer to give smaller landowners more equal opportunities. The unequal results of wood harvest between large and small farmers is a finding which, has not been given too much attention in existing articles of the field. In the article of Ha et al. (2013), this issue was shortly mentioned together with the occasional decision of the government to shorten the period between planting and logging. This thesis adds that to help the smaller farmers, taxes are sometimes paid by the companies which buy the wood from the farmers. When examining the findings of this commune in relation to the concepts outlined by Ribot and Peluso (2003) in the theoretical framework, it becomes clear that the agent-level factor of owning varied sizes of land by farmers has a huge influence on the unbalanced distribution of benefits. An example of a structural factor is the forest ratio because this government-created rule decreases the ability of small-sized farmers to enjoy the benefits of the ecosystem.

When observing the representation and participation in the commune, various results are put under discussion. A part of the farmers mentioned positive aspects of meetings in the commune because they said that authorities listened to their complaints and requests and sometimes made regulation changes in the commune. However, the results also show that Dat Mui seems to have a major say in what happens in the commune because half of the farmers are not invited to participate in meetings. Even when farmers are invited, a lot of ideas, which have been thought out carefully and even already gone through pilot trials, were not taken into consideration by the government. Consequently, an inequitable representation arises as Dat Mui, who exercises substantial influence, makes decisions concerning the farmers in the commune, who hold less power, similar to the argument put forth by Hein (2010). The policies that have been created in the commune are not always reflecting the interests of the community which was similarly argued in the research of Ha et al. (2013). Nevertheless, results also show that some farmers are satisfied with a representative going to meetings to represent them. Sending representatives to meetings would, according to Soma and Vatn (2009), decrease the risk of an excess of opinions which would make decision-making more

straightforward. However, even with the presence of representatives, a hierarchy is visible between the different stakeholders because the representatives also have acknowledged that their ideas and complaints have often not been dealt with. The farmers are thus still subordinated to authorities such as Dat Mui. This threatens the transparency of the whole co-management model.

4.4.3 Sustainability

Strong sustainability

The results found have partly shown that the commune and the co-management model rendered positive effects on sustainability. 18 out of 20 farmers think cooperation between them and the government within integrated mangrove-aquaculture farming is beneficial for the environment. Farmers do understand that the conservation of the forest is necessary for this commune to remain the way they do. An imbalance between humans and nature will be created if human interest is put too much above nature. One of the reasons farmers believe nature to be important for the commune is that the presence of mangrove trees results in a cooler and cleaner environment. According to 2 farmers, the quality of the air is very good in the commune because of the abundance of nature as well as the circulation of wind. If the trees were not existing in the area anymore, the climate would become much warmer in the commune, as declared by respondents. Moreover, farmer 11 argued that the quality of the water is also better with the presence of a forest than without it because mangrove trees filter pollutants and impurities out of the water in a natural way.

The importance of the forest has brought positive effects on the forest cover in the commune according to farmers. When discussing the changes in the farmers' forest cover, three farmers said that the forest cover on their lands had improved since they came here. The vice director of Minh Phu also said that the forest cover had improved since the start of the co-management model in the commune. Before the allocation of land started in the commune, land in this area had been used to produce vegetables. In that period, there was almost no forest. After the regulations were enforced in the commune, the forest cover of farmers' lands went up again. As per the account of 8 farmers, the forest cover did not increase but it remained the same from the time they acquired their land until now. According to many of them, the reason for the unchanged forest cover is their compliance with the regulation that mandates replanting after harvesting.

Farmers in the Vien An Dong commune also believe that their income is more sustainable than the income created with intensive farming. When asked to farmers if they would like to switch to a different aquaculture farming model with a higher income, 13 out of 20 farmers said they believe that their current way of doing aquaculture already gave the highest chance of a good income. Integrated mangrove aquaculture facilitates a natural method of farming that requires minimal intervention and investment in the process. The only intervention that is needed is the dredging of mud out of the pond when the shrimp season ends and the pond needs to be cleaned. Farmer 1 explained that intensive aquaculture farmers in neighboring districts with the same land size have a lower and less stable income than him, so he believes that the existence of this model is more feasible in the future. The implementation of a new project that gives out carbon credits to farmers, as mentioned by the vice director of Minh Phu, holds the potential to further improve economic and environmental sustainability in the future. He said that, then, farmers get paid an amount of money per year depending on the hectares of mangrove forest they have planted on their farms. He argued that this will give farmers more incentives to follow the 60/40 ratio rule.

Weak sustainability

Despite the positive aspects of the natural environment to the commune, sacrifices to nature have been made to enhance economic advantages. Over time, farmers said that they have become

increasingly reluctant to certain rules developed by the government because their yields and incomes have been decreasing gradually while their daily expenses for food, input costs, and the raising of their children increased a lot. 19 farmers, therefore, want to decrease the forest cover to enhance production and improve their income. 15 of these farmers want to decrease the forest ratio to 30/70, 40/60, or 50/50. 2 farmers did not know which ratio they exactly wanted their forest cover to decline to but they knew that they wanted to reduce it. The reduction of forests would give them more opportunities to increase their income and help them stay away from poverty. Farmers said that they would face the consequences of their actions if issues arose because of the forest reduction. A reduction in forest cover on individual land had already become visible for 9 farmers since they first arrived in the commune. 7 of these farmers did not see an extreme decrease. They reported that around 20 to 30 percent of the forest has been lost since they were allocated the land. A few of them did notice a bigger decline, namely 2 farmers said that the forest was fully covered when they arrived on their piece of land, indicating a difference in size of 40 percent or more compared to the present time.

Besides the reduction of forest cover in the commune, the increase in population of the commune led to negative consequences for nature. Firstly, biodiversity has been declining over time in Vien An Dong. 19 out of 20 farmers saw a loss of at least one kind of animal since they received the land. The three representative farmers also acknowledged this. Animals that disappeared were for example monkeys, wild pigs, snakes, and storks. Only the diversity of birds had increased in the last couple of years according to the data. Farmers believe that these animals have been disappearing in the commune because they do not like the high density of people and want to live in the protected forest which has a high forest cover. Besides the decline in animals, 4 farmers also saw a decline in the diversity of plants in the commune. The only trees that are left now are mangrove trees while before there was a bigger variety of plant species. The increase in population also led to an incline in human waste which is a polluting factor to the environment according to three farmers. Farmers are throwing waste in the rivers and other ponds with the consequence that other farmers' lands are also getting more polluted. Farmers also observed that the methods of waste disposal in the surroundings are lacking. Farmer 15 took an effort to decline the waste problem but it did not pay off like he wanted. He said: " I went to mobilize local people to collect garbage and have incinerators. I try to educate them but people do not listen." The spokesperson from Dat Mui replied to this issue that multiple solutions will hopefully be implemented in the future. These solutions include a program to treat human waste with septic toilets and a collection point for garbage so that individual households do not throw their garbage in the natural environment anymore.

