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HOW TO DEVELOP AGRICULTURE AND PROTECT THE ENVIRONMENT AROUND PROTECTED AREAS: A CASE ANALYSIS OF XUAN THUY NATIONAL PARK, VIETNAM

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Comment développer l’agriculture et protéger parallèlement l’environnement autour des aires protégées: Un modèle d'analyse du parc national de Xuan Thuy, Vietnam

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Abstract

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Agricultural development is still central to economic activity and employment in Vietnam. The developments in modern agriculture have led to a host of environmental concerns because it impinges on natural resources and heavily relies on synthetic fertilizers, pesticides and other chemicals. Agricultural developments include various influences on biodiversity and ecosystem functioning and services such as destruction of wildlife habitat, organic and nutrient enrichment, pollution risks, etc. The research throws light on an area not always foregrounded in the discussion of agricultural development surrounding protected areas in Vietnam. It raises an important question about how can manage agricultural production of protected area buffer zones to achieve economic viability and ensure ecological sustainability. This research has sought to analyze the agricultural development of local people and provide some perspectives on sustainable development toward agroecology nearby protected sites which are significant for Vietnam. The structure and emphasis of this research have been shaped mainly by the material gathered through the interviews.

Through the application of the systemic approach of agroecology (objectives-practices-outputs), this research reviews the current situation of agricultural development surrounding Xuan Thuy National Park, the first Ramsar site in Southeast Asia. In the protected area buffer zone, there is an existence of diverse farming systems (mono and poly-culture) but there is a dearth of ecological-based knowledge and practices of farm households. One indication that there have not different cultivation guidance and management for farmers in the communal buffer zone as compared with outer communes. Agricultural advisory services from the local government have been disseminated similarly in the whole district including the protected area buffer zone. Whole-farm performances gained with different levels of sustainability. From socio-economic perspectives, farm households achieve some profitability but less efficiency. From ecological perspectives, there are many issues related to environmental pollution including the spontaneous drainage of farm effluents, inordinate application of pest and

disease control, unwise utilization of synthetic fertilizers, wide use of antibiotics, and water conflicting between group users.

Through RAAIS (Rapid Appraisal of Agricultural Information System) analysis, this research identifies a vast range of elements that constitute constraints and underlying causes that hinder sustainable agricultural development and the application of ecological-based management practices in the protected area buffer zone. The top three clusters of constraints to achieving the development are mismanagement practices at the farm-scale, economic issues and environmental pollution. The analysis is undoubtedly brought about improvements in understanding the challenges and particular problems for agricultural developments around the protected area. Then the research focuses on the analysis of interlinked causes of the constraints.

The first cause relates to the poor policy development associated with low enforcement of agroecologically-based methods for the agriculture sector nearby protected areas. Meanwhile, literature and policy documents show that Vietnam has numerous laws, policies and regulations for sustainable agriculture and eco-friendly cultivation, they have not been effectively transferred into practices at this zone. There is no restriction upon the unwise use of agrochemicals such as chemical pesticides and fertilizers around the sensitive area. At the same time, there is a lack of economic incentives for farmers who conserve nature near the protected area. Authorities at district and commune levels manage agriculture toward intensification but deficient ecological knowledge. Xuan Thuy National Park management board has very little authorization in monitoring improper practices of peripheral communities even though the park has technicians working on the issues related to environmental protection and conservation. Farmers have little interaction with the park for agricultural production. Furthermore, the enforcement of environmental standards in farming activities is limited despite the existence of environmental regulations and laws. The weak enforcement attributes by the dearth of facilities, resource-conserving equipment, laboratories, and staff from district to communes. In other words, environmental standards are given too much emphasis, while they have not transferred into practice and materialized in this site.

The second emergent cause call for a reorientation is the agricultural advisory service system due to its low performance. Packages of technical advisory and problem-solving skillsets have not yet satisfied various needs of farmers or improved the economic and environmental outcomes of diverse production systems. Advisory providers have little role in assisting farmers to confront regional issues including negative impacts from pesticide contaminants and pond effluents, a disease outbreak in production, drastic weather, water conflicting between groups of farmer users, etc.

Another critical interlinked constraint is related to the gap between the objectives of farmers and the park authority. Primary, farmers have the top priority for profits and they want to satisfy their own needs rather than feeling responsible for long-term maintenance. This clearly expresses the improper farming methods in the land-use systems and thus partly leads to the undesirable environmental performance in surveyed farms. While the conservative authorities expect both conservation and development, but in most cases economic factors shaped the decision-making of provincial government and lower agencies. From the preservation perspective, there have not clear indicators or measures of environmental sustainability for agriculture.

Lastly, the findings of the research point out that farmers' knowledge of ecological agriculture is deficient, and these have an impact on the limited adoption of environmentally friendly production methods.

Several implications are arising from this research to reflect on what needs to be put in place to ensure the form of agriculture nearby sensitive sites. These include ways of the policy-making process and stakeholder engagement as well as fostering of local knowledge and capacities and sustainable management practices in the response of agricultural development and pollution mitigation. The changes require helps to regulate agriculture toward the preservation of local ecosystems.

Keywords:

Agricultural development, environmental protection, protected areas, Xuan Thuy National Park, Vietnam

Résumé

Nguyen Thi Trang Nhung (2021). Comment développer l'agriculture et protéger parallèlement l'environnement autour des aires protégées: Un modèle d' analyse du parc national de Xuan Thuy, Vietnam. Gembloux, Belgique, Gembloux Agro-Bio Tech, Université de Liège, 256 pages, 78 tableaux, 60 figures et 1 encadré.

Le développement agricole est toujours au cœur de l'activité économique et de l'emploi au Vietnam. L'évolution de l'agriculture moderne a suscité de nombreuses préoccupations environnementales, car elle empiète sur les ressources naturelles et dépend fortement des engrais synthétiques, des pesticides et d'autres produits chimiques. Le développement agricole influence diversement la biodiversité et le fonctionnement des écosystèmes et des services tels que la destruction de l'habitat faunique, l'enrichissement en matières organiques et en éléments nutritifs, les risques de pollution, etc. La recherche met la lumière sur une zone qui n'est pas toujours au premier plan dans la discussion du développement agricole entourant les zones protégées au Vietnam. Elle soulève une question importante sur la façon de gérer la production agricole des zones tampons protégées pour atteindre la viabilité socio-économique et assurer la durabilité écologique. Cette recherche a cherché à analyser le développement agricole des populations locales et à fournir des perspectives de développement durable vers l'agroécologie à proximité des sites protégés qui sont importants pour le Vietnam. La structure et l'importance de cette recherche ont été façonnées principalement par le matériel recueilli au cours des entrevues.

En appliquant l'approche systémique de l'agroécologie (objectifs-pratiques-résultats), cette recherche examine la situation actuelle du développement agricole autour du parc national Xuan Thuy, le premier site Ramsar en Asie du Sud-Est. Dans la zone tampon de l'aire protégée, il existe divers systèmes agricoles (mono et polyculture), mais les pratiques de production écologiques des ménages agricoles sont rares. Il n'existe pas de différence dans les directives agricoles pour les agriculteurs dans la zone tampon et ceux des zones extérieures. Les services de conseil agricole du gouvernement local ont été diffusés de façon similaire dans l'ensemble du district. Les performances des exploitations agricoles en ont bénéficié et atteignent différents niveaux de durabilité. Du point de vue socio-économique, les ménages agricoles atteignent une certaine rentabilité, mais moins de stabilité, d'efficacité et de résilience. Du point de vue écologique, il existe de nombreux problèmes liés à la pollution de

l’environnement, notamment le drainage spontané des effluents agricoles, l’application excessive de pesticides contre les ravageurs et les maladies, l’utilisation peu judicieuse d’engrais synthétiques, l’utilisation généralisée d’antibiotiques, et le conflit pour l’eau entre les utilisateurs du groupe.

En utilisant l’analyse par RAAIS (Rapid Appraisal of Agricultural Information System), cette recherche détermine des éléments qui entravent le développement agricole durable et l’application des pratiques de gestion écologiques dans la zone tampon de l’aire protégée et les causes de ses contraintes. Les trois principaux groupes de contraintes à la réalisation du développement sont les mauvaises pratiques de gestion à l’échelle de la ferme, les problèmes économiques et la pollution environnementale. L'analyse est certainement amenée à améliorer la compréhension des défis et des problèmes particuliers du développement agricole autour des aires protégées. Ensuite, la recherche se concentre sur l'analyse des causes interdépendantes des contraintes.

La première cause est liée au faible développement des politiques associé à une faible application de celles-ci au secteur agricole à proximité des aires protégées. En ce moment, le Vietnam a de nombreuses lois, politiques et réglementations pour une agriculture durable et une culture respectueuse de l'environnement, mais elles n'ont pas été effectivement transposées dans les pratiques de cette zone. Il n’y a aucune restriction quant à l’utilisation imprudente de produits agrochimiques comme les pesticides et les engrais dans la zone sensible. En même temps, il manque d’incitations économiques pour les agriculteurs qui conservent la nature à proximité de l’aire protégée. Les autorités, au niveau du district et de la commune, poussent l’agriculture vers l’intensification, mais avec une connaissance écologique insuffisante. Le conseil de gestion du parc national Xuan Thuy a très peu d’autorité pour surveiller les pratiques inappropriées des communautés périphériques, même si le parc a des techniciens qui travaillent sur les questions liées à la protection et à la conservation de l’environnement. Les agriculteurs ont peu d’interactions avec le parc pour la production agricole. De plus, l’application des normes environnementales dans les activités agricoles est limitée malgré l’existence de lois et de règlements environnementaux. Les faibles retombées de l’application de la loi sont dues au manque d’installations, d’équipement de conservation des ressources, de laboratoires et de personnel des districts et communes. Autrement dit, on met trop l’accent sur les normes environnementales, alors qu’elles ne se sont pas matérialisées dans ce site.

La deuxième cause émergente, appellée à une réorientation, est le système de conseil agricole en raison de ses faibles performances. Les ensembles de compétences techniques de conseil et de résolution de problèmes n'ont pas encore répondu aux divers besoins des agriculteurs ni amélioré les résultats économiques et environnementaux des divers systèmes de production. Les comités de conseils ont peu de moyens pour aider les agriculteurs à faire face aux problèmes régionaux, y compris les effets négatifs des contaminants, des pesticides et des effluents des étangs, une maladie dans la production, des conditions météorologiques extrêmes, des conflits pour l'eau entre les groupes d'agriculteurs utilisateurs. etc.

Une autre contrainte essentielle, c'est l'écart entre les objectifs des agriculteurs et ceux de l'autorité du parc. Dans le secteur primaire, les agriculteurs donnent la priorité absolue aux profits et ils veulent satisfaire leurs propres besoins plutôt que de se sentir responsables de l'entretien à long terme. Cela exprime clairement le caractère inapproprié des méthodes agricoles dans les systèmes d'utilisation des terres et conduit donc en partie à des performances environnementales indésirables dans les exploitations recensées. Alors que les autorités en charge de la conservation de la nature attendent à la fois la conservation et le développement, dans la plupart des cas, ce sont les facteurs économiques qui ont façonné la prise de décisions du gouvernement provincial et des organismes des échelons inférieurs. Du point de vue de la préservation, il n'y a pas d'indicateurs ou de mesures clairs de la durabilité environnementale pour l'agriculture.

Enfin, les résultats de la recherche soulignent que les connaissances des agriculteurs en matière d'agroécologie sont insuffisantes et qu'elles ont un impact sur l'adoption limitée de méthodes de production respectueuses de l'environnement.

Plusieurs implications découlent de cette recherche pour réfléchir à ce qui doit être mis en place pour déterminer la forme de l'agriculture à proximité des sites sensibles. Il s'agit notamment des processus d'élaboration des politiques et de mobilisation des parties prenantes, ainsi que de l'amélioration des connaissances et des capacités des responsables locaux et des pratiques de gestion durable pour le développement agricole en vue de l'atténuation de la pollution. Les changements nécessaires aident à réglementer l'agriculture pour la préservation des écosystèmes locaux.

Mots-clés:

Développement agricole, protection de l'environnement, zones protégées, Parc National de Xuan Thuy, Vietnam

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AAS	Agricultural Advisory Service
ASEAN	Association of Southeast Asian Nations
ASP	Advisory Service Provider
BAP	Best Aquaculture Practice
BDL	Biodiversity Loss
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CAB	Communal Agricultural Board
CAC	Communal Agricultural Cooperative
CAS	Center of Agricultural Services
COD	Chemical Oxygen Demand
CPC	Communal People's Committee
DARD	Department of Agriculture and Rural Development
DMU	Decision Making Unit
DoNRE	Department of Natural Resource and Environment
DEA	Data Envelopment Analysis
DPC	District People's Committee
EU	Europe
FAO	Food and Agriculture Organization
FCR	Feed Conversion Ratio
GAP	Good Agricultural Practice
GAqP	Good Aquaculture Practice
GDP	Gross Domestic Product
GSO	General Statistics Office
IAM	Integrated mangrove – aquaculture
ISH	Intensive shrimp
IUCN	International Union for Conservation of Nature
K	Potassium
MARD	Ministry of Agriculture and Rural Development
Mil.	Million
MoNRE	Ministry of Natural Resource and Environment
N	Nitrogen
NGOs	Non-Government Organizations
NPK	Nitrogen – Phosphorus – Potassium
P	Phosphorus
PL	Post-larvae
PPC	Provincial People's Committee
RAAIS	Rapid Appraisal of Agricultural Innovation System
RB	Rice-based
UNESCO	United Nations Educational Scientific and Cultural Organization
USD	United States Dollar (currency)
VND	Vietnam Dong (currency)
WAI	Weighted Average Index
WHO	World Health Organization

1

Introduction

1.1 Background and problem statement

Vietnam enjoys extraordinary biodiversity with a total of 279 protected areas located from north to south and at both national and international important levels. The total area of the protected area system in Vietnam is over 2.4 million hectares (account for about 7% of the terrestrial area of the whole country). Protected areas are essential for biodiversity preservation since they are designed for preventing or eliminating exploitation or harmful management practices of humans and maintaining natural resources of protected ecosystems. The protected areas in Vietnam are classified into two groups including 185 national protected areas (National Park, Nature Reserve, Species and Habitat Reserves, Protected Landscape, Experimental and Scientific Research Area, and Marine Protected Areas), and 94 international protected areas (Wetlands of international importance/Ramsar site, World heritage site, ASEAN heritages, and Important Bird Area) (Vietnam Association of National Park and Nature Reserve, 2021; Special-Used Forest Management Department, 2019; MoNRE, 2014). The establishment of a protected area system in Vietnam which commenced between the 1960s and 1980s created mechanisms to conserve the unique biodiversity values of the whole country. The Vietnamese Prime Minister declares functions of protected areas as: (1) to contribute to the protection of natural resources, biodiversity, and landscape in a sustainable development manner; (2) to raise awareness of people about the importance and value of natural resources as well as biodiversity and strengthen the participation of people in conserving protected areas; (3) to reform institutions and policies for the management of protected areas and enhance management capacities of local authorities and protected area management boards; (4) to strengthen the international cooperation (Decision 192/2003/QD-TTg). The area of protected sites has increased from 2.2 million hectares to 2.4 million hectares from 2017 to 2021 to meet conservation and development needs. However, natural resource conservation and management activities of protected areas along Vietnam have faced many challenges: negative impacts from surrounding communities, lack of funding for conservation activities, limited institutional management capacity of park managers, land-use conflicts, overlapping organizations, and lack of enforcement authority for the management boards (Le et al., 2018).

Geologically, protected areas in Vietnam have borders with buffer zones where have been designed for farmland and residential areas of communities. According to FAO (2004), buffer zones link protected areas to one another through the preservation of habitat. Buffer zones are designed to remain under wild cover or be managed to ensure that land-use activities are compatible with biological connectivity. Protected area buffer zones reduce the pressures on native vegetation for the production of foods and fuels for human consumption. Protected area buffer zones play an ecosystem function for the dispersal of plants as well as the movement and migration of animals between intact habitat types. To be effective, protected area buffer zones must offer suitable habitats to wildlife and preserve environments free of pollutants along such pathways.

Vietnam defines a protected area buffer zone as a forest, land or water surface, coastal land, or islands that are located inside the protected areas (inner buffer zone) or adjacently the protected areas (outer buffer zone). The buffer zones aim at preventing and mitigating the invasion from outside into protected areas and encouraging buffer communities to participate in co-management programs to improve their livelihoods (Decree 10/2014/TT-BNNPTNT). The protected area management boards (including director, deputy and staff) are in charge of applying laws on natural environmental protection and biodiversity conservation within protected areas. Moreover, the boards are responsible for organizing and cooperating with local authorities and communities to develop programs and projects for buffer zones (Decision 156/2018/ND-CP). The boards also have roles in organizing the participation of buffer communities in forest protection, conservation, wise utilization of natural resources, and environmental service provision (Decision 186/2006/QD-TTg). However, evidence around many protected areas in Vietnam shows the collaboration between buffer zones with their protected areas has focused more on biodiversity conservation and forestry management rather than socioeconomic development (Le et al., 2018). Protected area buffer zones are still considered as administrative units than ecological zones.

The integration of agricultural production in protected area buffer zones in Vietnam has been associated with simultaneous beneficial and detrimental consequences. Many issues related to environmental problems from agriculture have been profound. The conversion of wetland mangroves to other land-use forms of aquaculture raising has led to fragmentation of ecosystems and natural habitat degradation (Khai & Yabe, 2014). The expansion of farming to new areas has resulted in wide encroachment into protected areas and drainage of natural wetlands. Agricultural developments with improper practices have destroyed biodiversity and habitats, driven wild species to extinction, accelerated the loss of environmental services, and eroded agricultural genetic resources. Farms discharge large quantities of agrochemicals, organic matter, drug residues, and sediment into water bodies. The resultant water pollution poses demonstrated risks to aquatic ecosystems, human health, and productive activities (Pedersen, 1996; Buckton, 1999; Gilmour & San, 1999; Haneji et al., 2014; Khai & Yabe, 2014; Kamoshita et al., 2018). The question is how the residents living adjacent to the protected site use land and other natural resources for their livelihood in a way that does not impair the long-term viability of environmental assets of the areas? Or how the agricultural production systems around the conservation sites are designed and managed to enhance the positive impacts of conservation on protected areas and reduce the negative impacts of farming activities on the environment? Whether buffer communities should be treated differently from outer ones? How can communities and agencies involve more in conservation activities? Many challenges and constraints continue to pose problems to the sustainable development of agriculture nearby protected areas that aim to conserve the natural environment while providing the basis for the social and economic development of local residents. In most parts, biological fragmentation compares with social and economic fragmentation. This is crucial to appraise underlying causes of threats to protected areas and provide responses to the protected areas' governors and managers. The protected area practitioners should be equipped with the valuable information to achieve effective management as a basis for creating improved futures for species, ecosystems, and maintaining healthy environments. Due to diverse obstacles, policies should be translated into development and conservation activities in and around protected areas, and efforts to address the environmental problems associated with agricultural activities should focus on technical improvements in management practices with more rigorous monitoring and regulations. These measures have largely sought to control the environment in which agriculture takes place.

Xuan Thuy National Park plays an important ecological function in preventing damages of storms and tidal surges, supporting fisheries, birds and mangroves, absorbing waste and replacing sediment, maintaining biodiversity. The park also contributes greatly to economic values for people including reducing natural disaster losses, providing commercial values of fisheries and non-timber forest products, improve outcomes from farmed/harvested species (Hai & Nhan, 2015). Policymakers and governors recognize this park as a place to balance socioeconomic development and environmental protection (Leslie et al., 2018). The livelihood of most people living near the park depends heavily on agriculture (cropping, livestock and aquaculture account for over 90% of the total labor force). Farmland expansion and agricultural intensification for food demand of growing population around the park cause depletion of water quality, mangrove fragmentation and destruction, wetland biodiversity deterioration, and increasingly vulnerable levels (Beland, 2006; Nhuan et al., 2009; Nhan, 2014; Haneji et al., 2014; Hai & Nhan, 2015; Kamoshita et al., 2018). Rice-based, integrated aquaculture-mangrove and intensive farming systems dominate the buffer zone and provide main income sources for local farmers. Current farming practices in the buffer zone have created many problematic issues such as a similarly high rate of fertilizers and pesticides as compared with non-buffer zones (Kamoshita et al., 2018), water conflicting due to pollution from farms (Nguyen et al., 2019); higher concentration of pesticides and herbicides than allowed ranges (Mai & Nguyen, 2003).

In the light of the above, this research seeks to assess the current situation of agricultural production and its constraints around protected areas under the context of environmental protection for sustainable and foreseeable ecological agriculture, take Xuan Thuy National Park as a case analysis.

1.2 Research questions

This study has the overall research question as to develop agriculture while protecting the environment around protected areas in Vietnam. To deal with the topic, five detailed questions are verified as follow:

- What are the characteristics of protected areas in Vietnam?
- To the extent, there is a conflict of interest between the objectives of Xuan Thuy National Park and farming communities?
- How is the current situation of agricultural practices around Xuan Thuy National Park?
- What are farm outputs around Xuan Thuy National Park?
- What are the constraints that impede small farmers to move toward sustainable agriculture around Xuan Thuy National Park?

1.3 Research objectives

The main focus of this study is to analyze the agricultural development around Xuan Thuy National Park under the context of environmental protection for sustainable and foreseeable ecological agriculture. Thus, special attention is devoted to the household's farming management practices to cope with constraints and comply with specific requirements from legal normative documents issued by national and local authorities. Local farmers have to develop innovative approaches to manage production and care for environmental issues. Therefore, the specific objectives are:

- To examine natural-socio-economic-institutional characteristics of protected areas in Vietnam, take Xuan Thuy National Park as a case analysis;
- To assess the objectives of Xuan Thuy National Park managers and farming communities;
- To describe agricultural production practices of farmers around Xuan Thuy National Park;
- To analyze outcomes of agricultural production around Xuan Thuy National Park;
- To identify constraints and interlinked causes of sustainable agricultural development around Xuan Thuy National Park; and
- To propose recommendations for sustainable agricultural development around Xuan Thuy National Park, Vietnam.

1.4 Scale and scope of the research

Agriculture comprises diverse subsectors such as cropping, livestock raising, fisheries (aquaculture and capture), forestry, etc. In this research, we focus on cropping and aquaculture. In the cropping subsector, the rice-based farming system is chosen for the analysis. In the aquaculture subsector, intensive shrimp farming systems and integrated aquaculture-mangrove farming systems are chosen.

We have focused on farm households to evaluate the information on the interests of farmers, farming practices, and outcomes.

Diverse stakeholders involved in agricultural advisory services and several environmental authorities are also approached to examine the constraints of sustainable agriculture around the protected area.

1.5 Organization of the thesis

The dissertation is structured in six chapters. Chapter 1 (Introduction) provides the background of the protected area system in Vietnam. The statement of problems in regards to agricultural pollution around protected areas is also presented. The chapter emphasizes the necessity of managing agricultural production around protected areas to enhance the positive impacts of conservation on protected areas and reduce the negative impacts of farming activities on protected areas in the country. Also, this chapter includes the research questions and research objectives.

Chapter 2 (The review of literature) begins by reviewing theoretical perspectives of protected areas and their buffer zones, agroecology, constraints of sustainable agriculture around protected areas in developing countries, and experiences of agroecology in and around protected areas worldwide.

Chapter 3 (Research methodology) presents the choice of several protected areas in northern Vietnam for the comparative analysis of the protected sites in Vietnam. Then, Xuan Thuy National Park was selected as case analysis for deepening understanding of the current situation of agricultural production surrounding the protected area. This chapter also presents the analytical framework, research design, data collection methods, and data analysis.

Chapter 4 (Protected areas management in Vietnam) provides two main parts. The first part provides a general overview of the protected area system in Vietnam (statistics of protected area system, state organizations' involvement in protected area management, policies for protected areas). The second part compares differences between five surveyed protected sites regarding geographical and natural features, administration and workforce, the application of policies in protected areas, development and conservation activities, and the existing situation of agricultural production around the sites.

Chapter 5 (Agricultural development toward agroecology around Xuan Thuy National Park) deals with the current situation of agricultural development around Xuan Thuy National Park as a case analysis. The analysis bases on the systemic approach of agroecology (objectives-practice-outcomes). "Objectives" provides different aims of the park managers, communes, and farmers. "Practices" presents farming management practices of farmers. "Outcomes" evaluate outcome indicators toward agroecology.

Chapter 6 (Constraints and causes of sustainable agricultural development around Xuan Thuy National Park) covers the key constraints that affect the sustainable development and application of ecological-based agriculture around Xuan Thuy National Park. Moreover, the interlinked causes affecting agricultural activities in different sectors have been identified in the following content.

Chapter 7 (Conclusion and recommendation) summarizes the foregoing chapters, draws some conclusions, and offers recommendations and appropriate responses for different levels of government and diverse groups of farmers to address the current constraints.

2

Review of literature

In this section, we review the existing literature in regards to concepts of protected areas and their buffer zones, the importance of agroecology under the context of conservation around protected areas; application of agroecology around several protected areas; and the constraints that restraint sustainable agriculture around protected areas in developing countries.

2.1 Protected areas

2.1.1 Definition

- Protected area

According to Dudley (2008), a protected area has been defined by the IUCN (International Union for Conservation of Nature) as *"a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".* Also, his foreword in the IUCN Guidelines for Protected Areas Management published in 2008 stated that protected areas remain the fundamental building blocks of virtually all national and international conservation strategies, supported by governments and international institutions such as the Convention on Biological Diversity. Every word and phrase of this definition provides the framework for improved conservation and to identify the linkages between the bio and geo elements of conservation, and has a prescribed meaning (Gray et al., 2013; Gordon et al., 2018; Crofts, 2019). A new definition of protected areas was approved in the IUCN Guidelines for Protected Areas Management published in 2008, that took specific account of geo-conservation with the clear statement that all protected areas should aim where appropriate to **"**conserve significant landscape features, geomorphology, and geology**"** (Crofts, 2019; Dudley, 2008).

According to (Worboys et al., 2015), humanity aims to retain the extraordinary beauty and riches of the protected areas and all its benefits to people. Protected areas are the world heritage of evolution over four billion years, which is considered unique in the entire universe. Protected areas classify into majestic landscapes, remarkable flora and fauna, rocky mountains, spectacular cave formations, towering forests, majestic waterfalls, vast swamps and lakes, vast deserts, unspoiled coastlines, deep ocean mountains, and coral reefs. Through traditional management practices, protected areas can also preserve landscapes of great cultural value and beauty created by people over time (Worboys et al., 2015). They are vital to maintaining healthy ecosystems and environments for humans and all other species.

They are essential for biodiversity conservation of which geodiversity has an important ecological value in supporting biodiversity and ecosystem functioning (Crofts, 2019)**.** Protected areas deliver clean water and air and they are important to the cultures and livelihoods of traditional and indigenous communities. They bring sustainable development benefits to people through nature-based tourism that seek and expect a high level of service and product directly related to natural attractions, and they are willing to pay for it (Worboys et al., 2015). Also, they are the critical natural solution for climate change as they build resilience to climate change globally, mitigate the impacts of climate events, ensure the provision of ecosystem services and protect biodiversity. At one extreme, they are also important for their rich history and cultural associations. They encompass traditional, inhabited landscapes and seascapes where human actions have shaped cultural landscapes with high biodiversity (Dudley, 2008). They are typically protected, in perpetuity, by a nation's strongest laws (Worboys et al., 2015).