Discussion

A certain level of strong sustainability is visible in the commune because farmers are working in and with the natural environment. Compared to other aquatic systems in the region such as intensive farming, natural and human capital are working together more intensely. According to farmers and other stakeholders, the results of this cooperation benefits both the natural environment and the people residing in it. Compared to what Trung and Thuy (2020) argued in their paper, many of the interviewed farmers are aware of the reasons why the natural environment needs to be protected. They say that the air and water quality are better than with other aquacultural models. Additionally, the presence of mangrove trees within ponds helps reduce input costs so stakeholders believe that a cleaner environment causes farmers' income in this commune to be more consistent in the future. The system of land allocation also increases the likelihood of the survival of mangrove forests compared to a scenario where no regulations are in place. This was also mentioned by Nguyen et al. (2022) who said that regulations and institutionalization of coastal zone management are necessary to make preservation of the natural environment more long-lasting. If the scenario of a mangrove

forest without regulations would become true, the probability of all the trees being harvested to make room for aquatic ponds would be very high.

On the other hand, the commune is also facing challenges that make sustainability look weak in the commune. The increase of the population in the commune combined with the inclining pollution and reluctant attitude of farmers towards preservation rules such as the 60/40 ratio policy, have started to detach the natural system from economic and social capital. Even though almost all farmers believe that the environment needs to be protected, they also argue that the forest cannot be preserved at the expense of farmers' income. With the rules from the government, they have to obey to, farmers cannot make a sufficient living. This makes some farmers hesitant about their future in the commune. Therefore, almost all of the farmers want to increase their ponds even though this would mean that the natural environment would have to suffer. Some farmers already decreased the forest cover without the permission of Dat Mui. This challenge can be connected with the argument of Barbier and Markandya (1990) that farmers do have the future of the environment in mind but would still rather reduce the forest ratio to increase their income in contemporary times. The decrease in forest cover combined with the increase in population and insufficient waste treatment in Vien An Dong has caused many animals to flee from the commune to more protected areas.

5. Conclusion

The commune of Vien An Dong is characterized by farmers of different ages, genders, wealth, and stories but who are all allocated farmland by the Forest Management Board in order to produce aquatic animals in ponds while preserving mangrove trees. Co-management between farmers and other stakeholders is an important organizational mechanism in this commune. Stakeholders besides the farmers are the Department of Agriculture and Rural Development (DARD), the government department which is in charge of forest management and protection, Dat Mui, the Forest Management Board which executes the allocation of land for farmers in accordance with the law, and private companies such as Minh Phu, which is a private shrimp company. The government requires assistance from the local communities to protect the environment and the commune needs land and certain rights to do production and earn a living.

From the results, it turned out that farmers mostly cultivate shrimps and crabs. Occasionally farmers invest in the cultivation of oysters and clams but the risks of doing this are high, so this makes farmers hesitant to do investments. Natural fishes are also caught in the ponds which most often are captured for their own use. Taxes do not have to be paid on profits from aquaculture. Overall, farmers have a lot of freedom in the production of aquatic animals if they follow the most important rule which is that they remain 60 percent of their land to the forest and 40 percent to ponds for aquaculture. Besides the income from aquaculture, farmers may also harvest wood once every 10 to 15 years while following the forest ratio rule. On the profits of wood, the farmers must pay 10 percent to Dat Mui. Although in theory, this system of cooperation in integrated mangrove-aquaculture works well for nature and inhabitants in Vien An Dong, the operation of this model for the ecosystem is in reality far from perfect.

Efficiency in the commune was measured by looking at the lack of property rights, environmental externalities, and incomplete information. Even though farmers received land rights on their farms for 20 years, they are still bound to many regulations. Compliance with the 60/40 ratio rule is the driving force of the commune according to Dat Mui because it believes it is the most efficient way to preserve the mangrove forest. At the same time, it is the regulation that encounters the strongest resistance from farmers. A reason for this is that too much forest declines their production and leaves decay polluting the water in ponds. This declines people's will to invest in their farms. Together with the existence of pollution from external sources such as industries and intensive farms and the absence of enough information about production improvements, efficiency in the commune is lacking for the inhabitants and nature.

How equitable the co-management model in Vien An Dong is, is researched by examining the distribution of benefits as well as representation and participation in the commune. The results show that smaller farmers gain fewer economic advantages on their farms than bigger farmers. They are more negatively affected by the 60/40 ratio rule and obtain minimal benefits from harvesting wood. Regarding representation and participation, not all farmers have the chance to contribute in meetings and their complaints or ideas are not listened to enough by Dat Mui because changes do not occur often. Despite the existence of meetings, the equity of farmers, and specifically that of small farmers, is not very favorable in the commune because not everyone is fully represented and receives the same opportunities.

The thesis observed sustainability of Vien An Dong by using strong and weak sustainability. The regulated cooperation between people and nature showed to be good for the protection of the environment according to farmers and other stakeholders. They believe that intensive aquaculture farming is less sustainable because of the absence of preservation rules. Moreover, the quality of

water and air is better in the commune in accordance with farmers compared to other aquacultural farms in the region. Nevertheless, farmers are increasingly resisting preservation for their economic benefits which causes pollution to become more visible in Vien An Dong, animals to flee to more protected forests, and forest covers to decrease at some farms. Thus despite the cooperation between humans and nature, the will of humans gradually intrudes on the environment. Therefore, it can be said that this system is relatively sustainable but even in this commune shortcomings are visible.

To answer the research question with the use of knowledge gained from the case study, the thesis argues that the co-management model in communes that produce within integrated mangrove-aquaculture farming systems has a positive effect on farmers, other stakeholders, and the natural environment in the short run. The co-management model creates rules to preserve the forest and farmers have an opportunity to earn a reasonable income. However, in the long run, some problems such as farmers' resistance against the ratio rule, the slow penetration of pollution in the commune, the inequitable distribution of benefits, the unbalanced power relations and the insufficient distribution of knowledge from the government to the farmers can become irreconcilable. The use of the three criteria allows looking at the effects of the co-management model on the natural environment while also considering its implications from the human point of view. This creates a holistic image of the effects of the model in the commune. Previous research in the province of Ca Mau, with Ha et al., 2013, Ha et al., 2014, and Trung and Thuy, 2020, mostly investigated the unequal distribution of benefits and its consequences. With the comprehensive way of doing research in this case study using the criteria efficiency, equity, and sustainability, new knowledge is obtained about the effects of the model. An example is the farmer's incomplete information from Dat Mui because of limited distribution of knowledge via workshops and meetings. The acknowledgment by farmers of the model's benefits for the natural environment, juxtaposed with their increasing resistance towards the same model, also represents novel insights for co-management theories in the Ca Mau province.