- **Buffer zone**

Pressures on the quality of the environment caused by economic development, land-use change, and other human activities make it difficult to protect protected sites. Many studies have revealed the threats from surrounding areas call buffer zone on protected areas such as adjacent land development, human encroachment, soil erosion, conflict demands on management (Sharma, 1990; Wells & Bradon, 1992; Kozlowski & Vass-Bowen, 1997) in particular expansion and encroachment of agricultural activities (Wells & Bradon, 1992).

The concept of a buffer zone is applied widely in the period of the 1970s-1980s for preventing negative impacts from surrounding areas.

Ebregt & Greve (2000) define that buffer zone is any area often peripheral to a protected area, inside or outside, in which activities are implemented or the area managed with the aim of enhancing the positive and reducing the negative impacts of conservation on neighboring communities and neighboring communities on conservation.

According to the definition proposed by the World Park Congress in 1982, a buffer zone is an area around protected areas in which land use is restricted to serve as an added layer of protection to the protected area at the same time providing benefits to neighboring rural communities.

Dudley (2008) asserts that a buffer zone is an area around a protected area that is managed to help to maintain protected area values.

According to Kozlowski & Vass-Bowen (1997), a buffer zone is an area to protect protected areas from negative impacts originating from activities carried out in surrounding areas. It provides an added layer of protection to a protected area while providing benefits for local people.

2.1.2 Objectives and benefits of protected areas and buffer zones

- **Protected areas:**

Protected areas are essential for biodiversity preservation since they are designed for preventing or eliminating exploitation or harmful management practices of human activities and maintaining or upgrading the natural level of the protected ecosystem. Protected areas are clearly defined as geographical space through legal or other effective means, to achieve the long-term conservation of nature with associated cultural values.

The primary purpose of protected areas is not only the protection of ecological system, geological/geomorphological features, natural conditions biodiversity management, fauna and flora species preservation, but also the monitoring the interactions between human habitation and long-term environmental processes (Dudley, 2008; Worboys et al., 2015).

Table 2.1: Objectives of protected areas

	Classic model (Mid-1800s – 1970s)	**Modern model (1970s – Mid-2000s)**
Rationale for establishing protected areas	"Set aside" from productive use	Concurrent social, ecological and economic objectives
Purpose of protected areas	Established primarily for scenic values rather than functional values	Established for scientific, economic and cultural reasons
Management purpose	Managed mostly for park visitors	Managed with local people
Management actors	Managed by central government	Managed by central government and by local communities
Connection of protected areas with the surrounding landscape and human uses	Viewed as islands, isolated from the surrounding landscape, seascape and human use	Viewed as part of a comprehensive ecological network

(Source: Ervin, 2010)

In the classic model, protected areas were generally viewed as existing independently from their surrounding landscape and seascape. Instead of being considered as part of an integrated and comprehensive land-use plan, protected areas were often viewed as isolated and located in areas with low economic and ecological value. Until the 1970s, societal benefits were mostly viewed as incompatible with protected area objectives and attempts to steer protected areas toward delivering social and economic benefits were largely viewed as compromising biodiversity conservation objectives. Protected areas were primarily a government-driven enterprise – owned and managed by national and subnational governments, maintained and managed by government staff, and funded through tax dollars and annual government allocations.

The modern model of protected areas began to emerge in the 1970s, began to reflect a changing view of protected areas. Since then, the concept of protected areas has evolved significantly, reflecting the norms, attitudes and values. In this modern model, planners began to acknowledge the importance of local communities, recognize governance models beyond government-run national parks, and address the need for more systematically and comprehensively designed protected area networks. Protected areas began to be viewed more as social enterprises and managed with the needs of local communities, often in partnership with social scientists and local communities. New forms of protected areas – such as community-conserved areas – were created and/or recognized. Protected areas are expected to do more socially – economically - ecologically than they ever have before.

As determined by IUCN (Dudley, 2008), protected areas have multiple benefits as follow:

- Conserve significant landscape features, geomorphology and geology;
- Provide regulatory ecosystem services, including buffering against the impacts of climate change;
- Conserve natural and scenic areas of national and international significance for cultural, spiritual and scientific purposes;
- Deliver benefits to resident and local communities consistent with the other objectives of management;
- Deliver recreational benefits consistent with the other objectives of management;
- Facilitate low-impact scientific research activities and ecological monitoring related to and consistent with the values of the protected area;
- Use adaptive management strategies to improve management effectiveness and governance quality over time;
- Help to provide educational opportunities (including about management approaches);
- Help to develop public support for protection.

- **Buffer zones:**

Buffer zones are seen as a strategy in both conserving sites of protected areas and addressing development objectives (Ebregt & Greve, 2000). The dual objectives of protected area buffer zones are mentioned by Jotikapukkana & Pattanavibool (2010), as extension buffering of protected areas and social buffering to provide goods and services to people.

Several objectives of the buffer zone are mentioned by Poore & Sayer (1991) as below:

- Provide a physical barrier to human encroachment into the protected zone.
- Provide extra protection from natural damages.
- Enlarge the effective zone of natural species of protected areas.
- Enhance the environmental services of protected areas through protecting water resources and climatic regulation.
- Promote the sustainable use of plant and animal species by local people.
- Provide a mechanism to foster the interest of local people for conservation.
- Compensate local people for the loss of access to the protected areas.

Thus, buffer zones provide various benefits:

- Biological benefits: serving a filter or barrier against unsustainable use of the core zone or conservation area; protecting the protected sites from outside invasion.
- Social benefits: serving a resolution for conflicts between conservation interests and those of the surrounding inhabitants; building local support for conservation programs.
- Economic benefits: income of local people employed in the area, income from eco-tourism.
- Institutional benefits: participation of local people in management; stimulating responsibility with local government.

2.1.3 Types of protected areas and buffer zones

- **Types of protected areas:**

As protected areas were established in one nation after another, each nation developed its approach, and there were initially no common standards or terminology. The only shared idea was that important scenic, wildlife, or outdoor recreation areas should be identified and protected for the public good. According to the guidelines of IUCN, which helps categorize what exactly IUCN means for conserved territories or areas. These are "…site-based measures - regardless of availability acknowledged and reserved or only occasionally, even if management practices are clear and purposeful or not actual conservation outcomes have been achieved and/or conservation trends set positive and likely to sustain this trend in the long term…". This definition helps to maintain the integrity of protected areas categories that apply for the equal use of territories and areas on land, inland waters, coastal, and sea (Worboys et al., 2015; Dudley, 2008). The types of governance apply to both protected areas and territories and designated areas conservation is not recognized as "protected" by the IUCN or any particular government. In this sense, the terms "Private Reserve" and "ICCA" include land areas mainland, inland waters, coastal areas, and seas that are not areas designated by the government or IUCN recognized as "protected".

Accordingly, the key principles for protected areas management are as follows:

The first is to protect natural areas and landscapes of national and international importance for recreation, entertainment, education, scientific research, spiritual life, or tourism.

Second, the natural status quo, typical illustrations of biogeographic regions, biological populations, genetic resources and different species, ensuring ecological stability and diversity must be maintained in the long term.

Third, tourist management should be considered in the use of entertainment, entertainment, cultural and educational services to maintain natural characteristics or close to nature.

Fourth, the objective is to prevent and subsequently cease exploitation and seizure activities that harm the identified target. Fifth, protected area management should maintain and respect identified ecological, geomorphological, sacred, or aesthetic values.

Finally, the board of management should pay attention to the needs of ethnic minorities including their historical use of resources as they will not adversely affect other management objectives.

Based on the principles, the IUCN has developed an internationally accepted category system for protected areas that identify six categories of protected areas (Dudley, 2008; Worboys et al., 2015). These areas can be considered as truly protected areas, in which the habitats are mainly managed for biodiversity conservation.

Types of protected areas mentioned are as follow:

- *Strict nature*: These are strictly protected areas of land or sea dedicated to the protection and maintenance of biological diversity and natural resources, combined with the protection of cultural resources, and managed by legislation or other effective means. In a narrow sense, a nature reserve, also known as a nature reserve and habitat species conservation area, is a natural area established to ensure natural ecological succession. Nature reserves are strictly protected, only for scientific research, training, and long-term environmental monitoring activities as well as protecting other scarce natural resources and ecosystem services (Dudley, 2008; Dudley & Stolton, 2010; Worboys et al., 2015).
- *Wilderness areas:* These are regions where the land is in a natural state where impacts from human activities are minimal and that is, as a wilderness. It might also be called a *wild* or *natural* area. These nature reserves allow the preservation of populations of species and ecosystem processes with little or no disturbance. (Dudley, 2008; Worboys et al., 2015).
- *National parks:* These are large areas of natural beauty (in the sea or on land) that are preserved to protect one or several ecosystems and are used for educational and research purposes, science, recreation, and sightseeing. Resources in national parks are generally not allowed to be mined for commercial purposes.
- *Nature reserves (natural monument or feature)*: These are national works, with a narrower area, established to preserve the biological, geographical, geological, or cultural characteristics of certain local communities.

- *Wildlife habitat/species management areas:* these are similar to strictly protected areas, but allow some activities to be maintained to meet the unique needs of the community.
- *Landscape conservation areas on land and sea*: These were established to preserve the landscape. This area is allowed to explore and use resources in a traditional, non-destructive way, especially in places where the exploitation and use of resources have formed cultural, aesthetic, and ecological characteristics. distinctive ergonomics. These places create many development opportunities for the tourism industry. Besides, resource protected area was established to protect natural resources for the future. Here, the exploitation and use of resources are controlled under national policies. Biosphere reserves and anthropological reserves are established to preserve but still allow traditional communities the right to maintain their lives without outside interference. Usually, communities are still allowed to exploit resources to a certain extent to ensure their own lives. Traditional farming management practices are often associated with nature conservation and other environmental values in agricultural production. Multi-use management zones enable sustainable use of natural resources, including water resources, wildlife, livestock, timber, tourism, and fishing. Conservation of biological biomes is often done in conjunction with appropriate exploitation.

- **Main types of buffer zones:**

  - *Economic buffer zone:* It has a production function for example cash crops or adapted agricultural systems. Economic development is the priority, so investments are made. The improved infrastructure and increased production may attract people from outer areas to move into.
  - *Physical buffer zone:* the zone provides clear borders and prevents animals from leaving the core zone, restrain people from entering the core zone.
  - *Social buffer zone:* A social buffer zone approach uses the differences in culture of indigenous groups, and local organizations, to form a barrier, control and monitoring system between a conservation area and its surroundings.
  - *Streamside buffer zone:* A zone as forest or vegetation strips along lakes or rivers to protect water from disturbances by agriculture or other activities.

2.1.4 Integrating conservation and development in protected area buffer zones

The integrated conservation and development is a measurement for protected area management to link environmental protection with economic development by providing buffer communities with income sources that do not threaten natural resources especially in developing countries (Wells & Brandon, 1993). The integrated conservation and development approach attempts to reduce conflicts between protected areas and their nearby communities in an acceptable way (Du et al., 2015). Models of integrated conservation and developments worldwide (Integrated Conservation and Development Programs – ICDPs) establish protected areas that are restricted used while promoting socio-economic development and income generation activities in the adjacent areas (buffer zones) that are compatible with protected areas' objectives (Naughton-Treves, 2005).

The goals of integrated conservation and development tools are to change unsustainable land-use practices of buffer communities to sustainable economic alternatives. To achieve the goals, local people commit to conserve natural resources while their economic benefits are assured (Brandon & Well, 1992). Economic benefits are a common feature of integrated conservation and development strategy while securing environmental protection.

Integrated conservation and development strategies include management of protected areas and buffer zones, socio-economic development of local people. According to Well & Brandon (1992), socioeconomic development is central of ICDP concept to protected area management. The most common activities of integrated conservation and development to strengthen benefits for rural people in the buffer zones worldwide is natural resource management including agroforestry, irrigation management, water management, soil enhancement, erosion management, and farmed yield improvement, etc. (Brandon & Well, 1992).

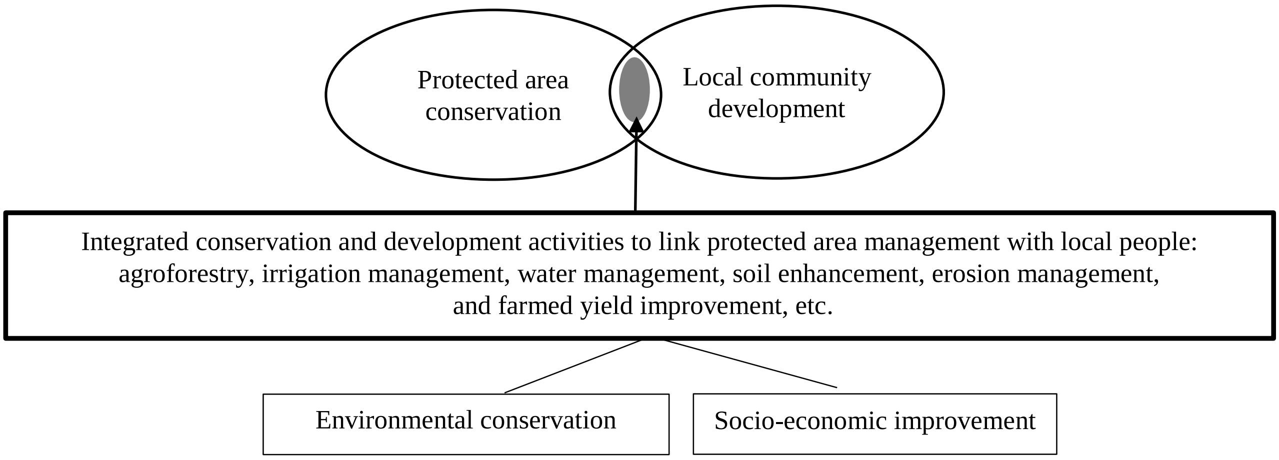


Figure 2.1: Integrated conservation and development approach for protected areas and buffer zones (Source: Brandon & Well, 1992)

The question of how to integrate conservation and development for local communities in protected area buffer zones is well documented. According to Peters (1999), Ranomanfana National Park Project in Madagascar applies ICDP concept with an aim at preserving biodiversity integrity of the park and providing support for specific conservation and rural development through alternative agricultural development (supporting irrigated rice cultivation with low-input use, food production diversification, agroforestry, market development, enhancement of income-generating enterprises.

Nepal is recognized for the success that combines community development with conservation through buffer zone legislation (created in 1994). Buffer zone legislation with a focus on community support and strong policies is the key. Policies enable practical works of communities within buffer zones and re-distribute funds back to local people (Allendorf & Gurung, 2016). How policies are translated into practices in the buffer zone are listed as below:

- Buffer zone regulation (1996) defines activities in the protected area buffer zones should comprise community development, environmental preservation, and forest resources.
- The government provides guidelines (1999) to strengthen conservation and development activities within the buffer zone:
  - Environmental protection and management: agriculture, agro-crop, diversification of crops, water conservation, soil conservation, alternative energy, natural forestry management, wildlife conservation, etc.
  - Economic development and skill development: vegetable farming training, agricultural nursery, building infrastructure for conservation, appropriate technology, enterprising oriented program, etc.
  - Conservation education: distribution of awareness-oriented conservation education materials, study tours, school conservation education programs, non-formal education.
  - Institutional support: training for capacity, community saving and mobilization, record keeping skills, auditing, coordination between groups, etc.
- The budget from the government distributes 50% for development and income generation, 40% for conservation and conservation education.
- Overall buffer zone management plan (5 years) is developed by a bottom-up process with the participation of communities: buffer zone user groups for men/women, buffer zone management council (chaired by managers of protected areas) (Allendorf & Gurung, 2016).

2.2 Agroecology for agricultural development around protected areas

2.2.1 Definitions of agroecology

Before the 1960s, researchers focused on short-term yields and economic returns and agroecology initially dealt with crop production and protection aspects. They focused on production and economics, but environmental and social aspects were not often mentioned. The negative impacts of agriculture were concerned after the Green Revolution (the 1950s-1960s). The environmental consequence was concerned with the problems of toxic substances such as pesticides on nature. Since the 1980s, agroecology has emerged as a distinct approach to define a way to protect the environment (of which organic is one system) (Altieri, 1989; Gliessman, 1997). Agroecology was described as a set of agricultural practices, with a particular focus on alternatives to synthetic fertilizers and pesticides, soil and agrobiodiversity conservation techniques.

Conway (1987) identified the main properties of agroecosystems including productivity, stability, sustainability in agriculture and these properties are applied at the levels of the farming system. Thus, agroecology provides a framework for assessing agriculture. In the 1990s, the word started to be used to express the relationship between agriculture and society. In recent decades, new dimensions of agroecology such as environmental, social, economic issues are becoming popular. According to Costa-Pierce (2010), the ecological approach not only brings technical solutions for ecosystems but also incorporates at the outset social ecology, planning for community development, and concerns for the wider social, economic and environmental contexts of farming.

According to Rasul & Thapa (2004), ecological agriculture has a tendency towards becoming ecologically, economically, and socially more sound than conventional agriculture because it requires remarkably fewer chemicals, adds more amount of organic matter to the soil, supplies balanced food, and uses more local inputs.

Table 2.2: Differences between conventional and ecological agriculture

Conventional	**Ecological**
Top-down	Participatory
A single goal: production	Multiple goals
Sectoral	Interaction with other sectors
Farm scale	Multiple scales
Predictive	Adaptive
Scientific knowledge	Extended knowledge
Prescriptions	Incentives
Corporate	Public/Transparent

(Source: Attwood et al., 2005)

Agroecology approach is the scientific discipline that uses ecological theory to study, design, manage and evaluate an agricultural system that is productive and resource-conserving. The definition of agroecology varies widely according to authors and graphical areas. In under-developed countries where the application of inputs and machinery is not developed, the traditional technique is considered as close to agroecological production. In developed countries such as the USA or Germany, agroecology approaches have been applying to reduce the use of pesticides (Trabelsi, 2016).

These are several selected **definitions of agroecology** as follow:

- A discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective (Altieri, 1987).
- The application of ecological concepts and principles to the design and management of sustainable agroecosystems (Altieri, 1995).
- The integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions (Francis et al., 2003).
- The study of interactions between plants, animals, humans and the environment within agricultural systems (Dalgaard et al., 2003).

- The science of applying ecological concepts and principles to the design and management of sustainable food systems (Gliessman, 2007).
- A discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective, and applies ecological concepts and principles to the design and management of sustainable agroecosystems (Wibbelmann et al, 2013).

2.2.2 Principles and goals of agroecology

- **Principles:**

According to the research of Altieri (2002), agroecology has five principles in particularly for small farming systems including: (1) maintain soil quality; (2) minimize losses of water, air, energy; (3) increase species and diversity in time and space; (4) recycle biomass and balance nutrient flow and; (5) improve biological interactions that promote key ecological process and services.

Later, Dumont et al. (2013) have developed the principles for the livestock sector: (1) decrease production inputs; (2) decrease pollution of farming systems; (3) increase diversity to strengthen farming systems' resilience; (4) conserve biodiversity through management practices and; (5) improve animal health.

The group on agroecological transitions (GTAE, 2018) which support the development of agroecology around the world defined the principles of agroecology:

(1) *Principle of development*: agroecology develops the ecosystems' potential in terms of the capture of external resources from the natural environment. The development principle of farming relates to the targets of quantity and quality (nutrition, health and taste), and the autonomy of families.

(2) *Principle of preservation*: agroecology contributes to the conservation or even restoration for agro-ecosystems including soil fertility and water availability which addresses goals of sustainability, the provision of various benefits for the environment (biodiversity, absence of contamination, etc.), climate change adaptation and mitigation.

- **Goals:**

Agroecology applies ecological principles to the interactions between humans and the environment, minimizes the negative consequences of humans. It aims at protecting the environment, ensuring the sustainable use of natural resources (water, soil, biodiversity, etc.) for production. By gradually eliminating the use of chemicals, it strives toward implementing environmentally-friendly farming, thus contributing to improving the health of farmers as well as buyers. Therefore, this approach enables the balance between people, agriculture and the environment (AGRISUD, 2010).

With the emphasis on the principles, agroecology has four goals: (1) conserve, maintain and restore the wild biodiversity and ecosystem services; (2) provide sustainable, productive, and ecologically compatible farming systems; (3) sustain and enhance the livelihood of all groups in landscapes; and (4) establish and maintain institutions in support of the implementation (Buck et al., 2006). As mentioned by Costa-Pierce (2010), ecological farming systems should be developed in the context of ecosystem services/ecosystem functions and other sectors as well as policy. Institutions transform knowledge into actions through extension organizations, community user groups, educational systems, or knowledge-based enterprises, etc.

2.2.3 Systemic approach of agroecology

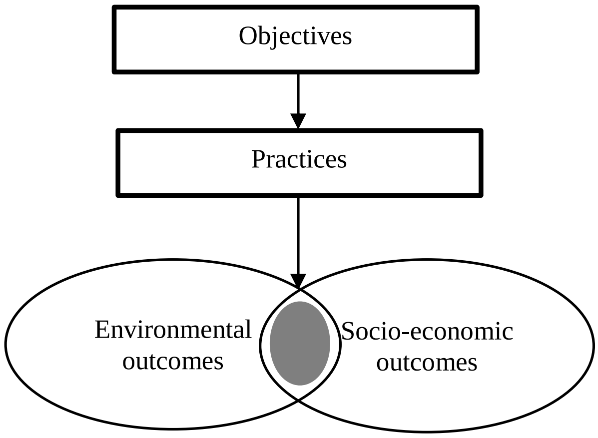


Figure 2.2: Systemic approach of agroecology
(Source: Adapted from Trabelsi et al., 2016; Trabelsi et al., 2019)

2.2.3.1 Objectives

Ecological agriculture is built on the concept of ecosystem management referring to land-use systems that are managed to produce food while protecting wildlife and other ecosystem services (McNeely & Scherr, 2002). Agroecology designs agricultural production that is less harmful to the environment avoids the overexploitation of natural resources and reduces the adoption of pesticides, synthetic fertilizers, and water (Trabelsi et al., 2016). According to Côte et al. (2019), agroecology contributes plenty of benefits for small family farming with a low level of chemical inputs as follow:

Table 2.3: Benefits of low-level use of the chemical in agroecology

Functions	Small family farming with low levels of chemical inputs
Maintain/ increase production	++
Improve incomes of farmers/increase farm resilience	+++
Decrease negative environmental impacts	+
Stimulate non-production services	++
Enhance rural employment	+++

Note: The number of crosses denotes the potential of the contribution of agroecology
(Source: Côte et al., 2019)

Agroecology has the objective of the development of sustainable food systems (Horlings & Marsden, 2011). According to AGRIUS (2010), from an environmental point of view, agroecology aims at reducing pressure on the environment with sustainable management of natural resources including soil fertility, water resource and biodiversity. From a socio-economic point of view, agroecology aims at reducing costs related to chemical inputs, increasing the durability of farm production, and enhancing the values of products (better prices, purchasing preference), improving autonomy for farmers by reducing dependence on input suppliers.

Pretty (2006) claimed that ecological agriculture is now widely seen as the best option for improving production and productivity with better soil nutrients and water management, and without the need for expensive chemical inputs. Ecological agriculture minimizes many of the impacts associated with the use of synthetic inputs: water pollution, air pollution, greenhouse gas emission, soil pollution, biodiversity impacts such as further pollinator declines or effects on pest predators, soil degradation, losses in resilience, etc. The efforts to increase yields need to be considered under the context of sustainable ecosystem services that a landscape provides, which are not only agricultural production, but also water filtration, nutrient cycling, carbon sequestration and other functions (Rockström et al., 2009).

Table 2.4: Main objectives of agroecology

Scales	Objectives
Environmental/ecological	Reduce water and soil pollution
	Preserve water resource
	Improve use of fertilizers
	Improve soil fertility
	Control pests and weeds
	Conserve biodiversity
Socio-economic	Improve income and its stability
	Improve technical efficiency
	Reduce dependence on external inputs
	Enhance social involvement

(Source: Trabelsi et al., 2016; Trabelsi et al., 2019)

Biodiversity for food and agriculture includes the key components of biological diversity that are essential for healthy diets and human health and improving the quality of life. It includes the variety and variability of ecosystems, animals, plants and micro-organisms, which are necessary to sustain human life as well as the key functions of ecosystems (Zimmerer et al., 2019; Tscharntke et al., 2012; Rawal et al., 2019; Fao et al., 2019). Biodiversity is an important regulator of agro-ecosystem functions, not only in the strictly biological sense of impact on production but also in satisfying a variety of needs of the farmer and society at large (Montoya et al., 2020, Zimmerer et al., 2019, Rawal et al., 2019, Fao et al., 2019). Agroecosystem managers, including farmers, can build upon, enhance and manage the essential ecosystem services provided by biodiversity to work towards sustainable agricultural production. Ecological agriculture is about nature's diversity, which is from the seed to the plate, and across the entire agricultural landscape (Brussaard, et al., 2010; Montoya et al., 2020; Rawal et al., 2019; Fao et al., 2019). The current monocultures with vast areas of land are given over to genetically uniform plants, with little biodiversity and norefuge for wild plants or animals (Koch et al., 2019). This way of farming minimizes the services the functioning ecosystem can provide, and it badly affects our health through poorer diets and a lack of nutritional diversity. Agroecosystems do the opposite. They place nature's diversity at their core. In doing so, they not only enhance the interaction between the environment, genetic resources and management practices that occurs in situ within agro-ecosystems ensures that a dynamic portfolio of biodiversity for food and agriculture (agricultural biodiversity) is maintained and adapts to changing conditions (Montoya et al. 2020; Zimmerer, et al., 2019; Rawal et al., 2019; Fao et al., 2019). They also provide biological support that makes up the biological diversity of the agro-ecosystem. For example, soil fauna and micro-organisms, together with the roots of plants and trees, ensure nutrient cycling; pests and diseases are kept in check by predators and disease control organisms, as well as genetic resistances in crop plants themselves; and insect pollinators contribute to the cross-fertilization of outcrossing crop plants (Rawal et al., 2019' Fao et al., 2019). In addition, they also widen ecological functions including the maintenance of soil fertility, water quality and climate regulation (Rawal et al., 2019; Fao et al., 2019). In general, ecological agriculture combines modern technology and farmers' knowledge to develop advanced crop genetic diversity, which helps farmers to grow more food in different agroecological conditions, without risking biodiversity or harming it with pesticides (Zimmerer et al., 2019; Rawal et al., 2019; Fao et al., 2019).

Pest management strategies have long been dominated by quests for "silver bullet" products to control pest outbreaks (Lewis et al., 1997). While chemical pesticides are responsible for extensive pollution of the environment, a serious health hazard due to the presence of their residues in food, the technological advances in chemistry, biochemistry, behavior, neurophysiology, molecular genetics, and genetic engineering have resulted in an array of biorational products and materials that are less toxic and hazardous to humans and the environment than conventional pesticides (Lewis et al., 1997; Sporleder & Lacey, 2013). In fact, many studies also proved that biopesticides should not be considered as a one-for-one replacement of chemical pesticides. However, ecological pest management relies on preventive rather than reactive strategies (Levine & Wetzler, 1996). Specifically, ecological pest management (EPM) uses many elements of integrated pest management (IPM), which are based on keeping and supporting the natural stability of the agro-ecosystem (Tshernyshev, 1995). For that reason, ecological agriculture enables farmers to control pests and weeds without the use of expensive chemical pesticides that can decrease soil nutrients, water and ecosystems, and the health of farmers and consumers. Unfortunately, the prevailed conventional farming model still depends on the large quantities of herbicides, fungicides, and insecticides.

Ecological agriculture integrates production and conservation at a landscape scale with the involvement of different stakeholders (Scherr & McNeely, 2002; Scherr & McNeely, 2008). While other approaches such as organic agriculture sought to reduce the ecological footprint of farmland and the damage to wild species from toxins, water pollution at farm-scale action rather than coordination among farmers and others to gain demonstrable environmental benefits at a landscape level (Scherr & McNeely, 2008). The landscape depends on special units. Landscapes serve a watershed function for example purifying water quality, regulating water flows, controlling floods, or sustaining species. Adequate management of agricultural landscapes can overcome extreme weather and provide green space for recreation. Landscapes are managed by stakeholders working together for biodiversity, production and livelihood. An ecological agriculture landscape uses land with a natural area which are managed to ensure agricultural livelihoods through positive interdependence with other benefits. An ecological agriculture landscape further has a production area with its productive, profitable, ensure food security and meet market demand. An ecological landscape also assures institutional mechanisms to coordinate to attain production, conservation and livelihood goals at a different landscape or community scale. According to (Wu, 2013; Mastrangelo et al., 2014), a landscape that supplies plenty of ecosystem services requires collective governance. The farm community is the principal of biodiversity and ecosystem services because they may own natural resources. This approach recognizes the economic and ecological synergy and mutual interdependence among agriculture, biodiversity and ecosystem services.

An agricultural system adopting the ecological approach will maximize the social-economic - ecological alliance and minimize the conflict between development and conservation. The ecological approach in agriculture recognizes that people are an important part of the ecosystem and people should be placed at the center of biodiversity management. Thus, participation should be emphasized in conservation activities. The stakeholders involved in ecological agriculture are plentiful including farmers; local communities or businesses reliant on processing, marketing, transport, etc.; authorities (local, regional, national, etc.); tourism; environmentalists; scientists; homeowners; recreational users; other enterprises directly using the rivers, lakes, coast and other marine body; food and health authorities. They have several criteria including those who have sufficient political clout to draw in officials with the public authority to make the decision; those who have legal standing and therefore the potential to block a decision; those who control resources necessary for the implementation of a decision; those who may not be sufficiently organized to pose a relevant threat today, but who may in the near future; and those who hold necessary information. According to Scherr & McNeely (2002), farmers can organize themselves or play a lead role in designing landscape and farm interventions for example forest user groups in Nepal and Landcare groups in Australia. The author also emphasized the supporting roles of other stakeholders such as scientists working in West Africa for natural biocide to control grasshopper and desert locust pests, veterinary researchers for livestock vaccine against a viral disease in buffalo in East Africa, crop breeders in the USA for native perennial grains that can be grown sustainably with much less environmental damage in dryland farms, researchers in Central America for modified coffee systems with domesticated native shade tree species that maintain yields and diversify incomes and conserve biodiversity.

2.2.3.2 Practices

The term agroecology practices firstly were used within the development of agroecology in the 1980s. According to AGRIUS (2010), agroecological practices combine technical solutions to reconcile productivity, reduce pressure on the environment and the sustainable management of natural resources. According Wezel, et al. (2014), agroecology practices contribute to improving the sustainability of farming systems based on ecosystem services and processes such as biological nitrogen fixation, natural regulation of pests, water conservation, soil conservation, biodiversity conservation. According to Hill & MacRae (1996), agroecology practices refer to: (1) efficiency (practices that reduce the use of inputs such as water, fertilizers, pesticides) but enhance productivity; (2) replacing (chemical pesticides are replaced by natural ones); and redesign (changes of the whole cropping system or farming system).

Agriculture is a dynamic system and no single practice or approach is guaranteed to function successfully. However, when multiple practices are implemented as a system, the effects are compounded and soil function increases. It is possible to increase soil fertility without the use of chemicals. However, a conventionally managed soil is very leaky, especially when it comes to nitrogen (Arcand, et al., 2016). Healthy soil has a balanced biological community and high organic matter with the capacity to retain and cycle nitrogen through a "living" and functioning ecosystem. In healthy soil systems, nutrient management is integrated with conservation crop rotations, no-till/strip-till, cover crops, precision farming, and conservation buffers that are planned and prescribed to complement each other. Healthy soils have soil aggregate stability and are resistant to the erosive forces of water and wind, has improved water infiltration, and also has a much higher water holding capacity (Karlen et al., 2019). Ecological agriculture protects soils from erosion, pollution, and acidification. By increasing soil organic matter where necessary, we can enhance water retention, and prevent land degradation (Claessens et al., 2014). Ecological agriculture also pays central attention to nourishing the soil. It maintains or builds up soil organic matter (for example with compost and manure), and, in doing so, feeds the diversity of soil organisms. It also aims to protect wells, rivers, and lakes from pollution, and to make the most efficient use of water. All this is vital in a world where agriculture now accounts for 70 percent of water withdrawals worldwide, plays a major role in water pollution as farms discharge large quantities of agrochemicals, organic matter, drug residues, sediments and saline drainage into water bodies, one of the major threats to the stability of life on the planet (Martinho, 2019; Steffen et al., 2015).

Table 2.5: Practices corresponding objectives of agroecology

Practices	Objectives					
	Reduce water & soil pollution	Increase soil fertility	Control weeds and pests	Conserve biodiversity	Preserve human health	Improve food quality
Reduce pesticides	x	x		x	x	x
Use of organic, natural pesticides	x	x	x	x	x	x
Use of biological control			x	x		
Reduce N fertilizers	x				x	
Cover crop	x	x				x
Association of crops		x	x	x		
Agroforestry	x	x	x	x		
Replace chemical fertilizer by organic ones	x	x	x			
Crop-livestock mixtures		x		x		
Crop rotation		x	x			x

(Source: Trabelsi, 2016)

To obtain the multiple objectives, a set of farming practices has been applied. Examples of agroecology practices in rice cultivation are: (1) crop rotation (rice-legume sequences help to control diseases, weeds, insects); polyculture (two or more crops within certain special proximity help to control pests and enhance crop yield stability); (3) green manure (improve soil structure and prevent erosion); (4) agroforestry (grow trees and annual crops together to improve soil fertility); (5) cover crop (use of pure or mixed stands of legumes-grass to improve soil moisture and temperature and prevent weeds); (6) crop-livestock mixtures (integrate crops and livestock to reduce external inputs).

FAO indicated that to minimize environmental contamination and conserve biodiversity, farmers should have good knowledge and apply responsible management that follow ecologically based practices at stages of production.

2.2.3.3 Outcomes

Ecological-based agriculture is defined as sustainable agriculture and associated natural resource management systems that stimulate productivity, rural livelihood, ecosystem services and biodiversity. Ecological agriculture includes a wide range of systems and practices that integrate farm productivity (crops, livestock, fish, trees, or forests) with the provision of ecosystem service at a landscape level. Ecological agriculture systems make more space for wildlife by designating protected areas that enhance the production of local people and their income and improve the habitat of production areas by reducing pollution, improving resource management while maintaining productivity.

Agroecological outcomes must meet their objectives as much as possible. Considered as a model of sustainable agriculture, agroecology focuses on the concept of sustainable agriculture that satisfies environmental, socio-economic interdependent scales (Trabelsi, 2019). Farmers produce food for their income and they also contribute to food security with better quality and nutrients through the adoption of ecologically responsible farming. The results can be measured through the socio-economic and environmental quality of their produce. From environmental perspectives, agroecological practices distinguish minimizing environmental risks as much as possible. The environmental outcomes are also assessed based on the objectives of agroecology (Table 2.7). These have already been used to monitor the impacts of agriculture on nature. Each objective corresponds to one outcome. From socio-economic perspectives, we distingue the issues of farming systems including autonomous (income and income stability, the problems of usage of external inputs) and efficient (technical efficiency). The socio-economic outcomes are also determined based on the objectives of agroecology. Each objective of the socio-economic scale corresponds to one or two outcomes.

Table 2.6: Outcomes of agroecology

Scales	Objectives	Outcomes
Environmental/ecological	Reduce water pollution	Discharge of wastewater to the environment
	Improve use of nitrogen fertilizers	Doses of nitrogen fertilizers
	Improve soil fertility	Soil fertility
	Control pests	Pest control
	Conserve biodiversity	Biodiversity
Socio-economic	Improve income	Income (and stability over time)
	Improve technical efficiency	Technical efficiency
	Reduce dependence on external inputs	Dependence on external inputs
	Enhance social involvement	Social involvement

(Soruce: Trabelsi et al., 2016; Trabelsi et al., 2019)

2.2.4 Agroecology for the reconciliation between agricultural development and conservation

2.2.4.1 Agroecology for sustainable agricultural development

Agroecology offers a sustainable path to agricultural development as it integrates ecological principles and socio-economic concerns into agricultural systems (D'Annolfo et al., 2017). Agroecology uses principles to design and manage a sustainable agricultural system. The approach addresses the root causes of poverty by helping to transform food systems through an approach that balances the three pillars of sustainability: social-economic- environmental. In agroecology production, ecological and socio-economic relations are closely tied together. Agroecologists examine and assess sustainable systems at the plot or field, farm or landscape agroecosystem levels (Wezel et al., 2009). According to Altieri (1999) and Gliessman (1997), the economic dimension of sustainability utilizes agroecosystem diversity to achieve minimum reliance on external inputs, applies crop-livestock integration for increased productivity, food security, diet diversity, and stable income as well as farm yield, thus serving livelihood and equity goals of resource-poor farmers. Concerning the environmental dimension, problems of pest resistance and disease outbreaks resulting from large-scale monoculture cultivation are minimized by small-scale multiple cropping, crop rotations, cover crop (Magdoff, 1995; Stinner & Blair, 1990; Liebman, 1989). Soil health is maintained through organic manure and legumes. These practices will lead to desirable environmental benefits such as increased agrobiodiversity, reduced leaching and run-off losses and wider environmental preservation (Magdoff, 1995). Agroecology has to date been the most effective facilitator of the concept of sustainable agriculture and the least compromised problems of modern industrial agriculture. This interdisciplinary has accomplished a major stride in agricultural development by promoting the empowerment of small-scale farmers in developing countries from holistic perspectives of agricultural sustainability (Altieri, 2002; Amekawa et al., 2010).

Agroecology is the "ecology of the food system" and a farming approach that is inspired by natural ecosystems. It combines local and scientific knowledge and applies ecological and social approaches to agricultural systems, focusing on the interactions between plants-animals-humans-and the environment (Francis et al., 2003). According to Scialabba & Hattam (2002), "Agroecological systems are typically multi-functional, diverse, and interconnected. They place a strong emphasis on environmental integrity and social well-being". The definition of ecological agriculture is similar to agroecology that it applies ecological principles to agricultural ecosystems (Magdoff, 2007). The agroecosystems can be approached as any other ecosystem to strengthen the sustainability of all parts of the food system, from the seed and the soil to the table, including ecological knowledge, economic viability, and social justice (Francis et al., 2003). To achieve this goal, agroecological approaches strive to minimize or exclude the use of fossil fuels, chemical inputs such as fertilizers and pesticides, and large-scale monocropping of a single crop on vast tracts of land. According to (Magdoff, 2007), ecological agriculture involves designing the natural ecosystem into an agroecosystem. Ecological agriculture is diverse, knowledge-intensive and low in external inputs and fossil fuels (Tittonell & Giller, 2013). It requires a systemic approach to agriculture from the field to the regional level, including diversity (soil, water, air and climate protection), but there is no universal prescription for what this approach should look like. In spite of all its diversity, a set of general principles underlying agroecosystems can be identified (Tirado, 2015).

Agroecology provides the knowledge for agricultural development that is environmentally sound and highly productive, socially equitable and economically viable. Through the application of agroecology, the basic challenge for sustainable agriculture can be easily achieved by minimizing the external inputs, and by effectively regenerating internal resources through diversification strategies (Altieri & Nicholls, 2000). Gliessman (1997) asserts that the discipline of agroecology holds integral missions of conserving natural resources as well as lifting productivity and economic viability of agriculture to meet the needs of the increasing human population based on modern and traditional ecological knowledge and methods.

Agroecology helped local farmers shift from high input and chemical-intensive agriculture onto the application of adapted methods such as agrobiodiversity preservation or soil fertility management (Wezel et al., 2009). Another evidence from Vietnam, the application of ecological practices in rice cultivation helps farmers in the Mekong River Delta gain higher economic value due to lower production costs and higher product prices as compared with the conventional method (Tu et al., 2018). The "One must do, five reduce" program in Vietnam requires farmers must grow rice with certified seeds and reduce seeds, chemical fertilizers, chemical pesticides, irrigated water, and losses after harvest. According to Stuart et al. (2018), the program improves the economic sustainability of rice in the Mekong Delta River. The clear limits on inputs reduce by 23% of the total cost and increase net farm income by 19% resulting in a 28% increase in the benefit-cost ratio. Moreover, the program maintains rice yield, labor productivity, and irrigation during cultivation.

Table 2.7: Objective – Practices - Outcomes of agroecology from scholarly researches

Objectives	Practices	Outcomes			
		Economic	Soil	Water	Biodiversity
Increase water availability/reduce run-off and erosion	Sustainable irrigation	++	+	+	+
Increase soil fertility/reduce soil erosion	Compost, manure	++	++	+	+
	Nitrogen-fixing crops	+-	++	+-	+-
Reduce use of chemical pesticides	IPM	+	+	+-	++
Increase income and biodiversity from diversified operations and establishing eco-corridors	Landscape planning	+-	+	-	++

(Source: Ferwerda, 2015)

Agroecology has main characteristics: (1) synergies among conservation, production and rural communities; and (2) conservation inside and outside the production areas and; (3) diverse scale level: ecological agriculture can apply at farm scale, watershed and it moves beyond the small scales to help the interaction between different uses of land at the landscape level (Buck et al., 2006; Costa-Pierce, 2010).

2.2.4.2 Agroecology for sustainable agricultural development in the protected area buffer zones

As FAO (2014) emphasized, the agroecology approach provides the way for the successful integration of protected areas and farm sites. Agroecological production is based on the sustainable use and maintenance of biodiversity, and well-informed farmers can produce enough food from protected areas without harming natural habitats. It concentrates on conserving the resources while ensuring food production for meeting the needs of the community dependent on protected areas.

Agroecology as the ecosystem-based approach to the agriculture sector limits the adoption of agrochemicals which are closely linked to severe disruption to nature and lessen risks and damages to the environment and humans. Agricultural systems are managed based on ecological principles to give answers on how to alleviate the negative effects of agricultural pollution on the surrounding sensitive areas at the same time strengthen socio-economic performances for the communities. The approaches can offer solutions for agricultural issues and provide an alternative to conserve and enhance biodiversity through management and integration of farming systems such as mixed-cropping, agroforestry, crop-livestock and aquaculture, and afforestation. Diverse regions of the world and farming systems have applied ecoagriculture then illustrate significant positive impacts on environmental protection, farm yields, and farm incomes (McNeely & Scherr, 2002).

Agroecology benefits farmers and rural communities around conservation areas. Nowadays, more food is being produced than ever before in human history. However, it is ironic in our current food system that the majority of those who suffer from hunger live in poor, rural communities in developing countries with livelihoods dedicated to producing food. It is hard to admit that the industrial, chemical-intensive agriculture system is deeply unfair, and unsustainable. Therefore, ecological agriculture contributes to rural development and fights the poverty trap and hunger through enhanced employment and closer connections with the local economy, connecting consumers with producers (Lobley et al., 2009). Evidence from ecological agriculture initiatives across the world shows that this approach with sufficient support by policy instruments can be a successful tool in providing stable financial benefits to smallholder farmers, in turn benefitting rural communities and advancing their rights to a rewarding and secure livelihood (Tirado, 2015). Also, it is relevant to consider how a market-oriented development of ecological agriculture combined with local or regional processing of products targeted at high-value markets may increase income, employment and capacity building of women and young people in rural societies. Market-driven product development helps rural people obtain a greater understanding of their customers' needs and then take action to develop successful products aligned with customer expectations and marketplace demand (Beverland et al., 2006).

Areas that need agroecology approach:

Ebregt & Greve (2000) emphasized that if a landscape is divided between a core zone and buffer zone, economic development activities or commercial agriculture in the buffer zone will be a risk of species disappearing. Therefore, the authors suggested that an ecosystem approach should be followed as much as possible, whereby the agricultural landscape around protected areas could be an extension of the ecosystem or could have a corridor function for wild species.

Scherr & McNeely (2008) asserts the areas that need agroecological practices as follow:

- Agricultural landscapes locate **in or around critical habitat areas** for wild species of local, national, or international importance, for example, landscapes in the highly-threatened habitats are dominated by farming.

- Degraded agricultural landscapes where restored ecosystem services will be essential to achieve both agricultural and biodiversity benefits.

- Agricultural landscapes that must also function to provide critical ecosystems services such as dense population area.

- Peri-urban agricultural systems where careful management is required to conserve ecological, wildlife, and human health.

2.2.5 Measurement of agroecology

According to Buck et al. (2006), the broadest-level aims of agroecological agriculture with respect to sustainable livelihood and sustainable development are:

- Maintaining, preserving nature (biodiversity, ecosystem service, etc.);
- Providing productive and ecological compatible agricultural production;
- Sustaining or enhancing living conditions of people in the landscape; and
- Establishing institutions, capacity-building, resource mobilization in support.

This part reviews core indicators of agroecological outcomes with links to the above aims. It provides synthetic information to farmers to understand the achieved results or compare with others to find ways for improvement. Table 2.8 presents indicators used if farms are utilizing agroecological principles in their design and management:

Table 2.8: Core indicators of agroecology with links to sustainable livelihood and sustainable agriculture

Indicators	**Sources**
Yields	Buck et al., 2006, Trabelsi et al., (2016); D'Annolfo et al (2017); FAO (2018); Trabelsi et al. (2019).
Net farm income	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Technical efficiency	Trabelsi et al., (2016); Trabelsi, et al. (2019); Stylianou et al., (2020)
Percentage of farmers applying agroecology	Trabelsi et al., (2016); D'Annolfo et al (2017); Trabelsi et al., (2019); D'Annolfo et al (2017).
Soil fertility	SOCLA & TWL (2015); Trabelsi et al., (2016); FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Pesticides management	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Fertilizer management	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019)
Biodiversity	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Water preservation	FAO (2018); Trabelsi et al. (2019)

- *Farm yields*: Farm yield measures the physical productivity of land in crops or aquaculture production. Yield of agroecological production measures amount of outputs obtained on a given of land for agroecology production (D'Annolfo et al., 2017). Yield enables higher production while reducing pressure on scarce land, common linked to biodiversity loss or deforestation.

- *Net farm income*: Income from agroecological production enables the economic viability of farms. Incomes of farms ensure households gain profits. Farm income is a measure of profitability and it is used to assess the economic viability of a farming system.

Net farm income is calculated by the formula: Revenue from animals/plants/other farm activities (quantity of crops/animals/other activities sold multiplied by the gate price) + Income in kind – Total operating expenses after rebate (input costs + depreciation of equipment and machinery + taxes + hired labor costs + interests + cost land rent + veterinary service costs) + subsidies (FAO, 2018; Mottet et al. 2020).

- *Percentage of farmers applying agroecology:* This indicator calculates the proportion of farmers incorporating agroecological practices for their production (D'Annolfo et al., 2017).

- *Technical efficiency:*

According to Pourzand & Bakhshoodeh (2014), the technical efficiency of farms is a key element of economic sustainability. In the view of Piot-Lepetit et al. (1997), efficiency relates to input use such as pesticides and fertilizers that cause environmental risks. Assessing technical efficiency helps to improve environmental performance through the proper use of commercial inputs. As De Koeijer et al. (1999) and Trabelsi et al. (2016) explained, the enhancement of technical efficiency may support sustainability through the reduction of polluting inputs, therefore, farmers simultaneously achieve economic and ecological objectives.

A Decision Making Unit (DMU) is considered technically efficient if it produces the maximum of outputs or if it produces a given quantity of outputs with smaller quantities inputs. Measuring the efficiency of a DMU determine whether it is able to increase production without consuming more resources, or it can reduce inputs while maintaining the same level of production (Atkinson & Cornwel, 1994).

According to Coelli et al. (2005), there are two typologies of technical efficiency: output-oriented efficiency (how much a firm can increase its output while keeping its inputs the same) and input-oriented efficiency (how much a firm can reduce its inputs while keeping its outputs unchanged).

Data envelopment analysis (DEA) methods (non-parametric) are widely used to measure the technical efficiency of each DMU. DEA is widely used because efficiency is easy to compute and does not require a functional relationship between inputs and outputs. DEA encompasses two main directions: CRS (Constant Return to Scale) model and VRS (Variable Return to Scale) model (Yannick et al, 2016). In both directions, the result obtained in CRS (farms operate under constant return to scale with overall technical efficiency) condition would be the same, and in variable return to scale (VRS) (farms operate under variable return to scale with pure technical efficiency) conditions would be different (Sherzod et al., 2018).

- *Use of biodiversity-friendly practices*

According to Mottet et al. (2020), the biodiversity of agroecological farming is evaluated through the method of FAO (2018). FAO (2018) uses elaborated methods of biodiversity-friendly practices to appraise environmental outcomes of crop or livestock production: (1) leaving at least 10% of the total area for natural or various vegetation; (2) non-pesticides and antimicrobials application; (3) at least two of the following contribute to the production: crop/pasture; trees; animal products; fish (each of them account at least 10% value of the holding production); (4) applying crop rotation at least 3 crops on at least 80% of farm area over 3 years; (5) using at least two different varieties for above 2 ha farmland; applying monoculture for below 2 ha farmland; (6) at least 50% of livestock population use local breeds. The sustainability of biodiversity are calculated as follow:

+ Desirable (green): farmers use at least four measures.
+ Acceptable (yellow): farmers use two-three measures.
+ Unsustainable (red): farmers use fewer than two measures.

In aquaculture, farmers should eliminate activities that affect habitats in sensitive areas by maintaining biodiversity and reducing impacts of aquafarming on species, especially non-target ones (Grieve et al., 2003). Chowdhury et al. (2015) use biodiversity loss (BDL) as an environmental indicator for impacts of aquaculture on the environment: farmers use hatchery and wild-collected post-larvae (fry) for their ponds. Natural fry collection is one of the fundamental factors of biodiversity degradation. Farmers are asked for the levels of wild post-larvae (natural) use in the production:

+ Use of wild post-larvae >50%: scoring value is 0.25.
+ Use of wild post-larvae from 20-49%: scoring value is 0.5.
+ Use of wild post-larvae < 20%: scoring value is 0.75
+ No use of wild post-larvae: scoring value is 1.0

The BDL is calculated by multiplying the frequency of responses with its scoring value, then divided into the total number of responses. The higher value of BDL is better. In the research of Chowdhury et al. (2015), the BDL of the shrimp-rice system is 0.72 and shrimp-only is 0.66 in Bangladesh which is resulted from poor enforcement of government law on banning natural fry collection.

o *Pesticide management*: Improper use of pesticides causes harm to people and the environment. Good practices can reduce the associated risks. Agroecology provides various methods to reduce the need for pesticides (Mottet et al., 2020). Pesticide management assessments of agroecology are proposed based on the methods of FAO (2018): FAO (2018) uses three measures for protecting health: (1) adherence to label recommendations; (2) cleansing equipment after use; (3) safe disposal of waste. FAO (2018) uses eight measures for protecting the environment: (1) following label recommendations; (2) applying good agricultural practices (crop rotation, mixed cropping, inter-cropping, crop spacing, etc.); (3) adopting biological pest control or bio-pesticides; (4) Adopting pasture rotation to suppress livestock post population; (5) applying pest resistant/tolerant rice varieties/disease resistant/certified seeds; (6) removing rice plant attacked by pest and disease; (7) cleansing equipment after use; (8) using less than two times for each pesticide in a season to restraint pesticide resistance. The sustainability levels of pesticide utilization are:

+ Desirable (green): farms do not use pesticides or use slightly hazardous pesticides (farmers follow three measures of health protection and at least four measures of environmental protection).
+ Acceptable (yellow): farm applies at least two measures of health protection and at least two measures of environmental protection.
+ Unsustainable (red): farm applies fewer than two measures of each above list.

o *Soil fertility*: Fertility refers to the capacity of a soil to provide crops with nutrients with stability over the years. Soil fertility or soil health underpins farmed outputs and ecosystem functioning. It is a core element of sustainable agroecology (Trabelsi et al., 2016; FAO, 2018; Trabelsi et al., 2019; Mottet et al., 2020). A range of agroecological activities can improve soil fertility such as crop residue protection, animal manure or cover crop, etc. (Mottet et al., 2017). The assessment of soil fertility is proposed based on the approach of FAO (2018): four threats are used to capture farmers' knowledge about the state of their soil: soil erosion; reduction of soil fertility; salinization or irrigated land; and waterlogging. The sustainability of soil fertility is conducted by FAO (2018):

+ Desirable (green): less than 10% of the farmland is affected by any of the four threats.
+ Acceptable (yellow): 10-50% of the land is affected by any of the four threats.
+ Unsustainable (red): above 50% of the land is affected by any of the four threats.

o *Fertilizer management*: Fertilizer management assessment of agroecology is proposed based on the methods of FAO (2018) that fertilizers must be managed sustainably: (1) not exceed dosages; (2) use organic nutrient sources; (3) use leguminous plants to reduce chemical fertilizers; (4) distribute fertilizers in several times over the growing period; (5) consider soils and climate conditions; (6) use soil sampling at lease every five years to calculate nutrient budget; (7) apply precision farming; (8) use buffer strips along with watercourses. The sustainability levels of fertilizer utilization are:

+ Desirable (green): farms do not use fertilizers or use fertilizers and apply at least four above measures.

+ Acceptable (yellow): farms do not use fertilizers or use fertilizers and apply at least two above measures.

+ Unsustainable (red): farms use fertilizers and apply non-above measures to mitigate environmental risks.

- *Water preservation*: Agriculture causes unsustainable use of water sources. Trabelsi et al., (2019) use techniques of wastewater or effluent treatment as an indicator to assess the water pollution indicator of agroecology. FAO (2018) conducts a farm survey that gathers information on farmers' awareness concerning water use: whether farmers use water to irrigate the cultivation, how they perceive water scarcity and how irrigation agents work effectively. These data provide alternative sources to assess official statistics on water resource use. FAO (2018) evaluates the sustainability of water preservation in crop cultivation are:

+ Desirable (green): farmers use irrigated water below 11% of farmland

+ Acceptable (yellow): farmers use irrigated water above 10% of farmland, or farmers do not know whether water stable in years; or farmers experience a shortage of water but irrigation agents allocate water effectively.

+ Unsustainable (red): others.