An evident challenge observed in this case study was the disparity in opinions between the farmers and stakeholders with higher authorities regarding the impact of the co-management model on the commune. While previous research on this topic in the province of Ca Mau, such as those by Trung and Thuy (2020) and Ha et al. (2013), addressed the unequal power relations between the stakeholders, they did not focus on the divergent viewpoints regarding the effects of the model. In this case study, the spokesperson from Dat Mui and the vice director from Minh Phu were mostly positive about the effects of the model on the commune. They did recognize some defects in the commune such as the malfunctioning of the waste treatment system and the sometimes inefficient production of ponds because of shades from the trees but they were certain that in the future these problems would be solved. Upon learning about the challenges faced by the farmers regarding the forest ratio rule, the men from Dat Mui and Minh Phu simply answered that the Vietnamese government had implemented the regulation for a reason and that this ratio was the most efficient for production and preservation. Despite claims made by Dat Mui and Minh Phu about the effective operation of the co-management model, farmers perceive numerous harmful aspects of the execution of the model to their farms. If the different stakeholders do not find a way to reconcile their opinions about the model, they will grow even further apart which will also negatively affect the successful operation of the co-management model.

To enhance the prospects that the co-management model of integrated mangrove-aquaculture farming survives in Ca Mau, the thesis puts forth several propositions. In terms of better efficiency, an argument in this thesis is that the ratio rule can be easier followed by farmers if

farmers would be allowed to make smaller alterations on their farms. An example could be that farmers can make renovations to their ponds without having to ask permission from Forest Management Boards. Moreover, Forest Management Boards should allow more farmers to attend workshops so that they can gain additional knowledge about productive farming. Finally, a system should be implemented which can coop better against environmental externalities. To improve equity, an argument is that financial support needs to be offered to smaller farmers. A reduction in taxes would probably also be an idea to make the commune more equitable. Moreover, every farmer should have the opportunity to go to meetings or at least have a representative who joins the meetings on his or her behalf. Lastly, farmers' desires and objections should be taken more seriously by the government during meetings. An argument to make sustainability stronger in the communes of Ca Mau is to start a program in the communes that brings farmers more awareness about the effects of pollution and forest clearance. Furthermore, it would be good to measure and regulate the water and soil quality, find effective ways to treat waste, and make better rules to protect the biodiversity in the communes.

Despite the limitations found in the research such as the personal relation with the author and Kim Delta, the involvement of Minh Phu in finding the respondents, and the few concepts researched in the three criteria efficiency, equity, and sustainability, the thesis yields some significant findings. The results of the research offers new knowledge to political organs such as DARD or companies like Minh Phu who are difficult to reach for the farmers themselves. Because of its qualitative nature, the thesis emphasizes farmers' opinions and wishes which are interesting for people in power to include when making decisions. This research shows that alterations in the co-management model have to be made in this commune. In future research, efficiency, equity, and sustainability can again be used to observe the operation of co-management in integrated mangrove-aquaculture farming. However, other sub-factors can be used to find new results, such as other inefficiencies within the efficiency criteria. Furthermore, other communes can also be investigated to perhaps make a comparison between communes.

6. References

- ABOUT US. (n.d.). Minh Phu Seafood Corporation. <https://minhphu.com/en/about-us/>.
- Agoubi, B. (2021). A review: saltwater intrusion in North Africa's coastal areas—current state and future challenges. *Environmental Science and Pollution Research*, 28(14), 17029-17043. <https://doi-org.proxy.library.uu.nl/10.1007/s11356-021-12741-z>.
- Alam, M. I., Rahman, M. S., Ahmed, M. U., Debrot, A. O., Ahsan, M. N., & Verdegem, M. (2022). Mangrove forest conservation vs shrimp production: Uncovering a sustainable co-management model and policy solution for mangrove greenbelt development in coastal Bangladesh. *Forest Policy and Economics*, 144, 102824, 1-7. <https://doi.org/10.1016/j.forpol.2022.102824>.
- Aquaculture production (metric tons) – Vietnam*. (n.d.). The Worldbank. <https://data.worldbank.org/indicator/ER.FSH.AQUA.MT?locations=VN>.
- Barbier, E. B., & Markandya, A. (1990). The conditions for achieving environmentally sustainable development. *European Economic Review*, 34(2–3), 659–669. [https://doi.org/10.1016/0014-2921\(90\)90138-o](https://doi.org/10.1016/0014-2921(90)90138-o).
- Beck, P. (2000). Collaboration and credible commitments: experiments with collaborative resource management in Uganda. In: *meeting of the International Association for the Society of Common-pool Property (IASCP)*, 1-29. <https://hdl.handle.net/10535/1051>.
- Berkes, F., George, P. & Preston, R. J. (1991). Co-management: the evolution in theory and practice of the joint administration of living resources. *Alternatives: Perspectives on Society, Technology and Environment*, 18(2), 12-18. <https://www.jstor.org/stable/45031306>.
- Berkes, F., Colding, J., & Folke, C. (2008). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press.
- Binh, C. T., Phillips, M., & Demaine, H. (1997). Integrated shrimp-mangrove farming systems in the Mekong delta of Vietnam. *Aquaculture Research*, 28(8), 599–610. <https://doi.org/10.1111/j.1365-2109.1997.tb01080.x>.
- Binh, T. N. K. D., Vromant, N., Hung, N. T., Hens, L., & Boon, E. (2005). Land Cover Changes Between 1968 and 2003 In Cai Nuoc, Ca Mau Peninsula, Vietnam. *Environment, Development and Sustainability*, 7(4), 519–536. <https://doi.org/10.1007/s10668-004-6001-z>.
- Brunckhorst, D. J., & Trammell, E. J. (2023). Future Options Redundancy Planning: Designing Multiple Pathways to Resilience in Urban and Landscape Systems Facing Complex Change. *Urban Science*, 7(1), 11. <https://doi.org/10.3390/urbansci7010011>.
- Bryman, A., & Bell, E. (2007). *Business research methods*, 2nd ed., Oxford: Oxford University Press.
- Carlsson, L., & Berkes, F. (2005). Co-management: concepts and methodological implications. *Journal of Environmental Management*, 75(1), 65–76. <https://doi.org/10.1016/j.jenvman.2004.11.008>.
- Castro, A., & Nielsen, E. (2001). Indigenous people and co-management: implications for conflict management. *Environmental Science & Policy*, 4(4–5), 229–239. [https://doi.org/10.1016/s1462-9011\(01\)00022-3](https://doi.org/10.1016/s1462-9011(01)00022-3).
- Clough, B., Johnston, D., Xuan, T. T., Phillips, M. J., Pednekar, S. S., Thien, N. H., Dan. T. H., & Thong, P. L. (2000). *Silvofishery farming systems in Ca Mau province, Vietnam*. Bangkok: World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment.
- Christensen, S. M., Tarp, P., & Hjørtsø, C. N. (2008). Mangrove forest management planning in coastal buffer and conservation zones, Vietnam: A multimethodological approach incorporating multiple stakeholders. *Ocean & Coastal Management*, 51(10), 712–726. <https://doi.org/10.1016/j.ocecoaman.2008.06.014>.