2.3 Application of agroecology in protected area buffer zones

The agricultural practices in and around protected areas have varying degrees of impact on the environment which influences the ability of the areas to serve as quality habitat. The experiences below illustrate how conversion to ecological management in these zones.

- **Kilimanjaro National Park**

Kilimanjaro National Park covers 75,575 ha which is a superlative natural phenomenon of Africa. It comprises mountains and forests. Farmers grow maize and beans and raise goats (for milk, manure, meat source). Farmers face increasing erosion in soil fertility and low farm productivity. After harvesting maize and beans, crop residues are removed and used for feeding goats. Thus, the soil is bare in heavy rain. That leads to declining yields that leave farmers hungry and poorer. Since 1990, the government and local NGO (Himo Environmental Management Trust Fund) has cooperated to manage and protect land - water - vegetation, promote income-generating activities.

The activities:

- Stimulating plenty of practices to improve soil structure and fertility: mixing crops to protect the soil from rain, using crop residues to conserve soil moisture, rotating crops of maize-tomatoes-legumes to conserve soil health and prevent pests, diseases and weed.
- Enhancing various technologies to conserve water and manage irrigation: digging trenches along gentle to moderate slope contour. Soil is piled into a ridge upslope to control water flow, prevent erosion and stimulate the natural formation of terraces. The ridge is planted with stabilizing trees and grass.
- Promoting the use of energy-saving wood stoves to reduce tree cut;
- Helping farmers, groups of farmers and institutions start tree nurseries, grow trees and fodder species seedling for sale and plant.

The implementation:

- These programs are promoted by training and demonstrations on farmers' fields through short courses with appropriate technologies. The organizers also teach farmers how to use techniques of soil and water conservation and farmers perform the works. The training covered diverse methods of erosion control and soil restoration through combined classroom discussion with visits to experiment farms of conservation agriculture. After training, village headers invited technicians from various fields (agriculture, natural resource, livestock, community development, etc.) to advise farmers on how to use the conservation methods for their farms.

- The organizers organized participatory rural appraisal for villages to form soil and water conservation committees. The committees were tasked with raising local awareness and the adoption of conservation measures (tree nurseries, agroforestry, irrigation rehabilitation, soil preservation, zero-grazing, etc.)
- The organizers also provide month-long training for farmers as advisory workers at the center of the program department.
- Village headers and advisory workers must observe the practices of farmers on soil and water preservation.
- The organizers kept in contact regularly with advisory workers and disseminate information on improving technologies from local research institutes. Furthermore, market information has also been provided for advisory workers since 2006.

The results:

- In 1996, 67% of farmers adopted at least some of the technologies;
- By 2005, 6,500 farmers in eight villages had adopted conservation techniques on about 4,000 ha of farmed land.
- Maize's yield has risen from1.3 to 2.6 tons/ha.
- Beans' yield has risen from 0.7 to 1.2 tons/ha.
- Farmers sell more milk to the market.
- Local authorities passed by-laws requiring all farmers to implement soil and water conservation techniques.
- Local and regional politicians, officials and the Minister of Environmental have visited the conservation farmers.

- **Luangwa Valley in Zambia**

The valley is ecologically rich and well-known as the honey pot of Zambia. North Luangwa National Park covers more than 4,000 km^2 and locates in Africa's Rift Valley ecosystem. There is a wide range of species within the park such as elephant, hippos, rhino, lions, birds, etc. Around the national forest park, poor farming practices (slash and burn agriculture) have degraded soils and contributed to deforestation. Poor families sell charcoal by cutting trees. The combination of illegal hunting activities and improper farming practices and falling forest trees have resulted in dramatic wildlife decline in this country.

In 2002, the Wildlife Conservation Society worked with communities to maintain natural resources and address food insecurity by providing alternative livelihood options. The project builds strong linkages between agricultural development and rural market and uphold land-use practice for resource conservation.

- Making agriculture profitable: The project provided farmers with maize seeds and conservation agriculture training. The training enabled farmers to apply homemade fertilizers, reduce fertilizer costs and maximize effectiveness, cover crop residue to prevent and eliminate weed as well as improve soil moisture. These helped farmers reduce their dependency on agrochemicals (herbicides, fertilizers) and reduce the costs of expensive inputs. The project has promoted crops that meet the sustenance needs of rice production. Crop rotation was also introduced with rice and groundnuts to fix nitrogen and produce good food. Plus, raising fish, poultry and egg selling were alternative sources of income. Honey was produced in trees which gives local farmers incentives to conserve forests. After learning new methods of farming, farmers diversified crop production and improved access to markets, gained new income sources.
- Income generation: The project established farmers' organizations to process, package, and market environmentally friendly products. The products have the name of COMACO (Community Market for Conservation) name. The profits were delivered to farmers and provided incentives to conserve nature. Farmers must adhere to community land-use plans and production practices that promote conservation targets.

- Agroecological practices:
  + Recurrent use of compost in the same planting holes to improve soil microflora and sustain nutrient generation for improved crop yields.
  + Mulching of crop residues to prevent weed and reduce soil loss from rain, thereby increasing incentives not to burn fields.
  + Applying crop rotation with soybeans or groundnuts to improve soil nitrogen fixation and sustain farmed yields. Crop rotation also contributes to reducing the need for pesticides in this area.
  + Using agroforestry species to maintain soil health by using fertilizers tree.

The project applied both technological innovation introduced methods and community identified methods for conservation the wild habitats.
The results:

- Since 2001, about 61,000 farmers have trained and adopted conservation agriculture.
- In 2006, about 25,000 km^2 had been covered.
- In 2009-2010, 74% of farmers had gained grain sufficient
- Farmers achieved a 19% higher yield of maize through composting and other conservation methods.
- 79% of households continued to apply conservation practices.
- Farmers received higher prices from rice, honey, chicken, groundnuts (with brand-name).
- Income diversification beyond on-farm sources included varieties of activities such as bee honey production.
- Saving more than 6,000 wild animals cross Luangwa Valley (elephant, zebra, wild dogs, etc.)

- **Keita Plateau in Niger**

Keita plateau covers 4,860 km^2 with rocky slopes and valleys. In 1960, the forests covered the plateau slopes, but by 1984 this area was completely deforested. Droughts, damaging farming practices and high population rates lead to environmental destruction. Without sustainable agriculture, credit systems nor marketing networks, agriculture in this area faces a crisis. In the period 1991-1996, the intervention started with conservation efforts:

- Utilization of restored land with appropriate sustainable cultivation technique based on conserving plant-water-soil balance, which increased agricultural production.
- Rehabilitation of desert lands for agriculture and forestry use.
- Transferring inputs for innovative agricultural production.
- Providing technical, financial support and logistics for agricultural production through assistance services.
- Enhancing credit system and marketing for agricultural production.
- Stimulating community involvement in equipment and fund management.
- Stimulating community involvement in restored communal natural resources.

Results:

- The project increased incomes by more than 6 million USD per year.
- Land degradation and desertification were recovered.
- Woodland increased 300% from 1984 (10,000 ha) to 2002 (45,000 ha).
- Cropland and agricultural surfaces increased by 80%.
- 184 woman groups with more than 10,000 members were established for saving and credit access.

- **Sierra Madre de Chiapas mountain protected area (Mexico)**

Sierra Madre de Chiapas covers 1.8 million ha with its global importance for biodiversity conservation and home of 2,000 species of plants and at least 600 species of vertebrates. Sierra Madre de Chiapas is an environmental service provider for agricultural plains in the countries. In the surrounding zones of these protected areas, there are three main production systems, comprising maize, cattle grazing and collecting forest products. The land used for these activities increased from 1975 to 2000, whist forest cover was reduced at the same time. Annual cropping (maize and bean), coffee production attributed most to forest loss. Moreover, the dissatisfaction of local inhabitants with the small size of landholding trigger deforestation because they have not enough land to produce maize for consumption lead to their higher prices for their food purchasing. Farmers did not receive compensation for their environmental protected services such as fighting forest fires or watching intruders in the forest, thus they would clear the forest in the future if they did not receive compensation for their losses and services.

To overcome deforestation and promote the living of local communities, the government enacted several resolutions. The land is allowed to use sustainably through a management plan, including promoting agro-ecologic or organic milpa (the clear-cutting of up to 10-year-old secondary vegetation), organic coffee cultivation, intensive cattle ranching, planned and legal forestry. At the same time, the government prohibits conventional coffee production, extensive cattle raising, unplanned and illegal forestry. The success and limitation of each alternative resolution are presented as follows:

- Technological change on farms and markets: Through programs of non-government organizations and government-based organizations, farmers converted traditional coffee production systems into organic plantations. Organic cultivation focused on shade management, native tree diversity preservation and, epiphyte and coffee residue retention. Furthermore, organizations supported coffee growers for webs and linkages in markets. This natural tree shade is recognized as one of the best solutions to remain biodiversity and insulate carbon and conserve soil.
- Shifting cultivation and fallow agricultural system: The conservative organizations encouraged farmers to change from shifting cultivation and fallow agricultural systems to organic and agroecological production by reducing the dependence on fallow rotations. However, the achievement of alternative resolutions was low due to poor definition. The implications were pointed out that greater regulation regarding location and size of clearing and limited amounts of fertilizers would be better than trying to replace shifting cultivation.
- Cattle ranching: Programs aimed at stimulating rotation grazing and increased use of forage legumes as live fences, scattered trees and, controlling the reproduction of cattle. However, these measurements produced a 30% higher price of cattle which prevented the acceptance of buyers in this area.
- Community work and policy changes: Conservative authorities encouraged conservation efforts of local people around the protected areas through escaping the agricultural encroaching on forests. Nevertheless, cooperation between communities and authorities was low because the needs of people were neglected. Thus, negotiations among communities and stakeholders for ecosystem protection and human development objectives would be equally included based on co-management mechanisms that promote sharing of responsibility and commitment, including loans and subsidies. This would enhance the conservative activities of farmers because they feel their importance in these efforts.
- Payments for environmental services: Sustainable environment and economic development activities of human are often conflict and benefits gained for one often causes destructive goals for the other. Deforestation is an explicit consequence of the conflict. Payments for environmental services programs are solutions to overcome conflicts between conservation and local livelihoods. Payments for environmental services programs have been implemented popularly from nationally publicly funded to small-scale private-led programs in many countries. In 2003, the National Forest Commission of Mexico established payments for hydrological environmental services programs with economic incentives to local communities for forest conservation.

This evidence of Mexico is from the research of Cortina-Villar et al. (2012).

- **Western Terai Landscape Complex (Nepal)**

The Western Terai Landscape Complex stretches from Bardia National Park in the east to Suklaphanta Wildlife Reserves in the west, covering a total area of 3,466 km^2 in three western districts of the southern plain area of Nepal, sharing borders with India in the south and west. The area consists of two topographical zones: the lowland Terai in the south and the Churia Hills in the north. Approximate 60% of the Western Terai

Landscape Complex is covered with forests with high biodiversity values and networks. There are also 79 wetlands, in which nine lakes cover 138 ha and Ghodaghodi lake is a Ramsar site of the world. This protected area provides productive agricultural land for 1.3 million people and most of the households depend on agriculture. The landscape has richness in agricultural biodiversity with a combination of food crops (rice, wheat, maize, potato, etc.), vegetables, fruits, and animal species and has a minimum fallow period. Agriculture is mainly subsistence with small land (less than 0.66 ha/holder) and produces for household consumption with limited market access. Crop species and livestock breeds are reducing due to poor production potential, the introduction of modern breeds and the lack of policies and market incentives. Growing human population, poverty land degradation, environmental change, the spontaneous introduction of modern crop varieties, animal breeds are responsible for genetic erosion in this protected site. The Western Terai Landscape Complex project was launched in 2005 (in 8 years) with the aim at safeguard the biology and ecological function through the intervention of government-managed forest and productive agricultural land. Agriculture-based interventions are implemented to improve agricultural biodiversity on private land, promote agriculture-based livelihood options, and reduce improper exploitation of forests in a protected site. Community actions have been initiated to conserve and utilize agrobiodiversity through agro-enterprise farmers' groups, forest users' groups, and other community-based organizations. Through these groups, the project staff facilitates village training programs to enhance the capacity of members and community-based rural institutions. The project has formed a community biodiversity fund to provide incentives for the conservation activities of farmers. The project also empowers local people to practice sustainable, biodiversity-friendly natural resources and land use management. The information on traditional knowledge and agro-ecological is provided for farmers through a community biodiversity register. Local crop fairs are organized to raise public awareness about biodiversity values, identify important areas of biodiversity, exchange and transfer knowledge among communities. The prize goes to groups that maximize biodiversity and the highest proportion of local genetic resources. The incentives encourage farmers to grow and cultivate diverse crops and share their knowledge with others. The project links local resource-based products with markets to provide economic incentives directly to the communities. Farmers' capacity for processing and packaging is planned to build (Gautam et al., 2008).

- **In Mesoamerican biodiversity hotspot**

Mesoamerican biodiversity hotspot has a high conservation value but it is experiencing a drastically growing human population, ecological degradation and loss of traditional farming systems. There are about 80% of its vegetation has been converted to farmland, more than 300 species of flora and fauna are threatened, the forest loses 1.2%/year. Many of the protected areas belong Mesoamerican hotspot are small, fragmented, isolated, or poorly protected. Most of these refuges are embedded within agricultural land, but their buffer zones are inadequate to eliminate contaminants of agrochemicals. Some actions with regards to socio-economic, legal and political aspects help to reconcile biodiversity conservation and farming in Mesoamerica comprising: (1) economic instruments (payment for environmental services, carbon financing) to promote farmers to retain tree cover and apply biodiversity-friendly cropping; (2) improve environmental laws and enforcement to reduce deforestation, regulate logging, conserve on-farm tree cover, limit agrochemicals, solve land tenure issues; (3) promoting local and regional alliances among farmers, agronomists, extensions, foresters, and biologists to strengthen ecologically sustainable farming systems; (4) facilitating participation in biodiversity-friendly certification schemes for agricultural and forest products and ensure certifications meet ecological and social criteria; (5) leverage local and regional political support for biodiversity conservation and sustainable development, building on existing initiatives (Harvey et al., 2008).

Several other solutions for harmonizing farming and environmental conservation goals around the world are listed below:

- ***Laws/regulations and enforcement***

Regulation enforcement limits on pesticide use or water abstracting through penalties. Brazil is a country that has launched programs of credit access for farmers whose highest deforestation rates. The programs contribute to dropping rates of deforestation to lower than 20% of the average proportion of the previous 10-year in these countries. Take another opposite case of New Zealand, the government leans on the regulatory minimization of the environmental impacts by agriculture while providing the least supports to domestic landowners. Therefore, the natural environment has been left vulnerable to the pressure of market forces, which is expediting production and land conversion with increasing demand for livestock. The conversion rate in grassland in the South of this nation has increased by 67% from the period between 1990-2010 to 2001-2008. Less than 5% of the agricultural sector is required biodiversity or ecosystem services maintenance. Low effective enforcement in regulation and interfered political system are blamed for the depleted environment conservation. Biodiversity protection activities have been implemented by small land, volunteers and set-asides of residual unproductive land and through patchy predation-trapping and stock fencing activities, supported by limited local and national funds.

- ***Community-based***

Community participation supports farmers and local stakeholders to work collectively in addressing environmental impacts. The Australian government has established successful partnerships between communities, government, and organizations since 1989 which engagement of about 30% farm communities. The 360 million USD programs contribute to improving water quality, reducing soil degradation, and restoring habitat.

- ***Economic instruments***

Economic instruments pay farmers directly or create markets for adopting practices that diminish environmental pollution and provide non-commodity outputs beyond those required by existing regulation; tariffs can also be used to estimate environmental costs. The United State created the Conservation Reserve Programs in 1985 to support farmers with annual rental payments for removing the most sensitive agricultural land from production for at least 10 years. As a result, there are about more than 10 million ha are attached in the programs and millions of tons of GHG emission and fertilizers are eradicated and tens of millions of birds and other habitats are supported

- ***Human development aspects:***

Education, training, and extension are the indispensable components of development and crucial factors in agricultural development. FAO (2002) indicated that primary education and literacy, training in basic skills, and extension services have an immediate and positive influence on farm yield. A farmer who attends a four-schooling year of fundamental level gains 8.7% more productive than those who have no education. Furthermore, higher educated farmers reach more income through new technology applications and adjust more rapidly to technological changes.

- ***Information and communication aspects:***

Information and communications are vital for agricultural development which requires awareness-raising, information access, experience sharing, attitude changing and, skill improvement. The up-gradation of information systems contribute to improved farmers' knowledge and management skills.

2.4 Constraints of sustainable agricultural development and protected area management

- **Constraints of sustainable agricultural development**

The analysis of the presence and functioning of structural conditions contribute to a better understanding of what stimulates or hamper the agricultural system as well as constraints or enables innovation capacity of agriculture. The structural conditions that enhance or constraint the innovation of agricultural systems includes four factors:

- *Institutions*: Institutional environment is concerned with intangible aspects of formal rules and informal constraints that farmers have to meet when producing products (Henry et al., 2014). This factor includes regulatory framework (e.g. policies, laws, regulations, formal rules, food quality standards, etc.) and the implementation and enforcement that enable agricultural production to be realized. The institutional environment is essential in organizing agricultural production. Lack of regulation or lack of regulation enforcement hinders innovation within the agricultural sector because this affords existing bad practices. Improper policies or rules restraint development and innovation. Low coordination of regulatory frameworks can contribute to inefficient enforcement which cannot stimulate innovation in agriculture (Van Mierlo et al., 2010; Woolthuis et al., 2005). According to North (1994) and Hampel-Milagrosa (2007), the institutional environment forms the structure of a society, determines the economic performance, and shapes events at the downstream level of governance. According to Hampel-Milagrosa (2007), well-organized institutions support a more favorable environment for product development and good governance structures. Good institutions and provide efficient information transfer for better decisions among stakeholders. The institutional supports in terms of policies, laws, regulations their enforcement for the agriculture sector including the provision of assistance, transportation, infrastructure, marketing facilities, taxes, subsidies, etc. The farm is influenced by the institutional environment, therefore its regulations and constraints are underlying determinants of farm performance.

- *Infrastructure*: This factor includes knowledge infrastructure (e.g. agricultural advisory service/extension), and physical infrastructure assets (e.g. roads, irrigation, electricity, canals, financial system, ecological infrastructure). If the costs of that infrastructure are too expensive, they affect negatively the development. (Van Mierlo et al., 2010; Woolthuis et al., 2005).

- *Interactions:* If interactions between actors are too strong or too weak, these cannot support well for agricultural innovation. When the interaction is too strong, actors are locked into relationships and that hinders new ideas and activities. When the interaction is too weak (un-connected/not well-connected), actors cannot exchange or combine knowledge and resources. The two constraints concern balanced interactions between actors, trust relationships or contracts (Van Mierlo et al., 2010; Woolthuis et al., 2005).

- *Stakeholder capacity*: education levels, human resources (quality and quantity) (Van Mierlo et al., 2010; Woolthuis et al., 2005).

➢ **Constraints of protected area management and development**

The effective establishment of protected areas provides desirable outcomes regarding ecology-environmental (biodiversity conservation, habitat and species protection, resilience) and socioeconomic (income, employment, food security, improved governance, maintain institutions). These achievements depend on the supports of three factors including governance, management, and local development.

- *Governance*: According to Henry et al. (2014), the governance structure is used to enforce the rules and regulations as defined by institutions. The governance structures are the ways to operate the laws and other formal rules by the institutional environment. Governance structures also partly determine the structure and conduct of agricultural production. Lack of governance structure partly deteriorates the landscapes even if they are currently in good condition. The governance of protected areas includes clear, enabling and harmonized institutions-laws, policies, cooperative networks.

- *Management*: The management of protected areas includes education, capacity, conflict management, enforcement of rules and regulations.

- *Development*: Local development includes capacity building, livelihood enhancement to develop skills and ensure other benefits for local people.

In contrast, the undesirable outcomes of protected areas depend on ineffective governance, management and development which hinder the achievements (Bennett & Dearden, 2014).

➢ **Constraints of sustainable agricultural development around protected areas**

In this research, to analyze the constraints of sustainable agricultural development toward agroecology near protected areas, we focus the factors including:

- *Institutions*: agricultural and environmental policies, laws, regulations and their implementation and enforcement.

- *Infrastructure*: roles and effectiveness of agricultural advisory service (including protected area managers), and physical infrastructure assets.

- *Interactions:* interaction between agricultural advisory services (including protected area managers) and farmers.

- *Stakeholder capacity*: education levels, human resources (quality and quantity) of stakeholders.

3

Research methodology

3.1 Selection of study sites

3.1.1 Selection of several protected areas of Vietnam

A total of five protected areas and their buffer zones locating in Northern Vietnam (Xuan Thuy National Park, Bai Tu Long National Park, Cat Ba National Park, Tam Dao National Park, and Tien Hai Nature Reserve) was approached to gather information to provide some comparison between the sites including geographical and natural features; administrative structure and workforce; application of policies; conservation and development activities of protected area management boards; characteristics of buffer zone communities; and existing situation of agricultural production around protected areas. This belongs to the content of Chapter 4.

Table 3.1 depicts profile information of the five areas regarding years of official establishment, areas, and agency of administration.

- Xuan Thuy National Park is established in Decision 01/2003-QD-TTg by the Vietnamese Prime Minister in 2003. Currently, the park is under the administrative management of Nam Dinh Provincial People's Committee (PPC). Xuan Thuy National Park is also designated as Ramsar site.

- Bai Tu Long National Park is established in Decision 85/2001/QD-TTg by the Vietnamese Prime Minister in 2001. The park is under the administrative management of Quang Ninh PPC. Bai Tu Long National Park has other designations as a marine protected area.

- Cat Ba National Park is established in Decision 79-CP by the central government in 1986. The park is under the administrative management of Hai Phong PPC. Cat Ba National Park has other designation as a marine protected area and United National Education, Scientific and Cultural Organization.

- Tam Dao National Park is established in Decision 601/NN-TCCB in 1996. The park is under the administrative management of the Vietnam Administration of Forestry (under the Ministry of Agriculture and Rural Development - MARD) because it is inter-province national park. It locates in three provinces (Vinh Phuc, Thai Nguyen, and Tuyen Quang).

- Tien Hai Nature Reserve is established in Decision 2159/2014-QD-UBND by Thai Binh PPC in 2014. The Nature Reserve is under the administrative management of Thai Binh PPC.

All of buffer zones are under administrative management of Communal People's Committees (CPCs). CPCs manage socio-economic activities of buffer zone communities.

Protected area management boards participate with CPC in several programs to stimulate conservative and development activities of buffer zones.

Table 3.1: Profile information of surveyed protected areas

Protected areas	**Year of establishment**	**Area (ha)**		**Administrative agency**
		Protected area	Buffer zone	
1. National park				
Xuan Thuy	2003	7,100.00	8,000.00	Nam Dinh PPC
Bai Tu Long	2001	15,283.00	16,743.00	Quang Ninh PPC
Cat Ba	1986	17,362.96	14,178.46	Hai Phong PPC
Tam Dao	1996	34,995.00	15,515.00	Vietnam Forestry Administration
2. Nature reserve				
Tien Hai	2014	12,500.00	1,700.00	Thai Binh PPC

(Source: Interview with Protected areas management boards, 2018)

Reasons for choosing the five cases:

Five protected areas are taken because they have several similar characteristics for the analysis and comparison: they belong in Northern Vietnam and local communities' livelihood depend mainly on agricultural activities. Five protected area buffer zones have cropping production (rice mainly) and coastal aquaculture production (except Tam Dao National Park).

3.1.2 Case analysis: Xuan Thuy National Park

The Xuan Thuy National Park locates in Giao Thuy district, Nam Dinh province of Vietnam. It was selected as the case analysis to describe the deeper understanding of agricultural development around the protected site (Chapter 5 and Chapter 6). Chapter 5 has information and analysis on: (1) objectives of farmers and local authorities, (2) farm management practices, (3) social-economic-environmental outcomes of different production systems toward agroecology. Chapter 6 has information and analysis of constraints and causes of agricultural development around Xuan Thuy National Park.

Reasons of choosing Xuan Thuy National Park as case analysis:

The case study taken is Xuan Thuy National Park because it meets several criteria which are suitable for the research topic:

- It has conservation and development functions:

Xuan Thuy National Park has particular environmental and economic significance because it has rich biodiversity and coastal protection role. Main functions of Xuan Thuy National Park are ecological function for the region and economic function for local communities which is based on the Decision 01/QD/TTg/2003 by the Vietnamese Prime Minister. There are six specific functions (Hai & Nhan, 2015):

- Conserving wetland with mangroves and wetland without mangroves;
- Preserving migratory and local birds;
- Sustainable using and preserving aquatic habitats;
- Adapting and minimizing vulnerability from climate change;
- Increasing benefits from ecosystem services for local communities; and
- Contributing to socio-economic development for the region.

- Xuan Thuy National Park is place for balancing socioeconomic development and environmental protection.

Policymakers and governors recognize this park is a place to balance socioeconomic development and environmental protection (Leslie et al., 2018). The park plays an important ecological function in protecting coasts against typhoons, storms, and tidal surges, providing sources of fisheries, mangroves, and replacing sediment. The park also contributes greatly to economic values for people including reduce natural disaster losses, provide commercial values of fisheries and non-timber forest products, improve outcomes from farmed/harvested species.

- Local communities continue to rely on Xuan Thuy National Park’s ecosystem for agriculture-and aquaculture-related livelihoods, but farming activities have created many problems:

The main occupation of local people is crop and livestock cultivation (75% of the total labor force, equivalent 19,500 labors), aquaculture farming (16%), aquaculture capture (4%). Crop cultivation provides the main livelihood for local people which satisfies the basic needs of foodstuffs. Very few households engage in business and government services. Since relying on crop and livestock cultivation creates an income deficit, other costs of living and furniture are provided from aquaculture raising, aquaculture collecting, wage labor or handicraft, etc.

Several farming systems exist and provide main income sources for local people: rice cropping and shrimp aquaculture systems. Current farming practices have created many problematic issues such as the high rate of fertilizers and pesticides, pollution from farms, etc. (Kamoshita et al., 2018; Nguyen et al., 2019).

Reasons for choosing main farming systems around Xuan Thuy National Park:

In this research, we chose three farming systems around Xuan Thuy National Park to elaborate understanding of agricultural development around the conservation site: Rice-based (RB), Integrated aquaculture mangroves (IAM), and Intensive shrimp (ISH). For agricultural focus, we used criteria of monoculture and mixed crop to classify the cropping systems. For aquaculture systems, we used a diversity of specific criteria to divide systems into specialized or diversified production: stocking density, farm size, input uses, and yield.