- Cohen-Shacham, E., Andrade, A., Dalton, J. T., Dudley, N., Jones, M. P., Kumar, C., Maginnis, S., Maynard, S., Nelson, C. R., Renaud, F. G., Welling, R., & Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. *Environmental Science & Policy*, 98, 20–29. <https://doi.org/10.1016/j.envsci.2019.04.014>.
- Cortner, H. J., Wallace, M. C., Burke, S., & Moote, M. A. (1998). Institutions matter: the need to address the institutional challenges of ecosystem management. *Landscape and Urban Planning*, 40(1–3), 159–166. [https://doi.org/10.1016/s0169-2046\(97\)00108-4](https://doi.org/10.1016/s0169-2046(97)00108-4).
- Cronkleton, P., Pulhin, J. M., & Saigal, S. (2012). Co-management in community forestry: How the partial devolution of management rights creates challenges for forest communities. *Conservation and Society*, 10(2), 91-102. <https://doi.org/10.4103/0972-4923.97481>.
- Das, S., & Crépin, A. S. (2013). Mangroves can provide protection against wind damage during storms. *Estuarine, Coastal and Shelf Science*, 134, 98–107. <https://doi.org/10.1016/j.ecss.2013.09.021>.
- De Graaf, G. J., & Xuan, T. T. (1998). Extensive shrimp farming, mangrove clearance and marine fisheries in the southern provinces of Vietnam. *Mangroves and salt marshes*, 2(3), 159-166. <https://doi-org.proxy.library.uu.nl/10.1023/A:1009975210487>.
- Department of Agriculture and Rural Development. (2019, December 03). Dat Mui Protection Forest Management Board. (N. Mao, Trans). <https://sonnptnt.camau.gov.vn/wps/portal/?1dmy&page=chitiet&urile=wcm%3Apath%3A/sonnptntlibrary/siteofnnpvtnt/noidungrss/gioithieu/donvitructhuoc/cactochucsunghieptructhuoc/banquanlyrunghonghodatmui/bqlrphonghodatmui>.
- Dunlop, T., Glamore, W., & Felder, S. (2023). Restoring estuarine ecosystems using nature-based solutions: Towards an integrated eco-engineering design guideline. *Science of The Total Environment*, 873, 1-16. <https://doi.org/10.1016/j.scitotenv.2023.162362>.
- Espinoza, O. (2007). Solving the equity–equality conceptual dilemma: a new model for analysis of the educational process. *Educational Research*, 49(4), 343–363. <https://doi.org/10.1080/00131880701717198>.
- Etikan, I., Musa, S. I., & Alkassim, R. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1-4. <https://doi.org/10.11648/j.ajtas.20160501.11>.
- Galiani, S., & Schargrodsy, E. (2011). Land Property Rights and Resource Allocation. *The Journal of Law and Economics*, 54(S4), S329–S345. <https://doi.org/10.1086/661957>.
- Ha, T. T. T. (2012). *Global and local governance of shrimp farming in the Mekong Delta, Vietnam*. Unpublished doctoral dissertation, Wageningen University and Research.
- Ha, T. T. T., van Dijk, H., & Bush, S. R. (2012). Mangrove conservation or shrimp farmer's livelihood? The devolution of forest management and benefit sharing in the Mekong Delta, Vietnam. *Ocean & Coastal Management*, 69, 185-193. <http://dx.doi.org/10.1016/j.ocecoaman.2012.07.034>.
- Ha, T. T. P., van Dijk, H., Bosma, R., & Sinh, L. X. (2013). Livelihood capabilities and pathways of shrimp farmers in the Mekong Delta, Vietnam. *Aquaculture economics & management*, 17(1), 1-30. <https://doi-org.proxy.library.uu.nl/10.1080/13657305.2013.747224>.
- Ha, T. V., Van Dijk, H., & Visser, L. (2014). Impacts of changes in mangrove forest management practices on forest accessibility and livelihood: A case study in mangrove-shrimp farming system in Ca Mau Province, Mekong Delta, Vietnam. *Land Use Policy*, 36, 89–101. <https://doi.org/10.1016/j.landusepol.2013.07.002>.

- Harsanyi, J. C. (1995). Games with Incomplete Information. *The American Economic Review*, 85(3), 291-303. <http://www.jstor.org/stable/2118175>.
- Hein, L. (2010). *Economics and Ecosystems: Efficiency, Sustainability and Equity in Ecosystem Management*. Edward Elgar Publishing.
- Hein, L., Van Koppen, C., De Groot, R., & Van Ierland, E. (2006). Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics*, 57(2), 209–228. <https://doi.org/10.1016/j.ecolecon.2005.04.005>.
- How Mangrove-Friendly shrimp farming is protecting the Mekong Delta*. (n.d.). Greater Mekong Subregion. <https://www.greatermekong.org/how-mangrove-friendly-shrimp-farming-protecting-mekong-delta>.
- Huxham, M., Whitlock, D., Githaiga, M., & Dencer-Brown, A. (2018). Carbon in the Coastal Seascape: How Interactions Between Mangrove Forests, Seagrass Meadows and Tidal Marshes Influence Carbon Storage. *Current Forestry Reports*, 4(2), 101–110. <https://doi.org/10.1007/s40725-018-0077-4>.
- Introduction Mard's*. (n.d.). Ministry of Agriculture and Rural Development of the Socialist Republic of Vietnam. <https://www.mard.gov.vn/en/Pages/history-of-establishing-and-developing-ministry-of-agriculture-and-rural-development.aspx>.
- IUCN French Committee. (2019). *Nature-based Solutions for climate change adaptation and disaster risk reduction*. France, Paris.
- Kabir, M. H., & Abdul Baten, M. (2019). Community Mangrove Aqua-Silviculture (CMAS Culture): An Innovation and Climate Resilient Practice by the Sundarbans Mangrove Forest Dependent Rural Communities of Bangladesh. *International Journal of Environment and Climate Change*, 9(1), 1–16. <https://doi.org/10.9734/ijecc/2019/v9i130093>.
- Korten, D. C. (1986). *Community management: Asian experience and perspectives*. Kumarian Press, West Hartford, Connecticut.
- Lai, Q., Tuan, V. K., Thuy, N. T. B., Huynh, L. D., & Duc, N. M. (2022). A closer look into shrimp yields and mangrove coverage ratio in integrated mangrove-shrimp farming systems in Ca Mau, Vietnam. *Aquaculture International*, 30(2), 863–882. <https://doi.org/10.1007/s10499-021-00831-1>.
- Mace, G. M. (2014). Whose conservation? Changes in the perception and goals of nature conservation require a solid scientific basis. *Science (Washington)*, 345(6204), 1558–1560. <https://doi.org/10.1126/science.1254704>.
- Mäler, K. (2000). Development, ecological resources and their management: A study of complex dynamic systems. *European Economic Review*, 44(4–6), 645–665. [https://doi.org/10.1016/s0014-2921\(00\)00043-x](https://doi.org/10.1016/s0014-2921(00)00043-x).
- Markiewicz, A., & Patrick, I. (2015). *Developing monitoring and evaluation frameworks*. Sage Publications.
- McEwin, A., & McNally, R. (2014). *Organic shrimp certification and carbon financing: An assessment for the Mangroves and Markets Project in Ca Mau Province, Vietnam*. REAP Project GIZ, SNV.
- Minh Phu Seafood Corp: Leading Light in Sustainable Shrimp Ecosystem Development*. (2022). Vietnam Business Forum of Vietnam Chamber of Commerce and Industry (VCCI)-Provinces & Cities. <https://vccinews.com/prode/48357/minh-phu-seafood-corp-leading-light-in-sustainable-shrimp-ecosystem-development.html>.
- Ministry of Agriculture and Rural Development (MARD Vietnam)*. (n.d.). Devex. <https://www.devex.com/organizations/ministry-of-agriculture-and-rural-development-mard-vietnam-48788>.
- Nair, S. (2015). Shrimp Aquaculture in Ca Mau, Vietnam. In Scherr, S. J., Mankad, K., Jaffee, S., & Negra, C. (Eds.). *Steps toward green: policy responses to the environmental footprint of commodity agriculture in East and Southeast Asia* (pp. 123-142). Washington: EcoAgriculture Partners.

- Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovács, E. K., Krauze, K., Külvik, M., Rey, F., Van Dijk, J. J., Vistad, O. I., Wilkinson, M. E., & Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Science of the Total Environment*, 579, 1215–1227. <https://doi.org/10.1016/j.scitotenv.2016.11.106>.
- Neumayer, E. (2003). *Weak Versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms* (2nd ed.). Edward Elgar Publishing.
- Nguyen, H. X., Chu, L., Harper, R., Dell, B., & Hoang, H. H. (2022). Mangrove-shrimp farming: A triple-win approach for communities in the Mekong River Delta. *Ocean & Coastal Management*, 221, 1-10. <https://doi.org/10.1016/j.ocecoaman.2022.106082>.
- Nguyen, H. X., Harper, R., & Dell, B. (2023). Examining local community understanding of mangrove carbon mitigation: A case study from Ca Mau province, Mekong River Delta, Vietnam. *Marine Policy*, 148, 1-10. <https://doi.org/10.1016/j.marpol.2022.105398>.
- Nicholls, R. J., & Lowe, J. (2004). Benefits of mitigation of climate change for coastal areas. *Global Environmental Change-human and Policy Dimensions*, 14(3), 229–244. <https://doi.org/10.1016/j.gloenvcha.2004.04.005>
- Njaya, F. (2007). Governance Challenges of the Implementation of Fisheries Co-Management : Experiences from Malawi. *The International Journal of the Commons*, 1(1), 137-153. <https://doi.org/10.18352/ijc.21>.
- Ott, K. (2003). The case for strong sustainability. In: *Greifswald's environmental ethics*. (pp. 59-64). Kiebu-Druck, Greifswald.
- Overbay, J.C. (1992). Ecosystem management. In Department of Agriculture, US Forest Service (Ed.), *Proceedings of the National Workshop: Taking an Ecological Approach to Management* (pp. 3-15). Washington, DC: WO-WSA-3.
- Peng, Y., Li, X., Wu, K., Peng, Y., & Chen, G. (2009). Effect of an integrated mangrove-aquaculture system on aquacultural health. *Frontiers of Biology in China*, 4(4), 579–584. <https://doi.org/10.1007/s11515-009-0056-z>.
- Peters, H. (2008). Finite Games with Incomplete Information. In: *Game Theory* (pp. 59–71). Springer, Berlin, Heidelberg. https://doi-org.proxy.library.uu.nl/10.1007/978-3-540-69291-1_5.
- Phan, L. K., van Thiel de Vries, J. S., & Stive, M. J. (2015). Coastal Mangrove Squeeze in the Mekong Delta. *Journal of Coastal Research*, 300, 233–243. <https://doi.org/10.2112/jcoastres-d-14-00049.1>.
- Pomeroy., R. S. (1998). A process for community-based fisheries co-management. *NAGA, the ICLARM Quarterly*, 21(1), 71–75. <http://hdl.handle.net/1834/26049>.
- Pomeroy, R. S. (2001). Devolution and fisheries co-management. In Zentralstelle für Ernährung und Landwirtschaft (Ed.), *Collective Action, Property Rights and Devolution of Natural Resource Management—Exchange of Knowledge and Implications for Policy* (pp. 111-146). Feldafing, Germany.
- Position, functions, tasks and powers of the Office of the Department of Agriculture and Rural Development*. (2019). Department of Agriculture and Rural Development. (2019). (N. Mao, trans). <https://sonnptnt.soctrang.gov.vn/snnptnt/1282/30591/57556/298919/V%C4%83n%20ph%C3%B2ng%20S%E1%BB%9F/vi-tri-chuc-nang-nhiem-vu-quyen-han-cua-van-phong-so-nong-nghiep-va-phat-trien-nong-thon.aspx>.
- Rejeki, S., Middeljans, M., Wiidowati, L. L., Ariyati, R. W., Elfitasari, T., & Bosma, R. H. (2019). The effects of decomposing mangrove leaf litter and its tannins on water quality and the growth and survival of tiger prawn (*Penaeus monodon*) post-larvae. *Biodiversitas*, 20(9), 2750-2757. <https://doi.org/10.13057/biodiv/d200941>.