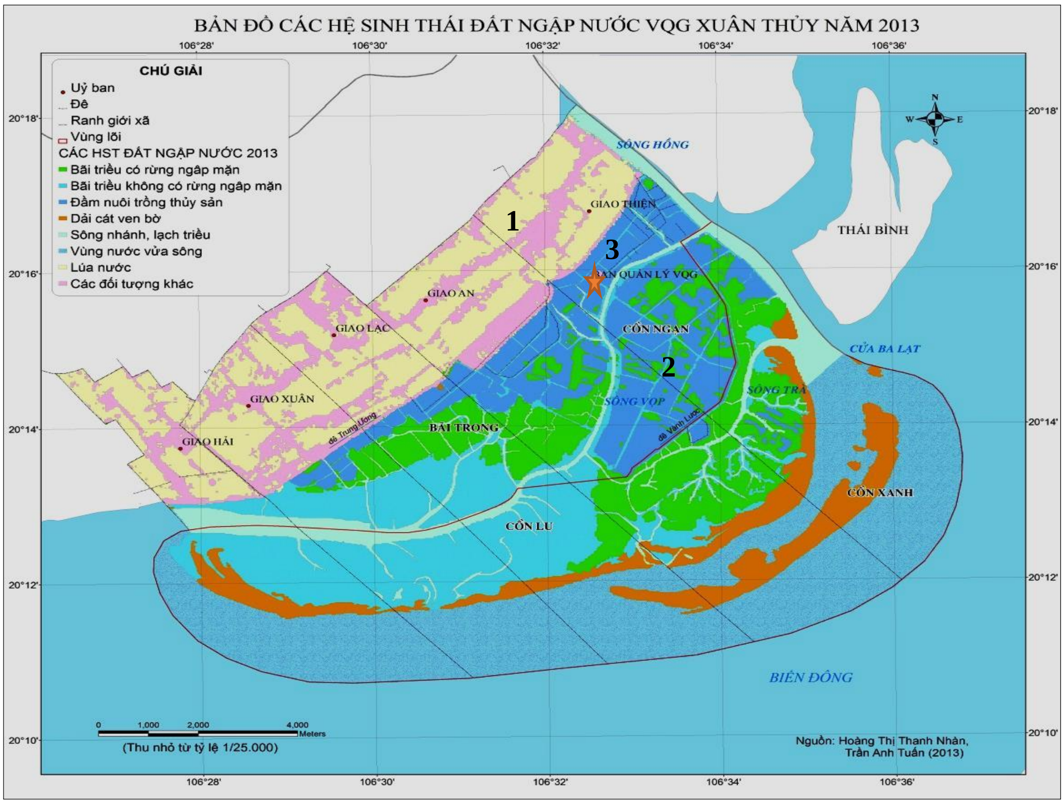


Figure 3.1: Study site: (1): RB, (2) IAM, (3) ISH, star symbol: Xuan Thuy National Park Office, green areas signify mangroves

There are several criteria for choosing the farming systems:

- Rice-based dominates cropland areas and it provides sufficient income and important food source for smallholder farmers:

Cropland (2,188.71 ha) is mainly used for rice (85.5%). Other crops (sweet potatoes, peanuts, maize, watermelon) are not popular. RB has been cultivated by most farm households since the establishment of the area (the 1940s) and it is the main income source and vital food of most local farmers.

- Aquaculture land (3,870 ha) in the buffer zone is dominated by IAM production since 1986s which combines black-tiger shrimps, crabs and mangroves. This system has been practiced for a long time and enhanced economic conditions for many households.

- ISH is considered an engine for the economic growth of the area. In 2014, Nam Dinh Provincial People's Committee decided to change 150 ha of rice-shrimp in the buffer zone to ISH to meet the high-yielding objectives of the province.

- Majority of farm owners are from buffer communes (about 95%), a small number of farmers are from outer communes (these farmers buy land-use right in the buffer zone). All of three farming systems locate in Ngan islet (Cồn Ngạn) which belongs to the buffer zone. Thus, they share the same source of water or have a relation with each other.

In this research, we focus on rice and brackish aquaculture production which accounts for the largest areas and provide main incomes and foods for local communities. We face time and budget limits, so we could not approach poultry, fish, peanut production.

3.1.2.1 The importance of Xuan Thuy National Park

In 1988, the national and international scientists conducted surveys at the wetland plain in the south Red River estuary in Xuan Thuy district, Ha Nam Ninh province (known nowadays as Nam Dinh Province) to apply for approval as a Ramsar site. It is the first officially recognized Ramsar site in Southeast Asia, declared in October 1989 under the Ramsar Convention on Wetlands by UNESCO, and the 50thRamsar site of the world. In 1992, Giao Thuy District People's Committee established the Center of Natural Resources and Environmental Protection to help Vietnam ensure international commitments on the conservation of Xuan Thuy Ramsar site. In 1993, the Provincial People's Committee of Ha Nam Ninh province cooperated with the Institute of Forest Planning and Investigation and Giao Thuy District People's Committee to propose the Technical and Economic Feasibility Study for Xuan Thuy Wetland Nature Reserve. In 1995, the Ministry of Forestry (known nowadays as Ministry of Agriculture and Rural Development - MARD) approved the Technical and Economic Feasibility Study under the management of the Forest Protection Department of Ha Nam province. Xuan Thuy Wetland Nature Reserve started to belong to the system of national parks and nature reserves of Vietnam (Decision 479/1995/QD-UBND).

In 2003, the Vietnamese Prime Minister signed Decision 01/2003/QD-TTg to upgrade Xuan Thuy Wetland Nature Reserve to Xuan Thuy National Park as the highest rank of the conservation area of Vietnam. According to this decision, the park covers total of 7,100 ha and its buffer zone is 8,000 ha. In 2004, UNESCO recognized Xuan Thuy National Park as a core zone of the Red River Delta's Biosphere Reserve. Currently, Xuan Thuy National Park is under the administrative management of Nam Dinh Provincial People's Committee and under the expertise management of the Provincial Department of Agricultural and Rural Development (DARD), Nam Dinh province. Provincial DARD is responsible for assigning its divisions of agriculture and rural development to support Xuan Thuy National Park in scientific research activities and applying advanced technology in environmental protection and biodiversity conservation (Decision 1893/2006/QD-UBND on the coordination of management of conservation of Xuan Thuy National Park issued by Nam Dinh PPC).

Xuan Thuy National park is recognized as a wetland area having international in national importance for conservation target. For international, this Ramsar site is an important sanctuary for migratory birds of the world. Every year in the winter (November - December), migratory birds from Siberia, North Korea and northern China migrate from the north to the south and they stay at Xuan Thuy National Park for months. In March and April when the spring becomes warmer, birds return from the South (Australia, Malaysia, Indonesia) back their nests and they also stay in the park. There are diverse bird species (about 30,000-40,000 migratory birds) that stay in the park during the migratory seasons such as Asian Dowitcher, Nordmann's Greenshank, Spoon-billed Sandpiper, Saunders's Gull and Black-faced Spoonbill. Eight species belong to the international Red book such as the black-faced spoonbill (Platalea minor). For Vietnam, Xuan Thuy National Park supplies inhabitation for water-birds (about 20,000 birds from 136 water-bird species) of Vietnam that contribute to the wildlife preservation of the national programs. The park is representative of the coastal wetland ecosystem of the Red River Delta. It also has a high value of biodiversity regarding flora and fauna, contributing to the vivid and rich panorama of the protected area system of the country. For the local region, Xuan Thuy National Park has great potential for natural resources that provides food, creating an environment and nursery for aquatic animals and plants. Also, the park contributes to shoreline protection and erosion prevention. Every year, the mudflats of Xuan Thuy National Park provide great sources of income for local communities through aquaculture farming, seafood capture and other non-timber forest products and ecotourism service provision.

Provisioning services

Provide food for local people: seafood from mangrove forest (clam, fish, crab, and shrimp).

Provide natural medicine for local people

Provide genetic resources, and habitats for native and migratory birds

Regulating services

Protect the coastline: increase the soil layer and reduce soil erosion from tides and waves.

Reduce negative impacts of wind and storm.

Regulate climate: regulate local climate (temperature, rainfall).

Regulate chemical polluted materials of

sea water and waste.

Cultural services

Educational services on mangrove forest, animals, marine for local people, students, and researchers.

Ecotourism activities: bird-watching, discover mangrove forest, discover culture

and fishing techniques of local communities.

Supporting services

Soil creation: keep alluvium and reduce soil erosion to maintain the lives of

mangrove forest's ecosystem.

Maintenance of nutrient, carbon cycle, balance amount of $O2/CO2$ in the air.

Living habitat for animals, especially endangered migrating birds.

Figure 3.2: Ecosystem services of mangrove forests in Xuan Thuy National Park

Ecosystem services are the benefits people obtain from ecosystems. Xuan Thuy National Park has four types of ecosystem service values which are presented in Figure 4.1. Provisioning services are the products obtained from ecosystems, it supplies direct benefits such as wild aquaculture capture and natural medicine. Total volumes of wild aquaculture capture (shrimps, fish, clam, mollusks) are estimated at 1,200 tons/year (61% of the total amount of aquatic exploitation in the Xuan Thuy National Park and 39% in the buffer zone). In the main season, there are about 1,400 people from buffer communes and outer communes collect wild aquatic species in estuary, rivers, tidal wetland and sea. Natural plant medicines (cỏ gấu: Cyperusrotundus L.; dứa dại: Pandanus tectorius Parkinson ex Du Roi.; sài hồ: PlucheapteropodaHemsl.; ô rô: Acanthus ebracteatusVahl., etc.) are mainly are in the Lu islet (the core zone) and they are harvested by 30-40 people.

Regulating services are defined as the benefits obtained from regulating ecosystem processes such as climate and water purification (forests, wetlands and protected areas with dedicated management actions often provide clean water at a much lower cost than man-made substitutes like water treatment plants). Regulating services of Xuan Thuy National Park provide crucial functions of the coastal ecosystem including coastline protection (typhoon, storm tidal surge), climate regulation, water purification, soil formation.

Supporting services of Xuan Thuy National Park serve essential functions for soil quality, atmosphere maintenance, and living habitat provision (feeding and resting sites for native and migratory water-birds), improving farm performance.

Cultural services are non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values. Cultural services of Xuan Thuy National Park afford spiritual values and recreation for national and international visitors such as environmental education and ecotourism attraction which are tangible and intangible values.

3.1.2.2 Natural and demographical characteristics

Xuan Thuy National Park extends from 20º10'to 20º15' North latitude and 106º20' to 106º32' East longitude within Giao Thuy district, Nam Dinh province. The park locates in the Northeast coastal area of Vietnam. It borders with the Red River to the north, with five buffer commune to the northwest, and with the Northern Gulf to the south. It has a mean height above the sea level from 0.5-0.9 m, especially the height of Lu islet is from 1.2-2.5 m above the sea level. Regarding climate conditions, the park belongs to the tropical monsoon region with two distinct seasons. It is hot and rainy from April to October, but cold and dry from November to March. The average temperature of a year is 24ºC with the highest one reaches 40,3ºC in the summers and the lowest one is 6,8ºC in winters. The average humidity is about 84%. The total rainfall is 1700-1800 mm per year with an average of 133 rainy days. August has the most rain which reaches 400 mm. There are about 80% of the total volume of water from the mainland flow to the sea through the Ba Lat estuary during the summer. Annual floods in the Red River Delta occur from July to October with strong flows and they have influences on the geomorphology of the park. The offshore salinity fluctuates from 5‰ - 33‰ depending on months. In rainy months, salinity at the Ba Lat estuary is from 5‰ - 15‰, but in the winter it reaches 22‰-33‰. The salinity intrudes to 10 km from the sea to the mainland at 1‰ salinity and 5 km at 5‰ salinity. Regarding tidal regimes, Xuan Thuy National Park has diurnal tidal regimes with a period of 23 hours. The average amplitude ranges from 1.5-1.8 m (highest 3.3 m to the lowest 0.25 m). Tidal fluctuation usually has one low tide and one high tide in half of the month.

The intertidal area of Giao Thuy district is supplied with water from the Red River which creates its river branches and canals inside Xuan Thuy National Park are Vop and Tra rivers. The flows of Tra and Vop together divide Xuan Thuy National Park and its buffer zone into four divisions comprising Ngan islet (10 km in length x 2 km in width with a total is 3,368.93 ha), Lu islet (12 km in length x 2 km in width with a total area is 1,822.77 ha), Bai Trong alluvia (12 km in length x 1.5 km in width with a total area of 2,000 ha), and Xanh islet (200 ha in low tide). Vop river starts from Ba Lat estuary to the sea of Giao Hai commune with 12 km in length. Vop River separates Ngan islet from Bai Trong alluvia. The construction of Vop weir since 1986 (for aquaculture exploitation in Ngan islet) leads to the separation of Vop river into two sides (north and south) which restraint the flows of the whole river. Vop wier separates freshwater from the Red River and brackish water from Giao Hai sea. In 2002, Vopwier was un-choked by the Vop bridge to help the stronger flows, but the water volume of the river is still low as compared with its natural capacity. Tra river starts from Ba Lat estuary to the south and meets Vop river at Giao Hai' sea. Tra river has a total of 12 km in length. Tra river separates Ngan islet and Lu islet. The middle of Tra river is filled with sand and this river is full of water when only in high tides.

Land in Xuan Thuy National Park area has been formulated from the alluvium of the Red River Delta including alluvial mud and sand. Currently, the land is unstable so it might have effects from tides, waves or floods. Mangrove forests play an important role in maintaining the stability of the land. For administrative purposes, 7,100 ha of the park is divided into three divisions including strictly protected (6,166 ha), ecological rehabilitation (916 ha), and service (office and housing, 28 ha). In the total area of Xuan Thuy National Park, there are4,000 ha of wetland and 3,100 ha terrestrial land in low tides. According to mangrove classification, there is 1,855 ha of land with mangroves and 5,245 ha of land without mangroves (Table 3.2). There are three types of mangrove forests including planting mangroves, natural mangroves, and mangroves in shrimp ponds.

Table 3.2: Land typologies of Xuan Thuy National Park

Land types	Area (ha)
1. Type 1	
Strictly protected division	6,166
Ecological rehabilitation division	916
Service division	28
2. Type 2	
Land with mangrove	1,855
Land without mangrove	5,245
3. Type 3	
Wetland	4,000
Terrestrial land (in low tides)	3,100
Total	**7,100**

(Source: Hai & Nhan, 2015)

The buffer zone covers 8,000 ha including 1,808 ha of shrimp aquaculture, 452.8 ha of residential land, 814 ha of planted forest, and 2,355.5 ha of others.

3.1.2.3 Ecological succession of Xuan Thuy National Park

Ecosystems are the habitat for many species, especially endangered ones. Each ecosystem needs a certain space to maintain its structure and function. Any change in the ecosystem affects on its species. Xuan Thuy National Park and its buffer zone have seven wetland ecosystems including tidal land with mangroves, tidal land without mangroves, sandy coastal lines, rivers/canals, estuary, aquaculture, and rice (Table 3.3). Ecological succession from the mainland to the sea of Xuan Thuy National Park area is dynamic in the last 200 years. In the period from 1986 to 1995, the mangrove forests reduce critically. There was 762 ha of mangrove loss from 1985 to 1995 in the buffer zone. According to Xuan Thuy National park management board, the loss of mangroves is the main cause of aquatic biodiversity degradation in this area. Alongside the forest reduction, the scale of aquaculture increased sharply for extensive shrimp raising mainly. There were more than 1,246 ha of aquaculture in the nine years from 1986-1995. In the period from 1995 to 2007, several programs of replanting mangroves helped to increase the forest areas. In this time, the total forest area has remained. However, the forest reduces slightly from 2007-2013 because farmers continued replacing some trees for aquaculture raising. The total area of integrated aquaculture – mangrove is 1,561 ha in the buffer zone (Hai, 2015).

Tidal land with mangroves (Aegiceras corniculata - sú, Sonneratia caseolaris – bần chua, Kandelia obovata - trang, and Rhizophora stylosa – đước) including 868 ha in the Xuan Thuy National Park and 884 ha in the buffer zone. This ecosystem belongs to Ngan islet and Lu islet (natural mangroves) and Bai Trong (replantation). Mangroves provide a favorable environment for dense benthos in this area such as crabs (Ocypodidae, Grapsidae), shrimps (Alpheidae), shell (Potamididae, Ellobiidae, Nassaridae, Littoridae, Neritidae, Assimineidae), bivalve (Ostreidae, Veneridae, Psammobidae, Glaucomyidae, Tellinidae), and reptile (frogs and snakes), etc. This ecosystem is a good place for water-birds and migratory birds. This ecosystem plays a very important role in preventing natural disasters such as storms and floods from the sea into the mainland and minimizing negative impacts from economic development activities of surrounding communities on the environment.

Tidal land without mangroves belongs to Xuan Thuy National Park (1,472 ha) and the buffer zone (884 ha). This ecosystem provides a living environment for migratory birds, shells (Crassostrea spp, Cerithideopsilla cingulate, Cerithideopsislargillierti, Nassariusjacksonianus, N. foveolatus), crustacean (Macrophthalmusspp., Ucaarcuata, U. borealis, worm (Polychaeta), etc. According to Nhan (2015), the biodiversity index and biomass of tidal land without mangrove in Xuan Thuy National Park are lower than those in tidal land with mangroves.

Table 3.3: Ecological succession of Xuan Thuy National Park area

Wetland ecosystems	1986	1995	2007	2013
1. Xuan Thuy National Park (ha)				
Tidal land with mangroves	262	617	842	868
Tidal land without mangroves	1,582	1,522	1,504	1,472
Sandy coastal lines	676	680	644	986
Rivers, canals	1,088	782	532	499
Estuary	3,492	3,402	3,439	3,137
Aquaculture	0	97	139	138
2. Xuan Thuy National Park's buffer zone (ha)				
Tidal land with mangroves	1,166	404	869	793
Tidal land without mangroves	1,593	1,536	893	884
Aquaculture	132	1,378	1,513	1,561
Rice	2,346	2,304	2,251	2,232
Sandy coastal lines	0	0	0	3
Rivers, canals	844	454	440	451

Source: Hai (2015)

Rivers and canals have a remarkable reduction in Xuan Thuy National Park (1,088 in 1986 to 499 ha in 2013) and buffer zone (844 ha to 451 ha) mainly due to human activities.

Sandy coastal lines strain along Lu islet with a total area of 986 ha in Xuan Thuy National Park and 3 ha in its buffer zone. In this area, casuarinas are planting (110 ha) to protect the coastlines. These are places for migratory water-birds and local clams. The increased area of sandy coastal lines is mainly due to natural causes.

Estuary (Ba Lat) starts from Giao Thien commune to Lu islet. It has a total area of 3,137 ha with a depth of 6 m in low tides(Hai, 2015). Diverse aquatic habitats are living in this ecosystem such as shrimps, crabs, snails, bivalves, etc. Local people usually collect seafood in this area.

Rice land locates inside and along the national dike of five buffer communes with a total area of 2,232 ha. In the paddy fields, there are poor fresh aquatic species but spreads of golden apple snails (Pomacea canaliculata) which are invasive species causing damages for rice plants in recent decades (Hai, 2015).

Shrimp aquaculture dominates in Ngan islet. Shrimp, fish, crabs, and seaweed are integrated into mangrove forests. Mangroves are mostly natural and some farmers replant more trees inside their ponds. Aquaculture ponds with mangroves are places for water-birds. Since the brackish water is maintained inside ponds to ensure a stable level for aquaculture, mangroves become scattered.

Figure 3.3 visualizes the main evolution of wetland ecologies in Xuan Thuy National Park area from the mainland to the sea. In 1934, Ngu Han dike was constructed to border Giao Thien, Giao An, Giao Lac, Giao Xuan, Giao Hai communes with a total area of 4,000 ha (inside dike). The soil was salty and the local people were encouraged to build residential houses inside the dike but they were allowed to cultivate farms outside the dike (in the wetland areas). In the period 1970s, Ngan grass dominated Xuan Thuy National Park area. So, the site used to be grassland. The dikes continued to be constructed with the evolution of "rice encroaches sedge, sedge encroaches mangrove, mangrove encroaches the sea" for many years. In 1984, local people and the military worked together to plant thousands of ha of mangroves in Ngan islet for flood prevention, after that they converted 300 ha of wetland mangroves in order to capture shrimps and fish. Other farmers cultivated rice in agricultural cooperatives with low yields and many of them were still suffered from insufficient grains. The wild aquaculture resources were diverse in dense mangrove forests. In the period from the 1990s, with the orientation of market access, economic development, and increased demands for aquaculture foods, the government implemented the strategy "shrimp aquaculture encroaches mangroves, mangroves encroach the sea". Thus, thousands ha of shrimp aquaculture started to be farmed in Ngan islet and Bai Trong alluvia. However, thousands of ha of mangroves were destroyed and replaced by aquaculture ponds. The exploitation of resources, population growth, changes of policies mainly affected mangrove forests and the ecosystem of the park. Overall, the mangroves move from the mainland toward the sea (from Ngan islet to Lu islet) due to two main reasons: (1) the development of shrimp aquaculture in Ngan islet replaces mangroves in this area; and (2) the structure of Ngan islet changes to be higher and its tidal regimes become less suitable for mangroves, so many mangroves die due to natural disasters (134 ha mangroves lose during storms in 2013).

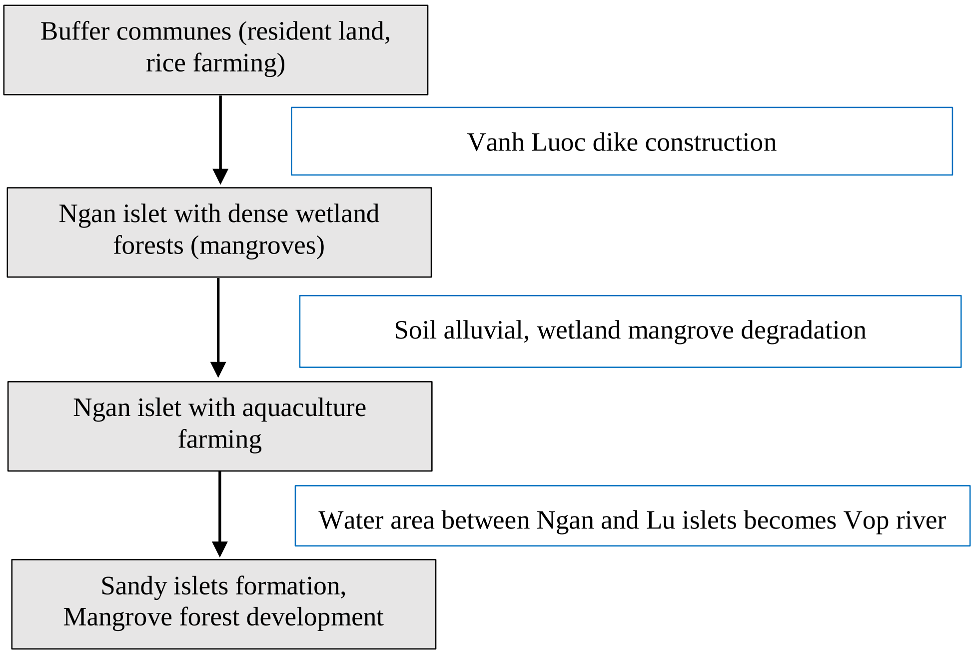


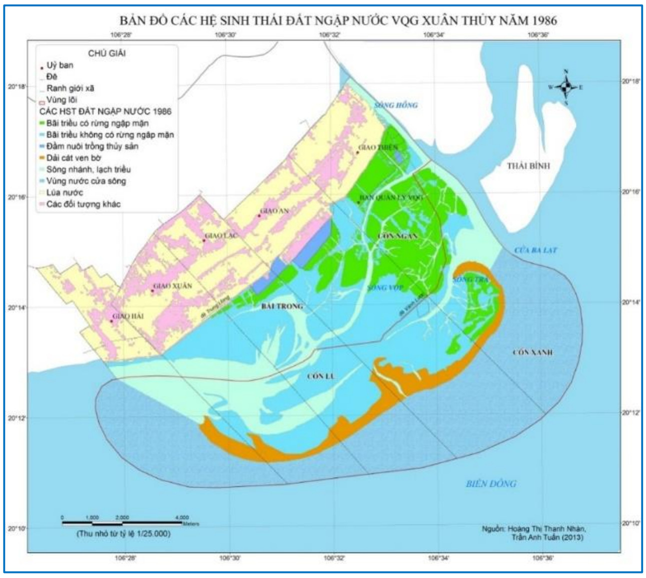
Figure 3.3: Ecological succession from the mainland to the sea of Xuan Thuy National Park area

In 1986, there was a large area of rice cultivation (2,346 ha) but the small scale of aquaculture (132 ha) around the park. In the 1989s, almost all wetland with mangroves in Ngan islet was designed for extensive aquaculture farms. The farms were distributed to individual farmers, government military, organizations of district and province. These activities had negative effects on biodiversity and mangrove loss. Giao Thuy District People's Committee proposed a program for the economic development of Ngan islet within 16 km of the national dike and diverse road systems in 1994.

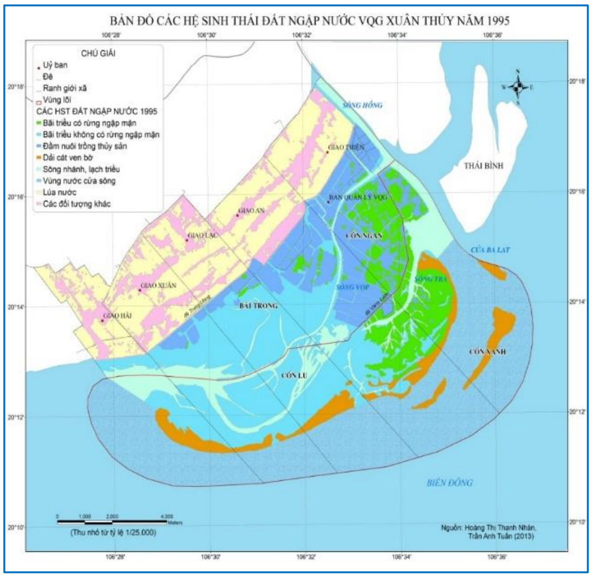
After that, in 1995, the Ministry of Labor, War Invalids and Social Affair approved the project of "residential land encroaches the sea" in Ngan islet and a total area of 3,200 ha of land inside the dike was formed. The stage of nine years from 1986 - 1995, there was 65.3% total area of wetland with mangroves in the buffer zone were replaced by shrimp ponds, and 2,000 ha of the surrounding wetland was constructed for water regulation of aquaculture ponds. At this time, aquaculture farmers simply collected wild-caught shrimps and other habitats for their ponds. They did not add any hatchery-raised species.

In the period from 1995-2007, mangroves increased 465 ha in the buffer zone and 225 ha in the core zone through efforts of replantation programs. Since 1995-2000, farmers start rearing black tiger shrimps in mangrove ponds together with collecting wild-caught species. The numbers of wild aquatic resources and water-birds reduced quickly.