- Rezai, A., Foley, D. K., & Taylor, L. (2012). Global warming and economic externalities. *Economic Theory*, 49(2), 329–351. <https://doi.org/10.1007/s00199-010-0592-4>.
- Ribot, J. C., & Peluso, N. L. (2009). A Theory of Access. *Rural Sociology*, 68(2), 153–181. <https://doi.org/10.1111/j.1549-0831.2003.tb00133.x>.
- Sandilyan, S., & Kathiresan, K. (2014). Decline of mangroves – A threat of heavy metal poisoning in Asia. *Ocean & Coastal Management*, 102, 161–168. <https://doi.org/10.1016/j.ocecoaman.2014.09.025>.
- Schmitt, K. (2009). Protection and sustainable use of coastal wetlands through co-management and mangrove rehabilitation with emphasis on resilience to climate change. *Management of Natural Resources in the Coastal Zone of Soc Trang Province*. GTZ and Soc Trang Provincial People’s Committee.
- Scott, A. D. (2000) Conceptual origins of rights based fishing. In: Neher, et al (eds.), *Rights Based Fishing*. Kluwer Academic Publishers, Dordrecht.
- Sea level rise: Everything you need to know*. (2022). World Economic Forum. <https://www.weforum.org/agenda/2022/09/rising-sea-levels-global-threat/>.
- Seddon, N., Chausson, A., Santos, R., Girardin, C. a. J., Turkelboom, F., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B*, 375(1794), 1-12. <https://doi.org/10.1098/rstb.2019.0120>.
- Shaw, D. M., & Elger, B. S. (2013). The relevance of relevance in research. *Swiss medical weekly*, 143. doi:10.4414/smw.2013.13792.
- Singleton, S., (1998). *Constructing Cooperation: the Evolution of Institutions of Comanagement*. University of Michigan Press, Ann Arbor.
- Solow, R. M. (1974). Intergenerational equity and exhaustible resources. *The Review of Economic Studies*, 41, 29. <https://doi.org/10.2307/2296370>.
- Soma, K., & Vatn, A. (2009). Local democracy implications for coastal zone management—A case study in southern Norway. *Land Use Policy*, 26(3), 755–762. <https://doi.org/10.1016/j.landusepol.2008.10.002>.
- Stanley, T.R. Jr., 1995. Ecosystem management and the arrogance of humanism. *Conservation Biology*, 9(2), 254–261. <https://doi.org/10.1046/j.1523-1739.1995.9020255.x>.
- Stewart, F., & Ghani, E. (1991). How significant are externalities for development? *World Development*. 19(6), 569-594. [https://doi.org/10.1016/0305-750x\(91\)90195-n](https://doi.org/10.1016/0305-750x(91)90195-n).
- Sutton-Grier, A. E., Gittman, R. K., Arkema, K. K., Bennett, R. M., Benoit, J., Blicht, S., Burks-Copes, K. A., Colden, A., Dausman, A. M., DeAngelis, B. M., Hughes, A. D., Scyphers, S. B., & Grabowski, J. H. (2018). Investing in Natural and Nature-Based Infrastructure: Building Better Along Our Coasts. *Sustainability*, 10(2), 1-11. <https://doi.org/10.3390/su10020523>.
- Tenzing, K., Millar, J., & Black, R. (2021). How property rights influence equity, efficiency and sustainability of high-altitude rangeland management in Bhutan. *Pastoralism*, 11(7), 1-13. <https://doi.org/10.1186/s13570-021-00193-6>.
- THE 17 GOALS | Sustainable Development*. (n.d.). United Nations. <https://sdgs.un.org/goals>.
- Thu, P. M., & Populus, J. (2007). Status and changes of mangrove forest in Mekong Delta: Case study in Tra Vinh, Vietnam. *Estuarine, Coastal and Shelf Science*, 71(1–2), 98–109. <https://doi.org/10.1016/j.ecss.2006.08.007>.

- Thuy, T. D., Tuan, V. Q., & Nam, P. K. (2021). Does the devolution of forest management help conserve mangrove in the Mekong Delta of Viet Nam? *Land Use Policy*, 106, 1-10. <https://doi.org/10.1016/j.landusepol.2021.105440>.
- Thoai, D. T., Dang, A. K., & Oanh, N. T. K. (2019). Analysis of coastline change in relation to meteorological conditions and human activities in Ca mau cape, Viet Nam. *Ocean & Coastal Management*, 171, 56–65. <https://doi.org/10.1016/j.ocecoaman.2019.01.007>.
- Tietenberg, T., & Lewis, L. (2018). *Environmental and Natural Resource Economics*. Taylor & Francis.
- Toimil, A., Losada, I. J., Nicholls, R. J., Dalrymple, R. A., & Stive, M. J. (2020). Addressing the challenges of climate change risks and adaptation in coastal areas: A review. *Coastal Engineering*, 156, 1-13. <https://doi.org/10.1016/j.coastaleng.2019.103611>.
- Trang, N. T. T., Toan, L. H., DO, Ai, T. T. H., Giang, N. V., & Hoa, P. V. (2016). Object-Based vs. Pixel-Based Classification of Mangrove Forest Mapping in Vien An Dong Commune, Ngoc Hien District, Ca Mau Province Using VNREDSat-1 Images. *Advances in Remote Sensing*, 05(04), 284–295. <https://doi.org/10.4236/ars.2016.54022>.
- Trung, T. C., & Thuy, D. V. (2020). Effectiveness of the Management Model of Mangrove Forests and Natural Resources for the Coastal Region of the Mekong River Delta. *Journal of Irrigation Science and Technology*, 56. (N. Mao, trans).
- Tole, L. (2010). Reforms from the Ground Up: A Review of Community-Based Forest Management in Tropical Developing Countries. *Environmental Management*, 45(6), 1312–1331. <https://doi.org/10.1007/s00267-010-9489-z>.
- Van Wilgen, B. W., Maitre, D. L., & Cowling, R. M. (1998). Ecosystem services, efficiency, sustainability and equity: South Africa's Working for Water programme. *Trends in Ecology and Evolution*, 13(9), 378. [https://doi.org/10.1016/s0169-5347\(98\)01434-7](https://doi.org/10.1016/s0169-5347(98)01434-7).
- Veettil, B. K., Ward, R. D., Quang, N. X., Trang, N. T., & Giang, T. N. (2019). Mangroves of Vietnam: Historical development, current state of research and future threats. *Estuarine Coastal and Shelf Science*, 218, 212–236. <https://doi.org/10.1016/j.ecss.2018.12.021>.
- Venkatachalam, S., Kandasamy, K., Krishnamoorthy, I., & Narayanasamy, R. (2018). Survival and growth of fish (Lates calcarifer) under integrated mangrove-aquaculture and open-aquaculture systems. *Aquaculture Reports*, 9, 18–24. <https://doi.org/10.1016/j.aqrep.2017.11.004>.
- Vien An Dong Commune, Ngoc Hien District – Planning – Map – Overview*. (2021). Thong Thai. https://diaochongthai.com/xa-vien-an-dong-ngoc-hien/#Lich_su_hinh_thanh_xa_Vien_An_Dong. (N. Mao, trans).
- Viiip. (n.d.). Ca Mau, Vietnam Industrial Parks. <https://viip.com/provinceen/?proid=34>.
- Vo, T. M., Kuenzer, C., & Oppelt, N. (2015). How remote sensing supports mangrove ecosystem service valuation: A case study in Ca Mau province, Vietnam. *Ecosystem Services*, 14, 67–75. <https://doi.org/10.1016/j.ecoser.2015.04.007>.
- Vogt, K. A., Gordon, J. I., Wargo, J. P., Vogt, D. J., Asbjornsen, H., Palmiotto, P. A., Clark, H. J., O'Hara, J. L., Keaton, W. S., Patel-Weynand, T., & Witten, E. (1996). Ecosystems: Balancing Science with Management. *Restoration Ecology* 8 (1). <https://ci.nii.ac.jp/ncid/BA29534419>.
- Von Neumann, J., & Morgenstern, O. (1945). Theory of Games and Economic Behavior. *The Journal of Philosophy*, 42(20), 550. <https://doi.org/10.2307/2019327>.