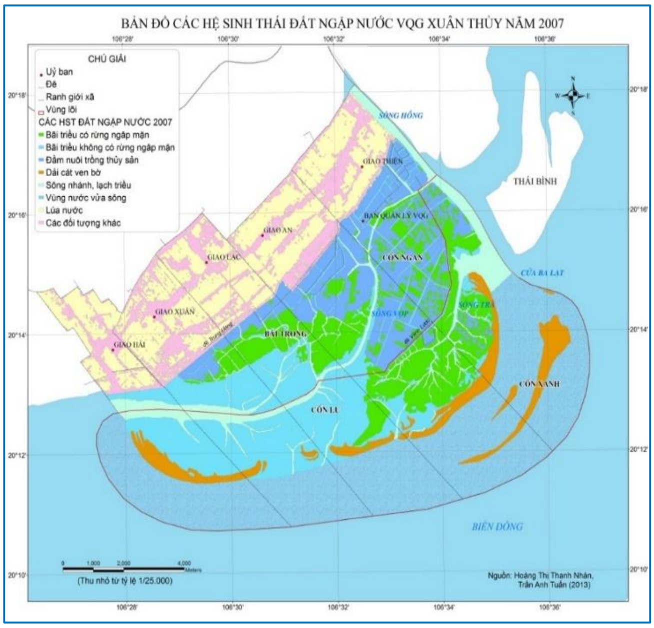
Rice areas reduced slightly but this plant continued playing very important roles for local people. In the stage of 2000-2005, the local government relocated aquaculture land for local people and more farmers started collecting wild aquatic habitats in Xuan Thuy National Park and its buffer zone for selling. The government also issued several policies for managing the collection of these resources. After 2005, aquaculture farmers claim for the critical reduction of wild-caught aquatic species for aquaculture ponds as well as birds around the site. Seaweed started to be harvested for selling at this time. The rice farms continued reducing but the yields increased remarkably. In 2007-2013, the government stopped planting mangroves and focused on maintain trees. In recent years, local people report for a considerable reduction in wild aquatic resources and several species disappeared. Farmers claim unstable yields in aquaculture as well as the more frequent disease outbreaks in crop cultivation. In conclusion, both human activities and natural factors have an impact on the evolution of the ecological succession of Xuan Thuy National Park area.



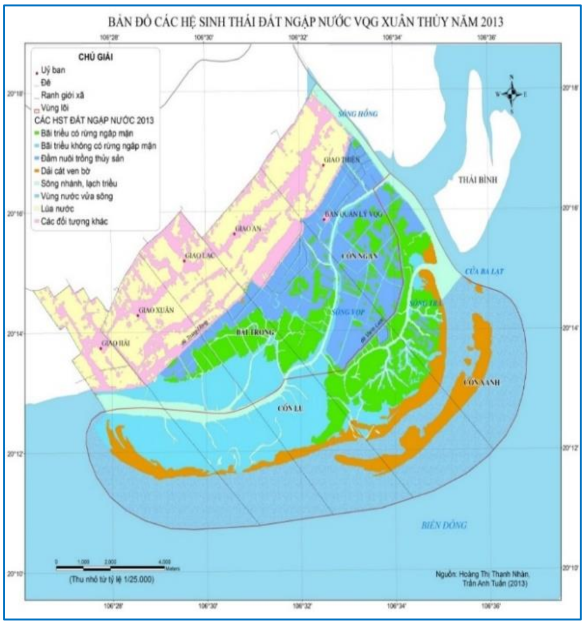
Wetland ecosystems - 1986



Wetland ecosystems - 1995



Wetland ecosystems - 2007



Wetland ecosystems - 2013

Figure 3.4: Changes in ecological systems of Xuan Thuy National Park
(Source: Hai & Nhan, 2015)

Box 3.1: Environmental quality of Xuan Thuy National Park

- From 1970 to 1985: The environment was really clean and there was no polltion. The Xuan Thuy National Park was flat and there were no administrative borders.
- From 1985 to 1995: The environment had been little negative effected by human activities.
- From 1995 to 2000: The environment was polluted.
- From 2000 to 2005: The environment pollution became serious issue. Storms and other natural disaters were unpredicted and damaged casuaria forests.
- From 2005 to present: The environment is polluted seriously and the climate change causes many problems. The natural aquatic species reduced gradually in both quantity and quality. Aquaculture raising activities of local communities are mainly spontaneous.

3.1.2.4 Socio-economic characteristics of local communities surrounding Xuan Thuy National Park

- *The population of buffer communes*

According to the Statistic Office of Nam Dinh province (2017), five communes in the buffer zone have 44,287 people (14,076 households) and the average growth rate of population is 0.37% per year. The population density is 1,108 people/km^2 which is nearly fourfold as high as Vietnam national average (290 people/km^2 (GSO, 2019). In the densely populated regions, land resources are often scarce and the little natural area remains. The labor force accounts for about 50.7% total population and there is an average of two labors per household. Female laborers are about 51.5% total labor force of the communes.

Table 3.4: Population of buffer communes of Xuan Thuy National Park

Commune	2015	2016	2017	Average growth rate
GiaoThien	9,689	9,846	9,911	1.14
Giao An	9,060	9,084	8,966	-0.52
Giao Lac	9,662	9,727	9,789	0.66
Giao Xuan	9,385	9,395	9,441	0.30
Giao Hai	6,163	6,158	6,180	0.14
Total	**43,959**	**44,210**	**44,287**	**0.37**

(Source: Statistic Office of Nam Dinh province (2017)

- *Land use patterns of buffer communes*

The land use around Xuan Thuy National Park is classified into four main types including cropland, aquaculture (freshwater and brackish water), resident, and specialized. Rice accounts for 85.5% of total cropland in the buffer zone, and 14.3% is used for maize, sweet potato, cassava, vegetables. As shown in Figure 3.4, Giao Thien has the second largest area the aquaculture farming (1,533 ha) among the five communes, followed by Giao An (1,032 ha), Giao Lac (675 ha), Giao Hai (399 ha), and Giao Xuan (330 ha). The area of cropland (mainly rice) is highest in Giao An (488.22 ha), followed by Giao Xuan (471.32 ha), Giao Thien (447.98 ha), Giao Lac (443.63 ha), and Giao Hai (337.56 ha). The details of land use in the buffer zone are presented in Figure 3.5:

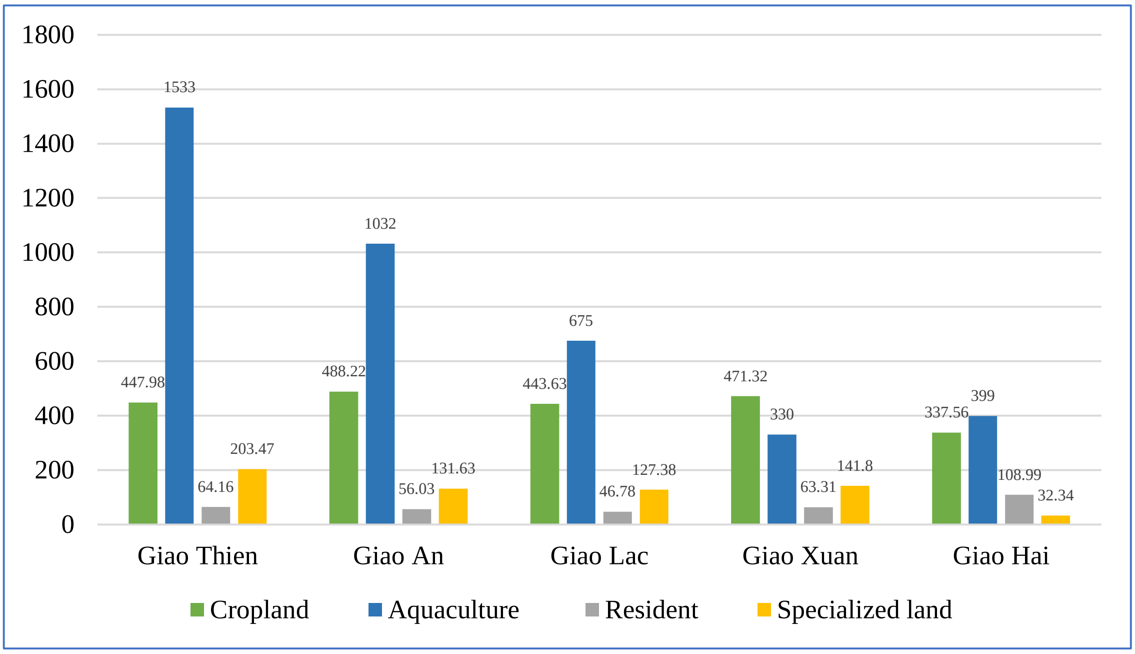


Figure 3.5: Land use in five buffer communes of Xuan Thuy National Park (2017) (ha)
(Source: Statistic Office of Nam Dinh province, 2017)

In the aquaculture sector, brackish aquaculture is dominant in Giao Thien and Giao An communes as compared with fresh aquaculture.

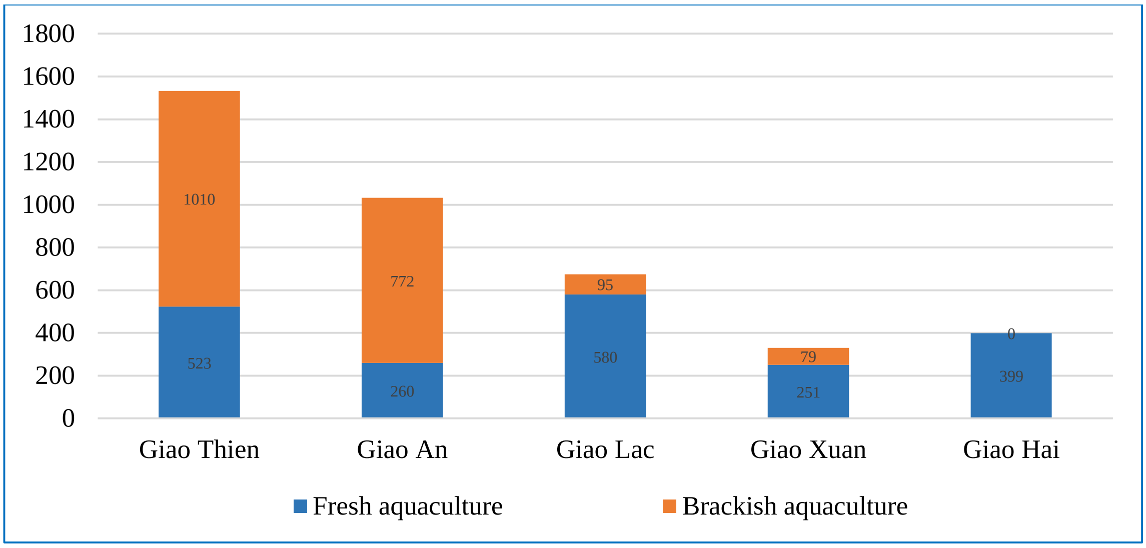


Figure 3.6: Aquaculture area in five buffer communes of Xuan Thuy National Park (2017) (ha)
(Source: Statistic Office of Nam Dinh province (2017), Department of Agriculture and Rural Development of Giao Thuy district (2017)

- *The main livelihood of local communities*

There are nearly 3,000 households (accounts for 20% of total households) that generate incomes directly from Xuan Thuy National Park and its buffer zone through aquaculture, collecting natural resources or service provision. There are about 700 people of five buffer communes collect wild aquatic resources in both Xuan Thuy National Park and the buffer zone such as Ngan and Lu islet, common estuary, rivers and canals inside mangroves. The exploitation of wildlife aquaculture is one of the pressures for the ecosystem of this protected area because they collect all of the months in years.

The main occupation of local people is crop and livestock cultivation (75% of the total labor force, equivalent 19,500 labors), aquaculture farming (16%), aquaculture capture (4%), service and sellers in the marketplace (2%), handicraft, construction, hired labor (3%). The crop cultivation provides the main livelihood for local people which satisfies the basic needs of foodstuffs. Very few households engage in business and government services. Since relying on crop and livestock cultivation creates an income deficit, other costs of living and furniture are provided from aquaculture raising, aquaculture collecting, wage labor or handicraft, etc.

Aquaculture farming plays an important role in rural households as its share in total values of the agro-forestry-fishery sector is about 18% (Statistic Office of Nam Dinh province, 2017). The poor households have limited rice land (less than 1 ha/household) and they do not own aquaculture land. Currently, among a total of 14,076 households in the buffer communes, there are 69 households have alternative livelihoods instead of wildlife exploitation including mushroom growing (20 households), beekeeping (10 households), ecotourism (14 households), earthworm (Perionyx excavates – 5 households), fish fresh aquaculture (20 households). There are about 64% of households are better-off, 23% rich and 13% poor households.

3.2 Analytical framework of the study

Protected area system in Vietnam is established with several assigned tasks including (1) managing, protecting and developing natural resources of protected areas; (2) conducting scientific research activities; (3) conducting environmental education activities; (4) organizing eco-tourism and entertainment activities; (5) cooperating with international organizations (the five tasks are assigned in all of five protected areas); (6) organizing environmental services; (7) developing livelihoods for buffer zones; (8) providing and transferring agricultural advisory services and agricultural models for the buffer zones. Through fulfill the tasks, protected areas achieve conservation goals (protect the natural environment) and development (improve the social-economic condition for local people).

Agricultural production surrounding protected areas in Vietnam are allowed because it is crucial for local people to earn income and ensure their livelihood. Farmers, communal authorities, and protected area managers have different priorities for their objectives. Yield and profit come firstly from the interest of farmers and communes, whilst conserve the environment is the primary objective of protected area managers.

Different production practices achieve different outcomes. Outcome indicators serve as a tool in planning and decision management in agriculture at farm households and numerous administrative levels. There is no "one size fits all". So it may unnecessary and impractical to use more than a few. In this research, we select main indicators of agroecology (Figure 3.7) which are retrieved from literature reviews in Chapter 2 to assess the outcomes of agricultural production management nearby Xuan Thuy National Park. The indicators meet some criteria of this study: necessary data available and can be gathered; be relevant to use and implement by farmers and local authorities; be simple but sufficient enough to fit with the research topic.

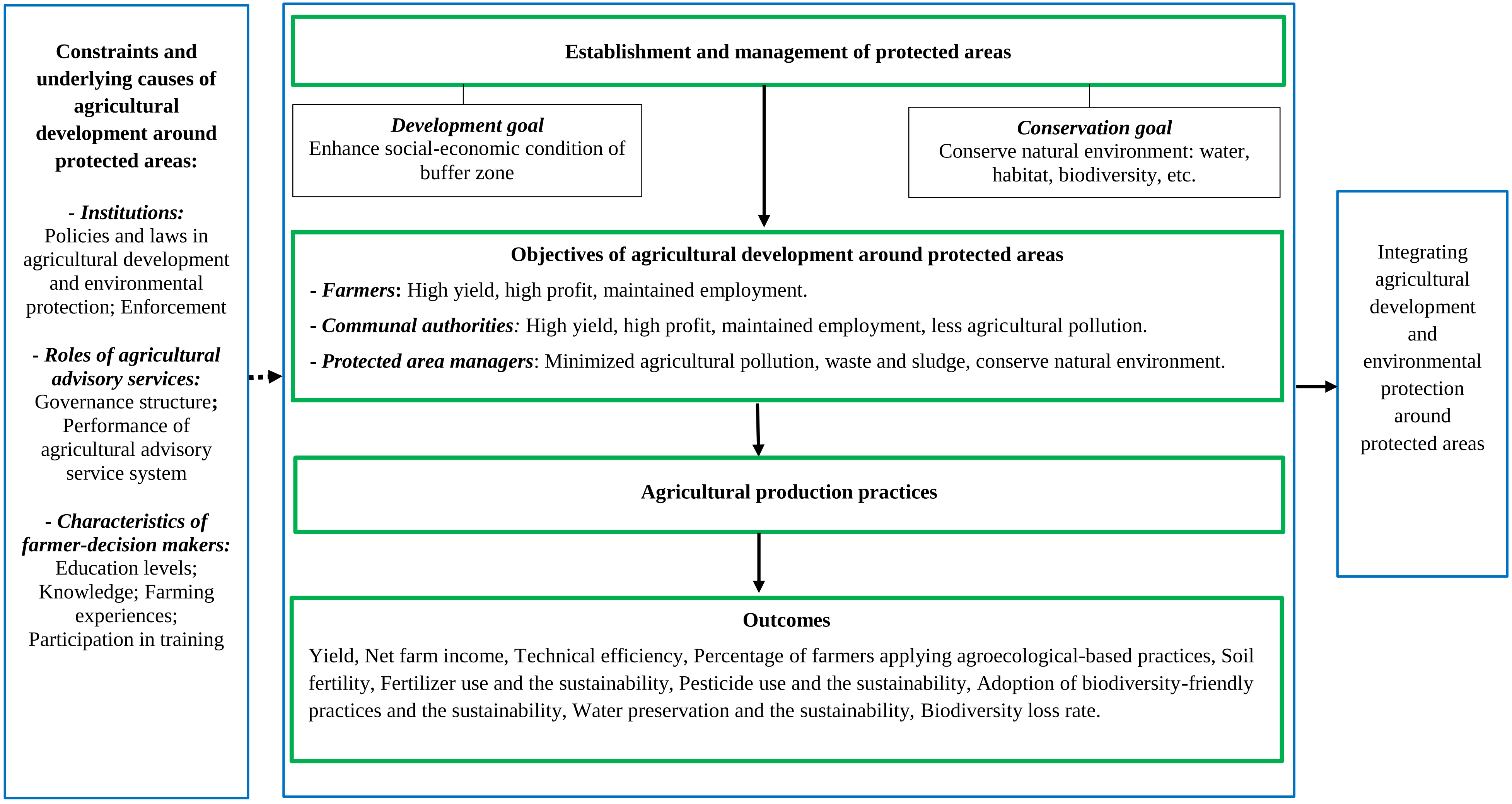


Figure 3.7: Analytical framework

Direct relationship — Interlinked constraints that prevent/hinder

3.3 Research design

Figure 3.8 presents the main stages of this research as follow:

Problem identification: Vietnam has a rich biodiversity with a total of 272 protected areas. The integration of agricultural production nearby protected areas of the country has been associated with simultaneous beneficial and detrimental consequences. The expansion of farming to new areas has resulted in wide encroachment into protected areas and drainage of natural wetlands. Agricultural intensification and expansion with improper management have destroyed biodiversity and habitats, driven wild species to extinction, accelerated the loss of environmental services, and eroded agricultural genetic resources. Farms discharge large quantities of agrochemicals, organic matter, drug residues, and sediment into water bodies. The resultant water pollution posed demonstrated risks to ecosystems and human health.

Study site selection: We chose four national parks and one nature reserve in Northern Vietnam to assess the natural-social-economic-institutional characteristics of protected areas of Vietnam and issues of agricultural production nearby these sites. Xuan Thuy National Park was selected for case analysis to deepen the understanding of the objectives of farmers and park managers, farm management practices, and farm outcomes.

Selection of local authorities: representatives of five protected areas, administrators of district and communes, staff from the specialized department of district and commune were approached for data collection.

Selection of farming systems: three farming systems around Xuan Thuy National Park which are the main income sources of farmers were selected for the analysis including integrated aquaculture-mangrove, intensive shrimp, and rice-based.

Household selection: Households represented for three farming systems were selected for data collection. A total of 234 households from three farming systems was approached including 54 intensive shrimp households, 84 integrate mangrove aquaculture household and 96 rice-based households.

Data collection: In this research, we conducted three tools for data collection including key informant interviews, household surveys, and RAAIS. Data collection method will be presented in detail in part 3.4.

Data analysis: Both of qualitative and quantitative methods were used for data analysis. Data analysis part will be presented in part 3.5.

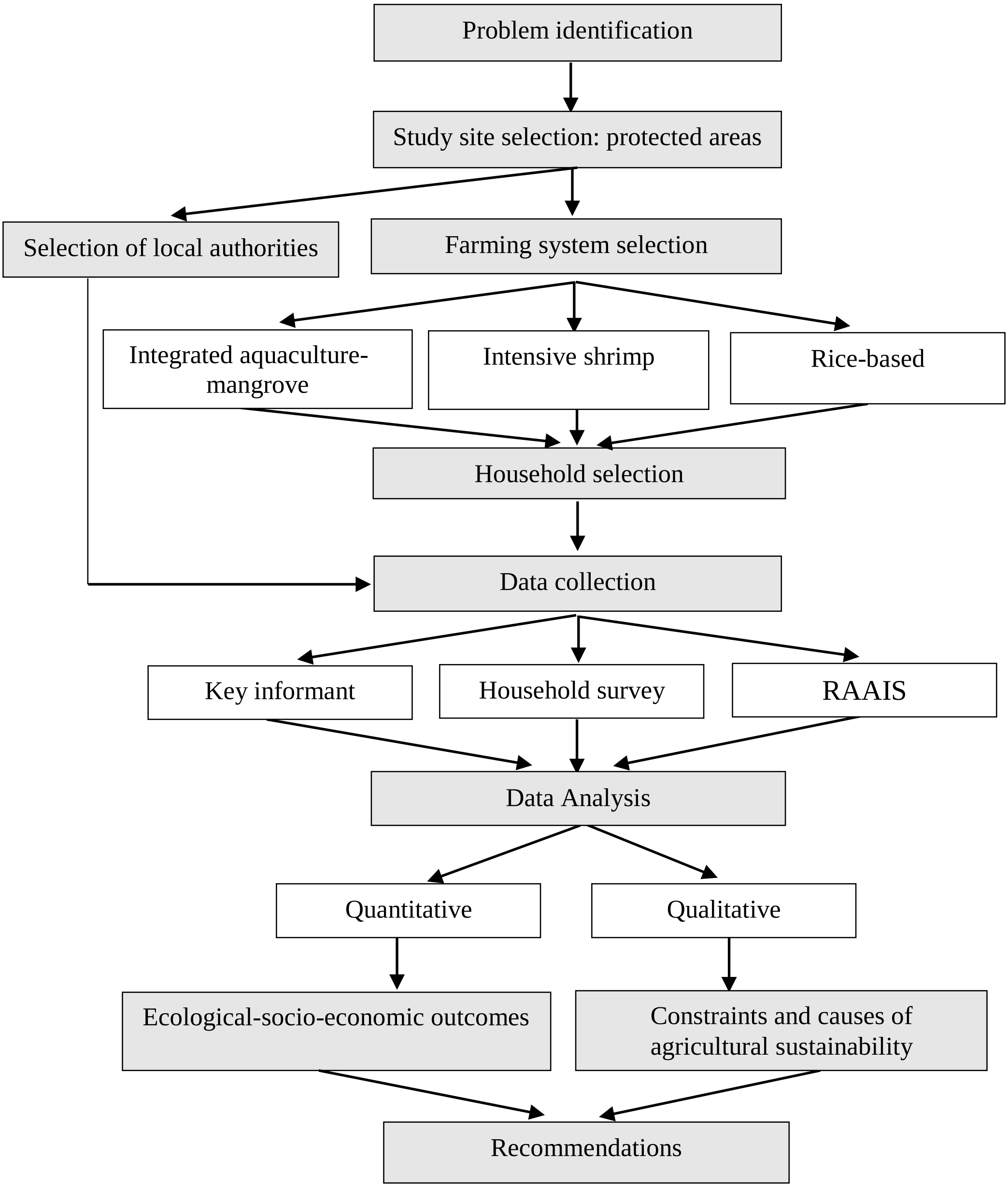


Figure 3.8: Research design

(Note: RAAIS: Rapid Appraisal of Agricultural Innovation System)

3.4 Data collection methods

3.4.1 Key informant interviews

The in-depth interviews with key informants firstly were used to provide comparative analysis of five protected sites (for the content of Chapter 4). Key informants are managers of five protected areas in Northern Vietnam including Xuan Thuy National Park, Cat Ba National Park, Bai Tu Long National Park, Tam Dao National Park, and Tien Hai Nature Reserve (one manager for each protected site).

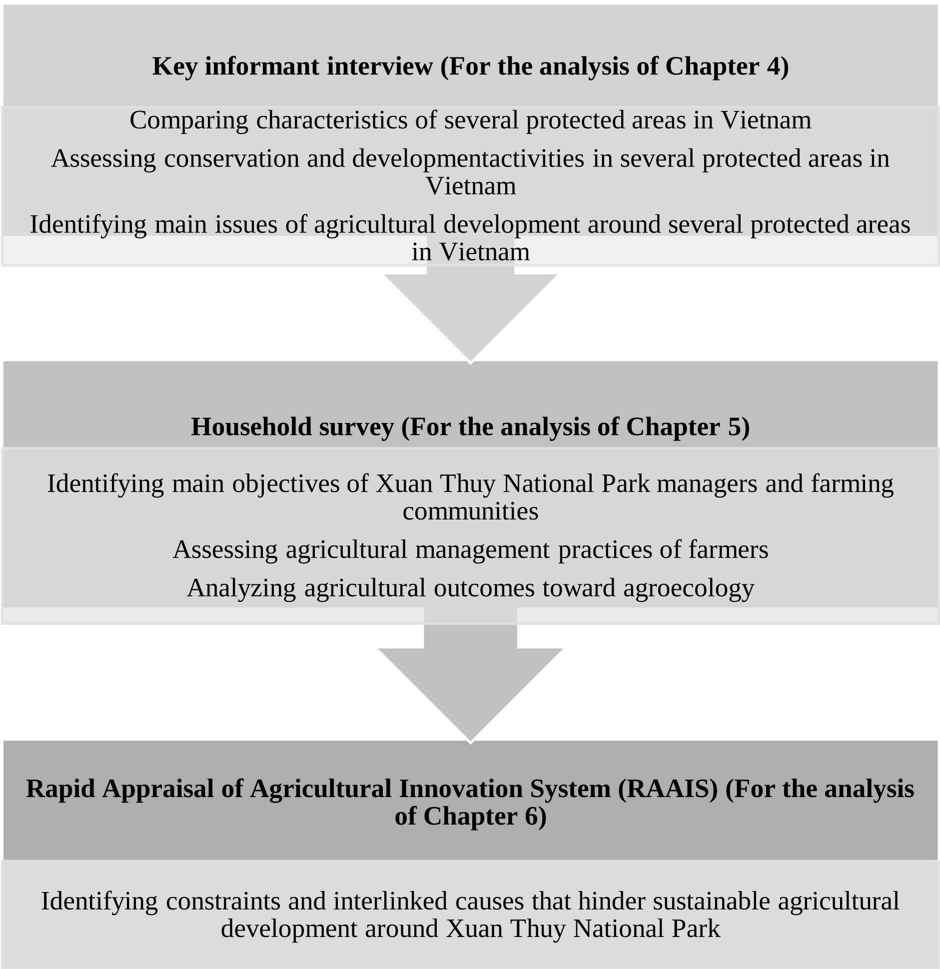


Figure 3.9: Data collection methods

Semi-structure questionnaires were used to collect data and information from protected area managers:

- Profile information: size and areas of core zone and buffer zone
- Objectives of protected areas
- Assigned tasks
- Administrative responsible organizations
- Agencies involved
- Geographical features
- Flora and fauna
- Administration and workforce
- Activities of conservation and development of the park management boards

Furthermore, to identify the characteristics of buffer communities and main issues of agricultural production around these protected areas, we interviewed five headers of agricultural cooperatives in five buffer zones to gather data:

- Objectives of communes for agriculture
- Characteristics of local people (population, main income source, etc.)
- Characteristics of main farming systems (technical aspect, yield, land use, etc.)
- Issues of agricultural production

A total of 10 key persons were approached to collect information on the overview of protected areas and agricultural-related issues around the sites in 2017.

3.4.2 Household surveys

Household surveys were conducted for the analysis of chapter 5 (Agricultural development toward agroecology around Xuan Thuy National Park).

To deepen understanding about the current situation of agricultural development under the context of environmental protection, we chose Xuan Thuy National Park as a case study.

For this study, three farming systems around Xuan Thuy National Park were selected purposively including integrated mangrove – aquaculture (IAM), intensive shrimp (ISH), and rice-based (RB). They were chosen because they are the main income sources of local farmers and they are cultivated in the buffer zone. Three kinds of farm households represented for three farming systems were approached: 84 IAM households, 54 ISH households, and 96 RB households. Thus, a total of 234 farm households were interviewed.

RB farmers cultivate individually, but many ISH and IAM farmers raise aquaculture in groups or several owners sold farms to others. Thus, it was complicated to choose farm owners for interviews based on lists of farmers provided by buffer communes. We decided to choose a sample size based on farm locations initially, then we found representatives of farms for face – to – face interviews.

After reviewing and assessing farm locations, farms in Ngan islet (buffer zone) which under the administrative management of buffer communes (Giao Thien and Giao An) meets set criteria and selected: (1) the farms situated near the core zone with the largest integrated aquaculture-mangrove farming among five communes, (2) it is the unique area which has 150 ha of intensive shrimp aquaculture among five buffer communes; (3) residents are concentrating on rice production and rice is the main cereal food of households; (4) farms are located adjacent to the Red River and Ba Lat estuary.

In 1992, the Ministry of Labor, War Invalids and Social Affairs issued the project of economic development in Ngan islet – buffer zone (Decision 455/1992/QD-LDTBXH). According to the decision, the total area aquaculture in Ngan islet – buffer zone is 1,779 ha which is under the administrative management of buffer communes (Giao Thien commune, Giao An commune). The local authorities allow farmers from five buffer communes and outer communes to raise aquaculture in this zone.

Thus, surveyed farms are under the administration of buffer communes, and farm owners are from both buffer communes and other communes of Giao Thuy district (Table 3.5).

Table 3.5: Administrative management and location of surveyed farms

	IAM	**ISH**	**RB**
Location of farms	Ngan islet- Buffer zone	Ngan islet- Buffer zone	Ngan islet- Buffer zone
Administrative commune	Buffer communes	Buffer communes	Buffer communes
Location of farm owners	Buffer communes; outer communes	Buffer communes; outer communes	Buffer communes

(Source: Xuan Thuy National Park Management Board, 2017)

Fieldwork is carried out from 2017 to 2018 with a total of 234 respondents to collect information of one year activities. A sample size of the household survey was calculated by the Toro Yamane equation:

$$n = \frac{N}{1 + N(e)^2}$$

where n = sample size; N = total households practicing each farming system group of IAM, ISH, and RB; e = level of precision (Table 3.6). In the case of RB, the research methodology accepts e = 0.1 due to the large population (N). In the case of IAM and ISH, the research methodology accepts e = 0.05 due to small population. For this parameters, n_1 = 96 RB, n_2 = 84 IAM, n_3 = 54 ISH.

Table 3.6: Distribution of respondents of farming system groups

Farming systems	**e**	**Total farm owners (N)**	**Number of respondents (n)**
RB	0.1	2,737	96
IAM	0.05	102	84
ISH	0.05	64	54
Total		**2,903**	**234**

The data and information were captured through household survey with 3 groups of production systems:

- Objectives of farmers in agricultural production
- Farm management practices in different stages of cropping seasons
- Areas and farm designation
- Costs of production
- Outcomes of agricultural production (farmed products, farm gate prices, etc.)
- Environmental issues (soil fertility, biodiversity, water preservation, etc.)

3.4.3 Rapid Appraisal of Agricultural Innovation System (RAAIS)

The RAAIS tool was conducted for the analysis of chapter 6 (Constraints and causes of agricultural development around Xuan Thuy National Park).

RAAIS tool provides an integrated analysis of complex agricultural problems. The tool is introduced by Schut et al. (2015) and it has been applied in the rice sector (Schut et al., 2015) and the aquaculture sector (Joffre et al., 2018) to identify constraints of agricultural development. The dimensions of constraints including infrastructure (physical and knowledge), hard institutions (formal rules, laws, regulations, strategies, etc.), soft institution (unwritten rules, norms, etc.), economic (market, value chain, prices, etc.) (Schut et al., 2015).

RAAIS further facilitates the analysis of innovation capacity in the agricultural systems within the institutional-sectoral-technological subsystems of agricultural systems. In this study, RAAIS uses the qualitative method and both insiders (stakeholders) as well as outsiders (researchers) for data gathering. The steps of data collection including multi-stakeholder workshops, in-depth interviews with stakeholders and secondary data gathering to complement the analysis, and site visits.

- First, the multi-stakeholder workshop was held in a buffer commune of Xuan Thuy National Park (Giao Thien commune) in December 2019, included 19 representatives from five different stakeholder groups: rice-based farmers (5), intensive shrimp farmers (3), integrated aquaculture-mangrove (3), Xuan Thuy National Park management board (3), district and communal authority (3), and technicians from private companies (2).

The starting point of the multi-stakeholder workshop was to determine constraints or challenges of agricultural development around Xuan Thuy National Park. The participants were guided through a series of participatory exercises to identify the main constraints and problems they faced in their work regarding socio-economic-environmental-institutional aspects. Participants were asked to list and write down the problematic issues, then they discussed with others to explore overlapping issues. The top main constraints then were concluded based on the consensus of the stakeholders. The researchers capture all the discussion of participants to ensure the quality of information.

- Second, in-depth interview and synthetic review of secondary data: to deepen the understanding of causes of constraints that hinder the production, further in-depth interviews (with a semi-structured questionnaire) were conducted with key-informants of each above group in the next few days. We continued gathering communication information, concerns and frustration from diverse respondents through recurring questions. Common themes arose throughout the in-depth interviews. Based on the topic lists, we collected related problems and all detailed notes from interesting storylines of respondents.

In order to assess the current situation of agricultural advisory services in Xuan Thuy National Park area, in-depth interviews were also used with 12 stakeholders to assess the policies and governance structure of agricultural advisory services in Nam Dinh province including Xuan Thuy National Park. The surveys were conducted with managers of the communal people's committee (CPC), headers of Communal Agricultural Board (CAB) and Communal Agricultural Cooperative (CAC), managers of Xuan Thuy National Park management board and officials of Giao Thuy district's Department of Agriculture and Rural Development (DARD) and Center of Agricultural Services (CAS).

Secondary data of policy documents of agriculture in Vietnam, regulations, plans, reports, projects, etc. of the agricultural sector in Vietnam, Nam Dinh province and Xuan Thuy National Park were gathered and synthetic review. The relevant data were collected through Google Scholar, Web of Science and internal documents from an involved organization such as Vietnam portal, Nam Dinh portal, etc. These data help to validate and triangulate the workshop and in-depth interview results.

- Third, site visits: we conducted further site visits to collect data on personal characteristics and assess the relationships between farmers' characteristics and the adoption of agroecological methods, assessment of farmers on the effectiveness of agricultural advisory services, the interaction of farmers and service providers, etc. The semi-structured interviews were used while we were visiting farms.

The RAAIS applied in our research was not only taken in farm-scale but higher levels of environmental managers and policy environment. Based on the analysis, we propose intervention beyond the farm level.

3.5 Data analysis

Chapter 5:

- Farm yields: Yield is core indicator of agroecological measurements. It measure outputs obtained on a specific area of land. We use farm yields of RB, ISH and IAM to evaluate the physical productivity of land and compare with those other regions.

- Net farm income: Net farm income is a key indicator of agroecology toward economic theme. In this research, we measure net farm income to assess the profitability of three farming systems. We adapted the calculation of Net farm income from FAO (2018) and Mottet et al. (2020):

Net farm income = Revenue from animals/plants/other farm activities (quantity of crops/animals/other activities sold multiplied by the gate price) – Total operating expenses after rebate (input costs + depreciation of equipment and machinery + taxes + hired labor costs + interests + cost land rent + veterinary service costs).

The variation in response among the different groups was investigated by Kruskal–Wallis (Breslow, 1970) to test the differences of economic indicators (revenue, cost, net farm income).

- Technical efficiency: Technical efficiency belongs to economic theme of agroecology outcomes. This indicator is used to evaluate the efficient levels of input uses in different farming systems. This research applies the non-parametric Data Envelopment Analysis (DEA) model (Callens & Tyteca, 1999) to estimate the technical efficiency of different farming systems. This is a mathematic technique that is widely applied to measure the relative efficiency of decision-making units (DMU) with multiple inputs and multiple outputs (Coelli et al., 2005). DEA model generates information about the benchmark farms for each individual production unit in the sample, which provides normative guidance for the management (De Koeijer et al., 2002). DEA focused on minimizing the amount of resources and increasing production. In both directions, the result obtained in constant return to scale (CRS) (farms operate under constant return to scale with overall technical efficiency) condition would be the same, and in variable return to scale (VRS) (farms operate under variable return to scale with pure technical efficiency) conditions would be different (Sherzod et al., 2018). Under these conditions, this research aims at saving input resources in production. Thus, the input-oriented VRS DEA method was used. Moreover, efficiency scores of a farming system under constant return (CRS) and scale efficiency (it indicates the farm size optimality) were estimated. DEA model was used with the application of software maxDEA8.

- Fertilizer dose: The dose of chemical fertilizers (NPK, N, P, K) in fields was used to monitor and assess fertilization of farmers. Whether farmers apply suitable dose or excessively as compare with local standards? Data analysis was conducted through the use of SPSS program version 22.0. A Mann-Whitney U test was used to analyze the difference-of-means of fertilizer doses according to different rice varieties and different cropping seasons.

- The **"Traffic light" approach**, concepts of the Inter-Agency and Expert Group on Sustainable Development Goals of FAO (2018), was used as an analytical technique to evaluate and visualize the environmental sustainability of RB cultivation. Farms that perform badly results are signified with unsustainable (marked with red), while others that achieved preferable outcomes are highlighted with sustainable/desirable (marked with green). Those performances obtained at neutral are being rated acceptable (but need to be improved) (marked with yellow). The ranking varies differently environmental indicators: soil fertility (soil health), water use, fertilizer management, pesticide management, and application of biodiversity-friendly practice. These indicators are used to assess the environmental risks of farming systems.

- The index of biodiversity loss (BDL): BDL is one indicator of agroecology outcomes. It is used to assess the environmental consequence of IAM and ISH systems. BDL can be evaluated by multiplying the responses with scoring value and dividing the total number of respondents. The scoring value of wild-caught habitats use in the cultivation are classified as >50% = 0.25; 20-49% = 0.5; < 20% = 0.75; and no natural fry use = 1 (Chowdhury et al., 2015).

Chapter 6:

- Constraints and causes of agricultural development: Constraints and underlying causes of sustainable agricultural development around Xuan Thuy National Park was analyzed through the application of RAAIS tool as follows:

  - During the multi-stakeholder workshop to identify and classify constraints and challenges of agricultural work, the researcher participated in all discussions of stakeholders for note-taking protocols. The note-taking ensures the workshop be organized and the quality of information gathered. Top constraints were identified and highlighted by stakeholders and refined later during the data analysis. Constraints were coded and recycled during and after the workshop. The data of note-takers (researchers) were used to validate and analyze constraints and relationships between constraints.
  - Information and notes from semi-structured in-depth interviews for causes of constraints were coded and analyzed by two researchers to ensure the quality of data analysis.
  - Secondary data are collected during and following interviews. They are verified with their relevance for the analysis of constraints and causes by stakeholders and researchers.

- Farmers' opinions and knowledge on the effective levels of agricultural advisory services were evaluated by weighted average index (WAI). The WAI is a social scaling for identifying the perception of farmers on aspects of sustainable agriculture (Zhen & Routray, 2003). This value can be estimated by multiplying the statement to its corresponding weight and dividing it by the total number of the respondent in each farming system (Chowdhury et al., 2015) as below:

$$WAI = [\sum(VL*0.2) + (L*0.4) + (M*0.6) + (H*0.8) + (VH*1.0)]/n$$

where WAI = the weighted average index ($0 < WAI \leq 1$); VL = number of farmers' response very low effectiveness and its weight is 0.2; L = number of farmers' response low effectiveness and its weight is 0.4; M = number of farmers' response medium effectiveness and its weight is 0.6; H = number of farmers' response high effectiveness and its weight is 0.8; VH = number of farmers' response very high effectiveness and its weight is 1.0; n = total number of respondents. The sustainable levels of WAI and PSI are assessed based on the research of Chowdhury et al. (2006) and Chowdhury et al. (2015) as follow:

Score	0.80-1.00	0.60-0.79	0.40-0.59	<0.40
Sustainable level	Sustainable	Moderate sustainable	Less sustainable	Unsustainable

- The relationships between the personal characteristics of farmers and the adoption of agroecological-based practices were tested through the use of Pearson Chi-square test. The test was applied for nominal and ordinal variables with Pvalues of 2-sided Asymp.Sig. The correlation coefficient (r) shows the strength of relationships:

- /r/ < 0.2 (negligible relationship);
- 0.21 < /r/ ≤ 0.40 (weak relationship);
- 0.41 > /r/ ≤ 0.7 (moderate relationship);
- 0.71 < /r/ ≤ 0.9 (strong relationship);
- /r/ > 0.9 (very strong relationship).

4

Protected area management in Vietnam

4.1 Overview of protected areas in Vietnam

In Part 4.1, we provide an overview of the protected system in Vietnam: the establishment and classification, the involvement of state organizations in the management, and the cover of policies for conservation and development in protected areas. We use secondary data, documents and reports from the Portal of Socialist Republic of Vietnam Government, ministries and other state organizations.

4.1.1 The establishment and classification of protected areas in Vietnam

The establishment of a protected area system in Vietnam commenced 59 years ago to conserve the unique biodiversity values of the whole country. The first protected area of Vietnam named Cuc Phuong Prohibited Forest (currently Cuc Phuong National Park) which was established in 1962. General goals of the establishment of protected areas are defined in Decision 192/2003/QD-TTg of the Vietnamese Prime Minister since 2003 as: (1) to contribute to the protection of natural resources, biodiversity, and landscape in a sustainable development manner; (2) to raise awareness of people about the importance and values of natural resources as well as biodiversity and strengthen the participation of people in protecting protected areas; (3) to reform institutions and policies for the management of protected areas and enhance management capacities of local authorities and protected areas' management boards; (4) to strengthen the international cooperation.

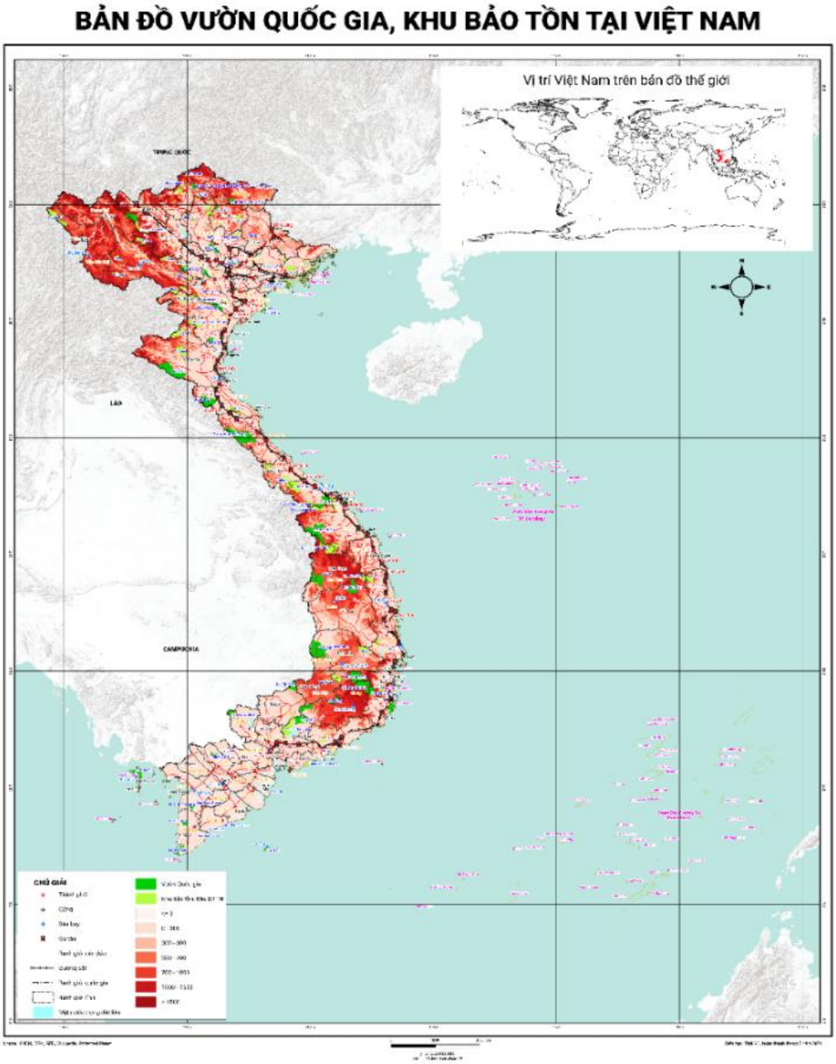


Figure 4.1: The map of National Park and Nature Reserves in Vietnam

(Source: Green Field Consulting and Development Ltd., 2021)

Most protected areas around Vietnam are designated as special-use forests. The first special-use forests originated in 1960. The expansion of special-use forests continues to cover the total number of 168 sites with 2,405,527 ha. The function of special-use forests is to preserve biodiversity as well as genetic resources and contribute to national socio-economic development. The special-use forests regulations are for preserving natural ecosystems, gene sources, scientific research, historical-cultural conservation areas, landscape or seascape, entertainment (except in strictly protected zones of forests) and, providing environmental services. According to the Law on Forestry 16/2017/QH14 issued in 2017 by the National Assembly, there are five types of protected areas that are regulated by special-use forests system, including (1) national parks; (2) nature reserves; (3) species or habitat management protected areas; (4) protected landscape or seascape (such as cultural/historical conservation forest) and; (5) experimental and scientific research areas e.g. forests for scientific research, national botanic garden (Table 4.1).

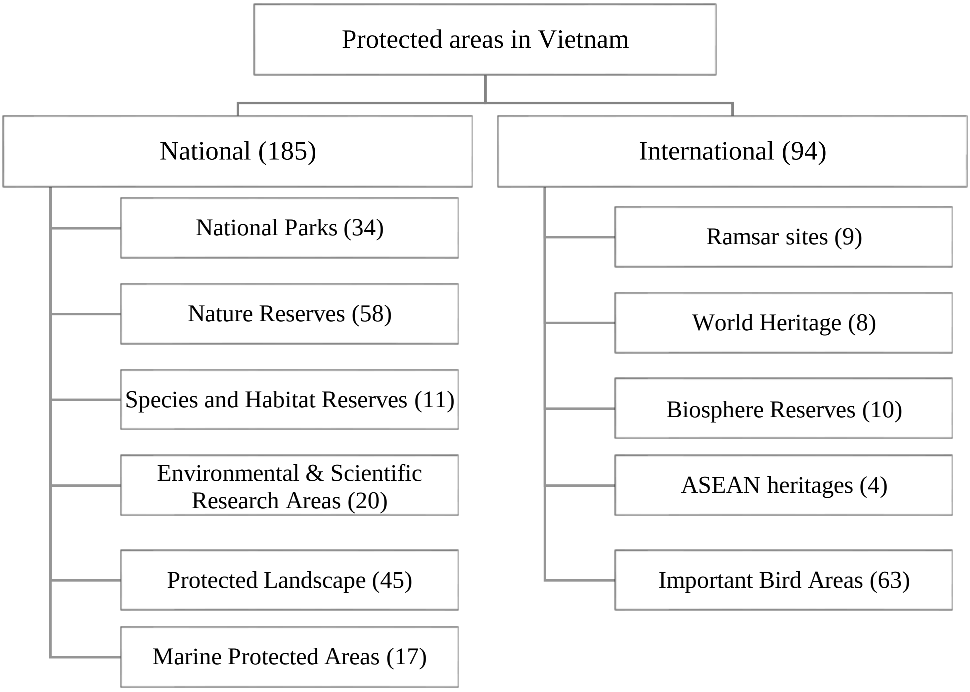
Table 4.1: Classification of protected areas in Vietnam

Categories	Total number	Total areas (ha)
1. National protected areas	185	-
1.1 Special-use forest	168	2,405,527
1.1.1 National parks	34	1,217,009
1.1.2 Conservation areas	69	
- Nature reserves	58	1,060,959
- Species and habitat reserves	11	38,777
1.1.3 Protected landscape	45	78,129
1.1.4 Experimental and scientific research areas	20	10,653
1.2 Marine protected areas	17	(included in special-use forests areas)
2. International protected areas	94	-
2.1 Wetlands of international importance (Ramsar site)	9	117,813
2.2 World Heritage Site by UNESCO	8	Not available
2.3 Biosphere Reserves by UNESCO	10	3.8 million ha
2.4 ASEAN heritages	4	Not available
2.5 Important Bird areas	63	1,689,900

(Source: Vietnam Association of National Park and Nature Reserve, 2021; Special-Used Forest Management Department, 2019; MoNRE, 2014)

Special-use forests are considered as important parts of the nature conservation of Vietnam, ensuring the protection of terrestrial forests, wetlands and marine areas for 50 years. The special-use forests system covers 2,405,527 ha (accounting for 7.4% of natural areas of the whole country) including 34 national parks; 58 nature reserves; 11 species and habitat conservation areas; 45 Landscape Protected Areas, and 20 Scientific and Experimental Forest Areas.

National Park and Nature Reserve are recognized as the most important sites covering up to 94% of the total area of the special-use forests in Vietnam. There are also 17 approved Marine Protected Areas, however, this system is overlapped by the special-use forests system.



Note: the numbers in the superscripts are numbers of protected areas

Figure 4.2: Classification of protected areas in Vietnam

(Source: Vietnam Association of National Park and Nature Reserve, 2021; Special-Used Forest Management Department, 2019; MoNRE, 2014)

There are 94 protected areas have been accorded international or regional importance including:

- Nine Ramsar sites (Xuan Thuy National park, Bau Sau in Cat Tien National Park, Ba Be National Park, Tram Chim National Park, Mui Ca Mau National Park, Con Dao National Park, U Minh Thuong National Park, Lang Sen Wetland National Park, Van Long Wetland);

- Ten Biosphere Reserve (Can Gio Mangrove Forest, Dong Nai, Cat Ba, Cat Tien, Red River Delta, Kien Giang, West Nghe An, Mui Ca Mau, Cu Lao Cham, Lang Biang);

- Eight World Heritage Sites (Ha Long bay, Phong Nha Ke Bang national park, My Son sanctuary, Ho Dynasty citadel, Trang An landscape complex, Hue citadel, Hoi An, Thang Long-Ha Noi); and

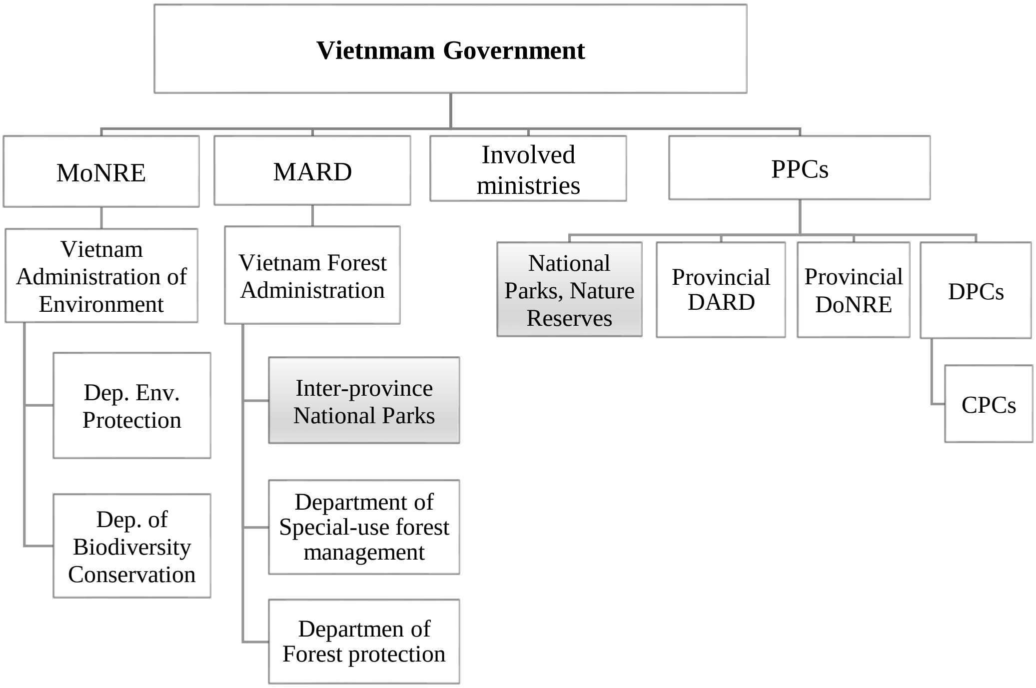
- Four ASEAN Heritage sites (Ba Be National Park, Kon Ka Kinh National Park, Chu Mon Ray National Park, Hoang Lien National Park, U Minh Thuong National Park).

4.1.2 State organizations responsible for protected areas in Vietnam

In this part, we describe the management mandates of national parks and nature reserves in Vietnam. Using the institutional management structure outlined in Figure 4.3, this part reviews the agencies which are in charge of national parks and nature reserves. There are two levels of administrative management involved in the system consisting of national and provincial. At the national level, the Vietnam Administration of Forestry (belongs to MARD) is responsible for managing six inter-provincial national parks, including Bach Ma, Cuc Phuong, Tam Dao, Ba Vi, Cat Tien, and Yok Don. At the provincial level, the PPCs are in charge of managing the remaining national parks, nature reserves and other forms of special-used forests.

National parks are ranked at the first conservative level by the Vietnamese government for protecting nature, including rare species, forest ecosystems, and genetic resources. National parks are defined as terrestrial or land on the sea which is not or almost not under the negative impacts of humans. National parks have rare and special animals and plants, national and international beautiful landscapes. The national parks have main objectives: (1) ecosystem protection; (2) scientific researching and; (3) ecotourism development (Decision 329 and 330 signed on 12th, May 2016 on forestry management regulations). According to Decree 156/2018/ND-CP approved in 2018, criteria of national parks are: (1) having at least one specific ecosystem at regional, national or international level, or at least one endemic living thing of Vietnam, or at least five rare and endangered plant or animal species; (2) having special values of scientific, educational aspects; having beautiful landscape for ecotourism and recreation; (3) have an area of above 7,000 ha in which forest covers at least 70%. Until 2017, Vietnam has a total of 30 national parks with 6 inter-province national parks (under the management of the Vietnam Forestry Administration – MARD) and 24 national parks (under the management of PPCs).

Nature reserves are ranked at the second conservative level following national parks. They have areas with typical ecosystems or high conservative animals or plants. The functions of the nature reserve are: (1) protecting and maintaining ecosystems, (2) Scientific research, education and environmental management, ecotourism development (Decision 329 and 330 signed on May 12th, 2016 about forestry management regulations). According to Decree 156/2018/ND-CP, nature reserves have the following criteria: (1) having natural ecosystem at national or international importance, or having at least five rare and endangered plant or animal species; (2) having special values of scientific, educational aspects; having beautiful landscape for ecotourism and recreation; (3) having an area of above 5,000 ha in which forest covers at least 90%.