Xuan, B. B., & Sandorf, E. D. (2020). Potential for sustainable aquaculture: insights from discrete choice experiments. *Environmental and Resource Economics*, 77, 401-421.

Young, O. R. (2013). *On environmental governance: sustainability, efficiency, and equity*. *Choice Reviews Online*, 51(01), 51–0521. <https://doi.org/10.5860/choice.51-0521>.

Appendix A

QUESTIONNAIRES FOR FARMERS

ID of respondent (code from 01-20)

OPENING QUESTIONS

1. What is your age:.....
2. What gender do you identify with?
 Male Female Not prefer to say
3. How many members in your family?
.....Male;Female;.....Children;..... Independent
4. How many years of experience of farming in the forest land?.....year
5. What education did you follow?
 Primary school Secondary school High school
 College - University Post-university)
6. What are all your resources of income?
 Aquaculture under forest
 Wood exploitation form the forest
 Other agriculture activities out of the forest
 Hired work (non-official workers)
 Salary (official workers)
 Lease land
 Remittances
 Other:.....

MAIN QUESTIONS

7. Which company or organization is responsible for handing out forest land to people?
.....
.....
8. Do you have an official forest land certification?
 No Yes. If yes, do you have a green or red certificate?.....
9. How much forest land has been handed out to you?.....(hectares)
10. When was the time when you were handed out forest land?.....
11. What aquatic animal are you growing in the forest land you were handed out?
.....
.....

Economic aspect

12. Before being appointed to this forest land, what did you do (occupation) for a living?
.....
.....
13. Did the annual yields from your production change compared to the moment you were handed out the forest land? If so, how did it change?
.....
.....
14. Has your annual income changed compared to the time before you were doing the work you are doing now? If so, how does it change?
.....
.....
15. Have your everyday spendings changed? If so, how does it change?
.....
.....
16. Do you have other benefits (besides production) from the forest land handed to you? If so, which ones?

.....
.....
17. Do you have to pay fees and taxes for income from fishery farming in the forest?
.....
.....

18. Do you receive any payment for your reforestation or conservation activities? If yes, from whom?
.....
.....

Ecological aspect

19. Just after the forest land was handed to you, how much was the forest cover?
.....
.....

20. What is the current forest cover?
.....
.....

21. Since people were handed out land for aquaculture, have you noticed any changes in the forest cover of the whole area in general? If yes, did it become more or less?
.....
.....

22. Compared to the time just after you were handed out forest land, do you have better soil and water or more pollution?
.....
.....

23. Compared to the time just after you were handed out forest land, has the flora (plants and trees) and fauna (animals) changed, specifically as follows:

What new species appear?
.....

Species that previously disappeared are now back?
.....

Some species that used to exist but now disappear?
.....

Social aspect

24. In your opinion, what are the advantages of the current allocation of land to people, and are there any problems that need to become better?
.....
.....
.....

25. To be allocated land, what requirements do you need to follow from the forest owners?
.....
.....
.....

26. What are you allowed to do in the land you were handed out?
.....
.....
.....

27. In case there are changes related to policies, regulations on forest land allocation or use, are you invited to come with ideas to the governing body or related parties? Are your comments (if any) received and answered?
.....

.....
.....
CLOSING QUESTIONS

28. What are the biggest opportunities about this allocation of forest land in your opinion?

.....
.....
.....

29. What are the biggest challenges about this allocation of forest land in your opinion?

.....
.....
.....

30. In your opinion, do you think this allocation of forest land can continue to be implemented in the future in this area? Why/Why not?

.....
.....
.....

31. Do you have anything more to add which has not been mentioned yet?

.....
.....
.....

*Thank you for participating in this interview.
I would like to mention again that the information you provided is kept confidential, you can ask for the transcript and audio recordings and you are always able to withdraw from the research.
If you want to know the outcomes of this research you can leave your phone number and I will send you the results once the thesis is finalized.*

Appendix B

Focus group discussion with representative farmers

Opening questions

1. How long have you lived in this commune?

.....
.....
.....
.....

2. How many years of farming experience do you have?

.....
.....
.....
.....

3. What is your main source of income?

.....
.....
.....
.....

4. Do you represent a certain Hamlet in the commune?

.....
.....
.....
.....

5. Do you want to mention something more about yourself?

.....
.....
.....
.....

Economic aspects:

6. Before being appointed to this forestland, what did most farmers do for a living?

.....
.....
.....
.....

7. How has the overall income changed in the commune compared to the time you were handed out the forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....

.....
.....

8. How has production changed in the commune compared to the time you were handed out forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

9. How have the everyday spendings changed in the commune compared to the time you were handed out forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

10. Can most farmers still pay for their everyday spendings with the income they have?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

11. Are there farmers who would want to leave this commune if they had the opportunity because they do not earn enough income? If yes, which kind of farmers are this?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

12. Do you think this co-management approach has been economically positive or negative for the commune?

-Positive: why

-Negative: why

.....
.....
.....
.....

Ecological aspects:

13. Have farmers noticed an incline or decline in forest cover in the commune compared to the time you were handed out the forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

14. Have farmers noticed a change in the soil and water quality in the commune compared to the time you were handed out the forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

15. Can you roughly draw on the map where most pollution in the soil and water is found?

.....
.....
.....
.....

16. Have farmers noticed an incline or decline in the biodiversity of plants and animals in the commune compared to the time you were handed out the forest land?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

17. Do you think this co-management model has been ecologically positive or negative for nature?

-Positive: why

-Negative: why

.....
.....
.....
.....

Social aspects:

18. What is the opinion of farmers about the 6/4 ratio?

-resemblances: Why is that?

-differences: Why is that?

.....
.....
.....
.....

19. Do you think that farmers are satisfied with the amount of control they have on their land?
-resemblances: Why is that?
-differences: Why is that?

.....
.....
.....
.....

20. In case there are changes related to policies, regulations on forest allocation or use, are farmers invited to come with ideas to the governing body or related parties? Are their comments (if any) received and answered?
-resemblances: Why is that?
-differences: Why is that?

.....
.....
.....
.....

21. Do you think this co-management model has been socially positive or negative for the commune?
-Positive: why
-Negative: why

.....
.....
.....
.....

Ending questions:

22. Overall, do you think farmers are happy to live in this commune?
-happy: Why is that?
-unhappy: Why is that?

.....
.....
.....
.....

23. Overall, do you think farmers see a future living in this commune?

.....
.....
.....
.....

24. Is there anything you want to add which has not been mentioned yet?

.....
.....
.....
.....

Appendix C

Interview with Minh Phu

Introduction questions:

1. Can you introduce the organization or company you are working for?

2. What is the company/organization's main role in the Vien An Dong commune?

3. How long has the company/organization been active in this commune? What is the reason you are active here?

Economic questions:

Questions about price and collection of aquatic animals:

4. What does the collection process look like? (sorting products by sizes, transportation, payment schemes, etc)

5. What does the company/organization pay the farmers for 1 kilo of shrimps/ crabs? Is it higher than the market price?

Questions about input, production and income:

6. What do farmers need to put into their farms? (fingerlings, pond cleaning equipment, etc...)

7. Do you think that this model of shrimp farming gives farmers the opportunity for good production and income? (compared to other models such as intensive shrimp farming or other forms of extensive shrimp farming) If yes, why. If no, why not?

8. Do you think that most farmers can pay for their everyday spendings with the current income they have? If yes, why? If no, why not?

9. Do you think that this mangrove-aquaculture model is more economically efficient than other models? (efficiency= highest level of performance (output) with a certain amount of inputs)

10. Do you think that farming with the 60/40 ratio rule is better for production than when another ratio is implemented? If yes, why? If not, why not?

Questions about income (in)equality:

11. Do you think that farmers earn a similar income or is there a big income gap between farmers? Why?

12. Do you think sufficient income is one of the incentives of farmers to continue farming the model? If yes, why?

Questions about economic support

13. Do you support the farmers financially? If yes, how. If no, why not?

14. Do you think there needs to be more/less economic support? Why/ why not?

End of the economic questions

Environmental questions

15. What are the economical opportunities of this commune?

16. What are the economic challenges of this commune? Do changes need to occur?

17. How much was the forest cover in when this commune was established?

18. How much is the forest cover now in the commune?

19. Compared to the time just after the establishment of this commune, do you think there is overall better soil and water or more pollution? If so, do you know the reasons for it?

Have you taken samples of the water and soil in the commune to find out if this is the case?

20. Compared to the time just after the establishment of this commune, has the flora and fauna changed? Do you have some data about this?

21. Do you think the 60/40 ratio rule gives more/less environmental advantages than other ratios?

22. Do you think this mangrove-aquaculture model gives more/less environmental advantages than other aquaculture models?

End of ecological questions

23. What are the ecological opportunities of this commune?

24. What are the ecological challenges of this commune? Do changes need to occur?

Questions about social aspects:

25. What do you think about the regulations and land rights farmers have on their land?

26. Does the company/organization organize meetings for farmers of the commune to join?
Has/can the company/organization ever made/make changes based on the ideas farmers came up with?

27. Does the company/organization organize workshops for farmers of the commune? If so, what kind of workshops?

28. Do you think that this mangrove-aquaculture model is more equal than other aquaculture models? (Are farmers more representative and participating?)

Kết thúc câu hỏi xã hội

29. What do you think are the social opportunities of this commune?

30. What do you think are the social challenges of this commune? Do changes need to occur?

Ending question

31. In your opinion, do you think this allocation of forest land can continue to be implemented in the future in this area? Why/Why not?

Appendix D

Questionnaire DAT MUI

Opening questions:

1. Can you introduce a little bit about DARD and the Forest Company Dat Mui?

.....
.....
.....
.....

2. What is the Forest Company's main role in the Vien An Dong commune? Is this a kind of co-management model between the Forest Company and farmers?

.....
.....
.....
.....

3. How long has the Forest Company been active in this commune? What is the reason the FC is active here?

.....
.....
.....
.....

Main questions:

Policy questions

Questions about land allocation:

4. When did the Forest Company start allocating land in Vien An Dong and how did the forest cover look then?

.....
.....
.....
.....

5. How did the forest cover change because of the allocation of farmers?

.....
.....
.....
.....

6. What zone is Vien An Dong located in? (production forest, protection forest, special use forest) Why?

.....
.....

.....
.....

7. What is the process of land allocation for a farmer? What is the difference between first and second generation land owners?

.....
.....
.....
.....

8. What requirements do farmers need to follow regarding harvest and aquaculture? (renovate ponds and empty ponds, harvest period)

.....
.....
.....
.....

9. Does every farmer receive a land certificate in this commune and which type of land certificate do they receive?

.....
.....
.....
.....

10. How is it decided what the size of a farmer's land is going to be?

.....
.....
.....
.....

11. What does the cooperation between the Forest Company and the farmers look like?

.....
.....
.....
.....

12. What does the Forest Company think about the current land rights of farmers?

.....
.....
.....
.....

13. Is all the mangrove-aquaculture farming in Ca Mau/ the Mekong Delta/ Vietnam regulated by the government in the same way as in the Vien An Dong commune?

.....
.....
.....
.....

14. Is this mangrove-aquaculture model provincially/ nationally stimulated? If yes, how?

.....
.....
.....
.....

Questions about 60/40 ratio rules:

15. What is the 60/40 (forest/aquaculture) ratio rule based on?

.....
.....
.....
.....

16. Why is it according to the Forest Company the best ratio for mangrove-aquaculture compared to other ratios?

.....
.....
.....
.....

17. What does the Forest Company think about a flexible forest rate?

.....
.....
.....
.....

Environmental section

Questions about pollution and biodiversity:

18. Compared to the time just after the establishment of this commune, do you think there is overall better soil and water or more pollution? If so, do you know the reasons for it?

Have you taken samples of the water and soil in the commune to find out if this is the case?

.....
.....
.....
.....

19. If the last question was answered with yes, can you roughly draw on the map where most pollution in the soil and water is found?

.....
.....

.....
.....

20. Compared to the time just after the establishment of this commune, has the flora and fauna changed? Do you have some data about this?

.....
.....
.....

Economic questions

Questions about taxes, financial assistance and wood prices:

21. When did the Forest Company abolish the tax on aquaculture and why?

.....
.....
.....

22. What is the tax farmers have to pay for harvesting?

.....
.....
.....

23. Can farmers sell the wood directly to the buyers they prefer at the market price or are the buyers chosen by the Forest Company?

.....
.....
.....

24. Does the Forest Company give financial assistance to farmers? If yes, in what way?

.....
.....
.....

25. Does the Forest Company give other support to farmers? If yes, in what way?

.....
.....
.....

Social section

Questions about meetings and workshops:

26. Does the Forest Company organize meetings for farmers of the commune to join? If yes, are other stakeholders such as Minh Phu also included in these meetings?

.....
.....
.....
.....

27. Has the Forest Company made changes based on the ideas farmers came up with?

.....
.....
.....
.....

28. Does the Forest Company organize workshops for farmers of the commune? If so, what kind of workshops?

.....
.....
.....
.....

Ending questions:

29. What are the opportunities of this model?

.....
.....
.....
.....

30. What are the challenges of this model?

.....
.....
.....
.....

31. Do you have anything more to add?

.....
.....
.....
.....

Appendix E

Code tree