Note: PPCs: Provincial People's Committees, DPCs: District People's Committees, CPCs: Communal People's Committees; Dep.: Department, Env.: Environment

Figure 4.3: State organization responsible for protected areas in Vietnam

(Source: Adapted from Vietnam Association of National Park and Nature Reserve, 2021)

There are several actors involved in the institutional management of the national parks and nature reserves (Figure 4.3). The central government issues and enforces legal normative documents, formulate and implement plans on biodiversity and conservation nationwide. Ministry of Agriculture and Rural Development (MARD) and the Ministry of Natural Resource and Environment (MoNRE) are two backbone specialized agencies working under the central government. MARD and MoRE are responsible for executing the management of forest, land, and other natural resources in the whole country as well as those in protected areas.

MARD has main roles in managing agriculture, forests, fishery, salt, rural development, irrigation, natural disaster prevention at the national level. MARD also regulates and implements a national master plan for Special-use forests and other protected areas. The national master plan is based on national socio-economic development and forest protection. That is defined in the Decision 192/2003/QD-TTg issued in 2003, Decree 117/2010/ND-CP issued in 2010 and Decree 15/2017/ND-CP issued in 2017. MARD has overall responsibility for reviewing budget allocation for these Protected areas. Vietnam Forestry Administration, a primary national focal organization, works to help MARD to manage forests and enforce related-legal documents of environmental protection and biodiversity conservation nationwide as well as manage six inter-provincial national parks (Tam Dao, Bach Ma, Cuc Phuong, Ba Vi, Cat Tien, and Yok Don) as assigned in the Decision 28/2017/QD-TTg issued in 2017 by the Prime Minister. Under Vietnam Forest Administration, the Department of Forest Protection is crucial because it disseminates regulations on forest protection and development, ensures enforcement at the local level. It also organizes communes on forest protection and development.

MoNRE is tasked with managing land, water resources, mineral resources, environment, climate change, and biodiversity as defined in the Biodiversity Law issued in 2008, Decree 36/2017/TT-CP, and Decision 192/2003/QD-TTg issued in 2003. MoNRE also coordinates the implementation of the national Biodiversity Action Plan. Under MoNRE, Vietnam Environment Administration helps MoNRE to enforce Environmental law and Biodiversity law to protect the environment as well as conserve natural resources as issued in the decision 15/2018/QD-TTg issued in 2018 by the Prime Minister.

The involvement of other supporting ministries is also important for protected area management. The Ministry of Planning and Investment is responsible for allocating budget and coordinating funds, investments and other subsidies for protected areas with sectoral ministries and provinces. The Ministry of Finance is responsible for financing environmental protection, biodiversity conservation for protected areas. Ministry of Science and Technology develops scientific research programs to protect natural resources and biodiversity. Ministry of Education and Training works for implementing environmental education programs in schools. Ministry of Culture, Sport and Tourism have a role in developing tourism in the whole country as well as in national parks and cultural-historical-environmental sites.

At the provincial level, PPCs are administrative organizations with roles in ensuring adherence to the constitution, national laws at the provincial level. They are also tasked with finding and implementing socio-economic development plans. According to the Decision 192/2003/QD-TTgissued in 2003 and Decision 186/2006/QD-TTg issued in 2006 of the Prime Minister, PPCs have roles in implementing strategies on environmental protection at the provincial level including that of protected areas located entirely within one province. Department of Agriculture and Rural Development (DARD) and Department of Natural Resource and Environment (DoNRE) are two specialized departments working under the administration of PPCs and reporting to PPCs. DARD and DoNRE receive technical guidance from MARD and MoNRE. Through the professional works of DARD and DoNRE, PPCs manage National parks and Nature reserves. DARD and DoNRE are responsible for disseminating laws to communes, consulting resource users, and enforcing laws on natural environmental protection at the local level.

At the district level, District People's Committees (DPCs) support programs of socio-economic development, biodiversity conservation and raise awareness of people at the local level. Currently, DPCs do not participate much in the environmental management of protected areas.

At the communal level, The Communal People's Committees (CPCs) are the lowest hierarchical level of administration. The commune usually consists of several villages. CPC may allocate use rights to buffer communities and designate them to manage forests together with protected area management boards. CPCs manage the socio-economic development of buffer zones.

Management boards of protected areas are administrative organizations. They are in charge of applying laws on natural environmental protection and biodiversity conservation within protected areas. As approved in the Decree 117/2010/ND-CP, the boards are funded from diverse sources to cover basic running costs and conservative programs: (1) public sources (central and provincial government), (2) individuals and organizations from national and international, (3) own funds through provision of tourism activities and forest environmental services (e.g. clean water, eco-tourism, hydropower plants) for stakeholders (e.g. enterprises, tourists, etc.). As approved in the Decision 186/2006/QD-TTg, protected area management boards also have roles in organizing the participation of buffer communities in forest protection, conservation, wise utilization of natural resources, and environmental service provision. Decision 156/2018/ND-CP of the Vietnamese Government assigns the protected area management boards to organize and cooperate with local authorities and communities to develop programs and projects for buffer zones. However, evidence from Le et al. (2018) reveals that the collaboration between protected area management boards with buffer zones for socioeconomic development is moderate (only 40% of the managers reported). The researchers also emphasize the protected area management boards face limited institutional capacity and a lack of enforcement authority for the buffer zones.

4.1.3 Policies for protected areas in Vietnam

This part reviews publicly available national-level laws and other related legal:

Since the 1960s, to prevent biodiversity degradation and environmental pollution, the Vietnamese government has issued and reformed a range of laws and policies.

Currently, the country has plentiful instruments for managing and monitoring activities of protected areas and the buffer zones including laws, decrees, circulars, decisions, etc.

The National Assembly, the highest legislative organization, issues Law on Environmental protection 55/2014/QH13, Law on Biodiversity 20/2008/QH12, Law on Forestry 16/2017/QH14, Law on Fishery 18/2017-QH14.

MARD, MoNRE, and provincial government organizations issue lower legal documents to instruct the application of the laws promulgated by the National Assembly.

Table 4.2 depicts predominant policies and legislation that is a foundation for the management and conservation of protected areas.

Table 4.2: Cover of policies for protected area management toward environmental protection and agricultural production

Policies	Environmental protection and conservation	Agriculture production/buffer zone development
1. Biodiversity law 20/2008/QH12 issued in 2008, Decree 65/2010/ND-CP, Decision 1250/2013/QD-TTg	+	+
2. Environmental protection law 55/2014/QH13 and Decree 19/2015/ND-CP	+	+
3. Forestry law 16/2017/QH14 and Decree 156/2018/ND-CP: Guidelines of implementation articles of Forestry law	+	+

4. Decree 99/2010/ND-CP: Policies on payment of forest environmental services and amended Decree 147/2016/ND-CP	+	-
5. Fishery law 18/2017-QH14 & Decree 26/2019/ND-CP: Guidelines of implementation articles of Fishery law	+	+
6. Decision 24/2012/QD-TTg: Policies of investment and development of Special-use forest in 2011-2020	+	+
7. Decision 218/2014/QD-TTG: Management strategy on Special-use forests to 2020, with a vision to 2030	+	-
8. Decree 117/2010/ND-CP: Organization and management of Special-use forests and Circular 78/2011/TT-BNNPTNT	+	+

Note: (+): yes; (-): no

(Source: Socialist Republic of Vietnam Government Portal, 2020; MoNRE, 2014)

✓ Environmental protection law 55/2014/QH13 and Decree 19/2015/ND-CP: Guidelines for implementing articles of Environmental protection law:

The law and decree are fundamental to overcome environmental pollution in Vietnam. They focus on environmental protection activities; measures and resources used for environmental protection; duties and obligations of agencies, organizations, households, and individuals in Vietnam. The Law mentions that "environmental protection" refers to the environmental conservation, the prevention and control of harmful impacts on the environment; the mitigation of pollution and degradation for the environment.

The Law defines principles of environmental protection in Vietnam, including: (1) environmental protection must reconcile with the economic growth and social security; (2) environmental protection must assure the proper use of natural resources and minimize waste substances; (3) environmental protection must comply with the existing cultural-social-economic development of Vietnam; (4) environmental protection activities must be conducted in a regular and concentrate on the prevention and control of environmental pollution, emergencies and degradation; (7) people who uses and receive benefits from the environment must contribute finance to promote environmental protection; (7) people who cause environmental pollution and degradation must pay damages.

The Law stipulates several obligation of individuals and organization for environmental protection in crop cultivation: (1) people who produce, imports, sells or uses pesticides and veterinary medicines must follow its regulations; (2) users must treat fertilizers, veterinary medicines and containers in accordance with waste management regulations; (3) livestock zones must ensure environmental hygienic for residential areas; collect, treat wastewater and solid wastes in accordance with waste management regulations; frequently clean farms, cages to prevent diseases; deal with dead animals in accordance with hygiene regulations.

The Law stipulates several obligations of individuals and organizations for environmental protection in aquaculture cultivation: (1) follow the regulations on the treatment of waste, drugs, medicines, sludge, and un-eaten food; (2) remedy the environment after quitting aquaculture raising; (3) ensure environmental hygiene condition and prevention of aquatic disease together with no harmful chemicals; (4) do not raise aquaculture on an alluvial ground that is forming an estuary; (5) do not destroy mangroves for aquaculture farming.

✓ Biodiversity law 20/2008/QH12 issued in 2008 (with the amended Biodiversity law 32/2018/VBHN-VPQH), Decree 65/2010/ND-CP: Guidelines for implementing articles of Biodiversity law, Decision 1250/2013/QD-TTg: Strategy for managing the biodiversity to 2020, with a vision toward 2030:

The Law focuses on biodiversity conservation and sustainable development for organizations, households and individuals in Vietnam.

The Law defines the importance of the conservation and sustainable development of protected areas including national parks; nature reserves; species/habitat conservation areas; and landscape conservation areas. The Law also prohibits harmful activities for protected areas including (1) hunting, fishing and exploiting wild species in a strictly protected zone of protected areas; encroaching on land, destroying the landscape, deteriorating ecosystems and rearing or planting invasive species; (2) building infrastructures or houses in strictly protected zones of protected areas; building houses in ecological restoration zones of protected areas; (3) raising livestock and aquaculture in large scale in strictly protected zones and ecological restoration zones of protected areas; (4) hunting, fishing, exploiting, illegally killing, consuming, transporting, purchasing and selling rare and endangered species; (5) rearing or growing endangered and rare species of wild fauna and flora; (6) importing or releasing genetically modified organisms; (7) importing and developing invasive alien species; (8) changing land use purposes in protected areas.

The Law also defines responsibilities of management boards protected areas: (1) conserving biodiversity; (2) planning programs and projects to rehabilitate natural ecosystems in national parks and nature reserves; (3) managing research activities and data gathering, building a database of biodiversity status of national parks and nature reserves; (4) developing ecotourism and other services in protected areas; (5) collaborating with rangers of the forest, environmental police, fire protection forces, and local authorities to conserve biodiversity in protected areas. The management of the protected area buffer zone is also mentioned: projects and programs in buffer zones are carried out along with environmental impact assessment reports. The reports are approved by a council with representatives of protected area managers.

✓ Forestry law 16/2017/QH14 and Decree 156/2018/ND-CP: Guidelines of implementation articles of Forestry law, Decree 99/2010/ND-CP: Policies on payment of forest environmental services and its amended Decree 147/2016/ND-CP:

The law defines the roles of different zones in protected areas. A buffer zone of national parks and nature reserves are forests, land or water surface situate adjacently borders of their core zone. The function of the buffer zone is resisting or minimizing negative impacts on the core zone. Strictly protected zones of national parks and nature reserves are areas for intact protection including (1) maintaining natural structure; (2) ensuring natural growth of the forest. The ecological rehabilitation zone of national parks and nature reserves are zones that are under management and protection for rehabilitating natural ecosystems through replanting local plant species. Service and administration zone of national parks and nature reserves are areas used for managerial activities of national parks and nature reserves management boards, research places, service places, and other infrastructure.

The Law also mentions the development of livelihood of communities inside and surrounding protected areas: (1) prohibiting migrating from outer place to the core zones; (2) protected area managers sign contracts with local communities to protect and develop forests; (3) management boards of protected areas have responsibility for building programs or projects to invest and develop social-economic conditions of the buffer zones with participatory of local communities and authorities; (5) local communities of buffer zones can supervise, participate and co-managing programs and projects of buffer zones

The Law determines that users of forest environmental services (aquaculture farmers, hydropower plant enterprises, etc.) have to pay fees for the providers (forest owners, organizations, households, and communities). The Law also classify five types of forest environmental services including (1) soil protection, erosion prevention, sediment of rivers/lakes/streams; (2) water management for social life and production; (3) conservation of landscapes and biodiversity for eco-tourism development; (4) provision of forest carbon sequestration and retention, reduction of greenhouse gas emissions by measures of preventing forest degeneration and developing forests in a sustainable manner; (5) provision of spawning grounds, feed and natural seeds, and water for aquaculture farming.

✓ Fishery law 18/2017-QH14 and Decree 26/2019/ND-CP: Guidelines of implementation articles of Fishery law:

The law focus on major viewpoints: protection and development and aquatic resources (including those in protected areas), environmental monitoring in aquaculture farming, and fishing. The Law prohibits people (individuals, households, organizations, agencies in Vietnam) from: (1): destroying aquatic resources; (2) restraining natural migration of aquatic species; (3) exploiting and raising aquaculture in the strictly protected zone and rehabilitation zone of protected areas; (4) releasing aquaculture tools in the natural water bodies; (5) use antibiotics, probiotics, veterinary drugs and other pesticides which do not belong the list of Vietnam. Local communities and authorities participate in co-management to protect aquatic resources. The Law stipulates that management boards of special-used forests have to protect and conserve marine resources and ecosystems of Special-use forests through works of aquatic staff.

✓ Decision 24/2012/QD-TTg: Policies of investment and development of Special-use forests in the period 2011-2020:

The central government encourages protected area management boards to develop eco-tourism tours inside Special-use forests. The government allows the management boards to lease Special-use forests for eco-tourism and scientific research purposes. The profits from these activities are distributed to support salary for the staff of Special-use forests, invest in buffer zones of Special-use forests, invest in eco-tourism activities. The Decision 24/2012-QD-TTg decides each village located in protected area buffer zones of Special-use forests receives 40 million VND (about nearly 2,000 USD) annually from the state budget for participating in co-management of forests. The subsidies are divided into two categories: (1) capacity building (farmers, agricultural extension, forestry extension, seed, livestock, equipment); (2) public infrastructure construction in buffer zones (water, electricity, information systems, road, public housing, etc.). Management boards of Special-use forests are mainly responsible for managing the subsidies and cooperating with CPCs to decide which village is invested.

✓ Decision 218/2014/QD-TTg: Approving management strategy on Special-use forests, marine Protected areas, internal water reserves of Vietnam through 2020 and vision toward 2030:

The Decision determines the targets by 2020: the area of Special-use forests, marine protected areas and internal water reserves of Vietnam cover 9% of the total land area and 0.24% of the total sea area. New management methods including co-management and benefit-sharing along with capacity building programs are used to control, conserve and develop the fauna and flora of these protected areas.

✓ Decree 117/2010/ND-CP: Organization and management of Special-use forests system and Circular 78/2011/TT-BNNPTNT: Guidelines of implementation articles of Decree 117.

The Decree and Circular demonstrate the national master plan on the Special-use forests system and determine the roles of protected area buffer zones as preventing and minimizing the invasion of outsiders to protected areas at the same time improve livelihoods and develop sustainable social-economic conditions for local communities. The Decree assigned responsibilities for stakeholders in protected area buffer zone management. Management boards of protected areas cooperate with PPCs, DPCs and CPCs to attract communities to participate in protecting the environment of protected areas as well as in conservation projects of buff zones. The projects focus on the theme of (1) forest protection, ecosystem and biodiversity conservation; (2) agriculture/aquaculture/forestry development; (3) benefit-sharing of Special-use forests' resources; (4) awareness raising toward environmental protection and policies; (5) infrastructure development for a buffer zone to reduce pressures on Special-use forests. PPCs assign DPCs and CPCs to (1) propagate buffer communities to prevent the invasion into the protected areas; (2) manage and use natural resources following laws and plans; (3) cooperate with Special-use forests management boards to implement projects for buffer zone development.

4.2 Five cases of protected areas in Vietnam

In Part 4.2, we analyze the characteristics of five protected areas that belong to the special-use forest system and locate in Northern Vietnam to provide several comparisons between the sites: Tam Dao National Park (under the management of the Vietnam Administration of Forestry - MARD) and Xuan Thuy National Park, Bai Tu Long National Park, Cat Ba National Park and, Tien Hai Nature

Reserve (under the management of PPCs). The data and information are mainly from in-depth interviews with protected area managers. Besides, we use some statistics and documents from PPCs, DPCs, CPCs, and Statistical offices. This part provides some comparison among the five cases regarding geographical features - administrative structure - workforce - development and conservation activities - effectiveness of management boards - agricultural issues in protected area buffer zones.

4.2.1 Profile information

Xuan Thuy National Park is established in Decision 01/2003-QD-TTg by the Vietnamese Prime Minister in 2003. Currently, the park is under the administrative management of Nam Dinh PPC.

Bai Tu Long National Park is established in Decision 85/2001/QD-TTg by the Vietnamese Prime Minister in 2001. The park is under the administrative management of Quang Ninh PPC. Bai Tu Long National Park has other designations as a marine protected area.

Cat Ba National Park is established in Decision 79/1986/QD-CP by the central government in 1986. The park is under the administrative management of Hai Phong PPC. Cat Ba National Park has other designation as a marine protected area and United National Education, Scientific and Cultural Organization.

Tam Dao National Park is established in Decision 601/NN-TCCB in 1996. The park is under the administrative management of the Vietnam Administration of Forestry (MARD).

Tien Hai Nature Reserve is established in Decision 2159/2014-QD-UBND by Thai Binh PPC in 2014. The park is under the administrative management of Thai Binh PPC.

Table 4.3: General information of surveyed protected areas

Protected areas	**Year of establishment**	**Area (ha)**		**Administrative management organization**
		Protected area	Buffer zone	
1. National Park				
Xuan Thuy	2003	7,100.00	8,000.00	Nam Dinh PPC
Bai Tu Long	2001	15,283.00	16,743.00	Quang Ninh PPC
Cat Ba	1986	17,362.96	14,178.46	Hai Phong PPC
Tam Dao	1996	34,995.00	15,515.00	Vietnam Administration of Forestry
2. Nature Reserve				
Tien Hai	2014	12,500.00	1,700.00	Thai Binh PPC

(Source: Interview with protected areas management boards, 2018)

4.2.2 Geographical features

- ***Xuan Thuy National Park***

Xuan Thuy National Park extends from 20°10’ to 20°15’ North latitude and 106°20’ to 106°32’ East longitude within Giao Thuy district, Nam Dinh province. It locates on the Ba Lat estuary of the Red River delta. The park provides a wetland ecosystem for about 40,000 migratory birds from other countries yearly. For Vietnam, it provides food and a nursery for diverse aquatic habitats. Moreover, the site contributes to shoreline protection, erosion prevention for coastal zones.

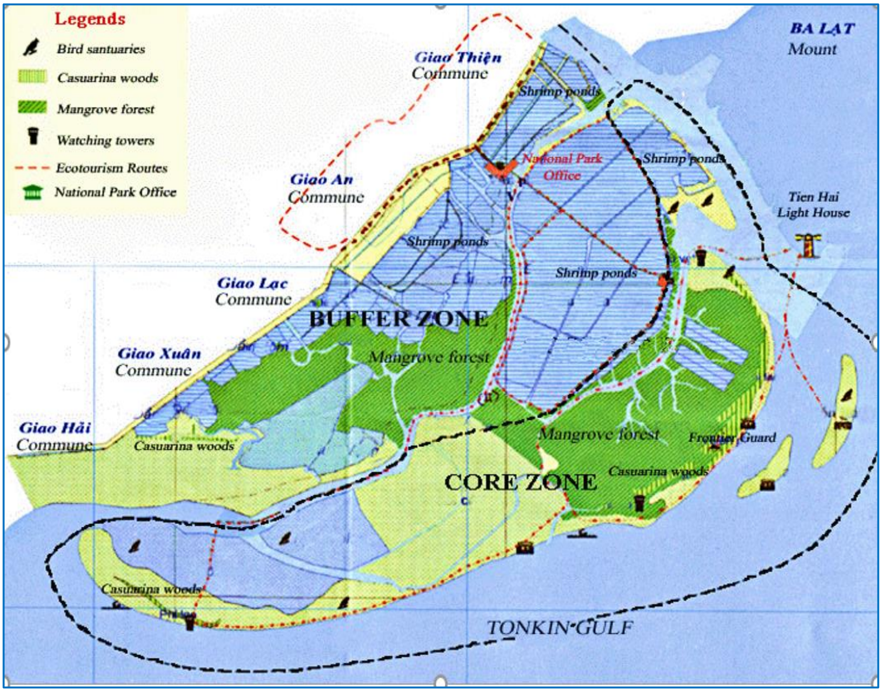


Figure 4.4: Map of Xuan Thuy National Park
(Source: Xuan Thuy National Park Management Board, 2018)

The core zone of Xuan Thuy National Park covers 7,100 ha including two areas of terrestrial land in low tides (3,100 ha) and wetland (4,000 ha). The park has six ecosystem typologies, including tidal wetland with mangroves, tidal wetland without mangroves, aquaculture-mangrove farming, sandy coastal line, tidal rivers, and estuary (Table 4.4).

Table 4.4: Ecological typologies in Xuan Thuy National Park

Ecological typologies	**Area (ha)**
1. Wetland with mangrove	868
2. Wetland without mangrove	1,472
3. Combined aquaculture and mangroves	138
4. Sandy coast	986
5. Tidal rivers	499
6. Estuary	3,137
Total	**7.100**

(Source: Xuan Thuy National Park Management Board, 2018)

The mangrove forest is an important ecosystem in this site. There are two types of mangroves consisting of natural and planted. The natural mangrove forest has higher biodiversity values (Hai, 2015). It ranges between eight to ten meters in height. They are three canopies and seven species of mangrove in this area. The planted mangroves include two species that are of lower stature at five meters. Mangroves also play crucial functions in the park as providing living conditions for habitats and other wetland species, especially for migratory birds. The buffer zone covers 8,000 ha including Ngan islet (the boundary runs from the lagoon dike to the Vop river), Bai Trong and five communes (Giao Thien, Giao An, Giao Lac, Giao Xuan, and Giao Hai).

- ***Bai Tu Long National Park***

Bai Tu Long National Park extends from 20°55’ to 21°15’ North latitude and from 107°30’ to 107°46’ East longitude with two ecological types compromising forest and marine ecosystems. The park has a size of 15.783 ha including marine area (9,658ha), strictly protected zone (3,025 ha), ecological rehabilitation zone (1,726 ha) and, administrative and service zone (1,374 ha). According to decision number 3559/2018/QD-UBND of Quang Ninh PPC, the total area of Bai Tu Long National Park is reduced 500 ha. Currently, the total area of the core zone is 15,283 ha, in which islands cover 5,702.26 ha and the sea covers 9,580.74 ha. The islands are distributed into three zones: strictly protection zone (3,464.35 ha), ecological rehabilitation zone (1,964.2 ha) and administrative and service zone (273.71 ha).

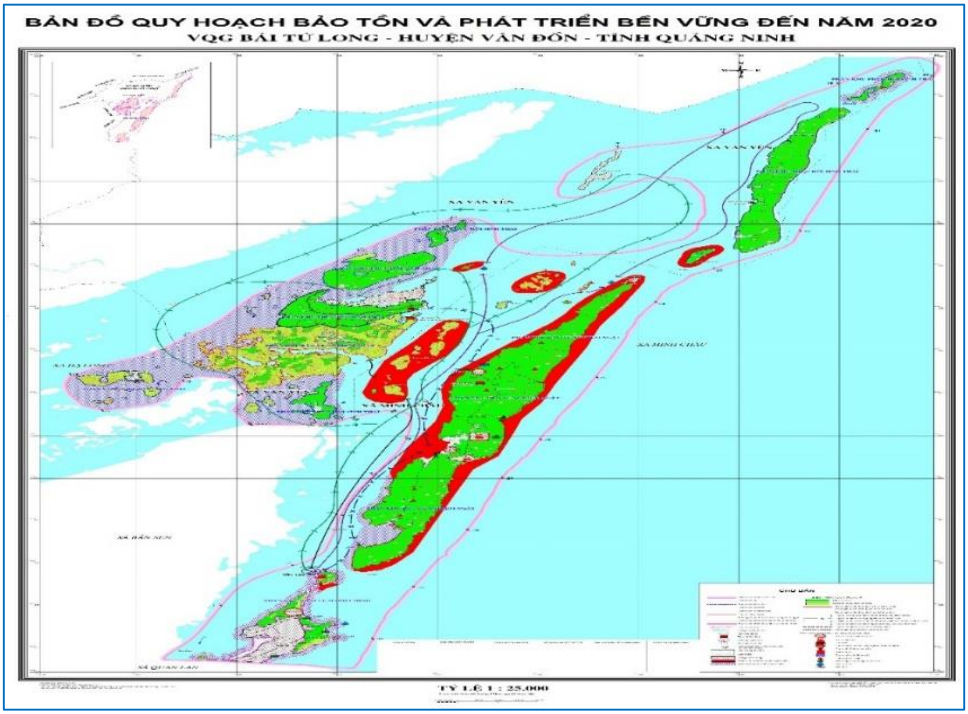


Figure 4.5: Map of Bai Tu Long National Park
(Source: Bai Tu Long National Park Management Board, 2018)

Table 4.5: Ecological typologies of Bai Tu Long National Park

Types	Strictly protected zone (ha)	Ecological rehabilitation zone (ha)	Administrative and service zone (ha)	Total (ha)
1. Island	3,464.35	1,964.20	273.71	5,702.26
In which:				
- Land with forest	2,398.94	1,644.44	151.81	4,195.19
- Land without forest	959.16	269.31	36.37	1,264.84
- Others	106.25	50.45	85.53	242.23
2. Sea	-	-	-	9,580.74
Total	**-**	**-**	**-**	**15,283.00**

(Source: Interview with Bai Tu Long National Park management board, 2018)

Five communes are living inside and adjacent the Bai Tu Long National Park. Three of the communes of Ha Long, Van Yen, and Minh Chau are inner buffer zone because they locate in the core zone. Two other communes including

Quan Lan and Ban Sen are outer buffer zone because they locate outside the core zone. The total area of the buffer zone is 16,743 hectares of forestry belonging to five communes as defined in Decision 3559/QD-UBND of Quang Ninh PPC in September 2018. In which, the inner buffer zone is 500 ha with residential land and forest. The outer buffer zone is 16,243 ha with residential land, agricultural land, and other infrastructure areas.

- ***Cat Ba National Park***

Cat Ba National Park extends from 20°48’35’’ to 20°49’48’’ North latitude and from 106°57’42’’ to 107°54’46’’ East longitude. The core zone covers 17,362.96 ha including terrestrial area and marine area (Decision number 2501/QD-UBND) of Hai Phong PPC in November 2014.

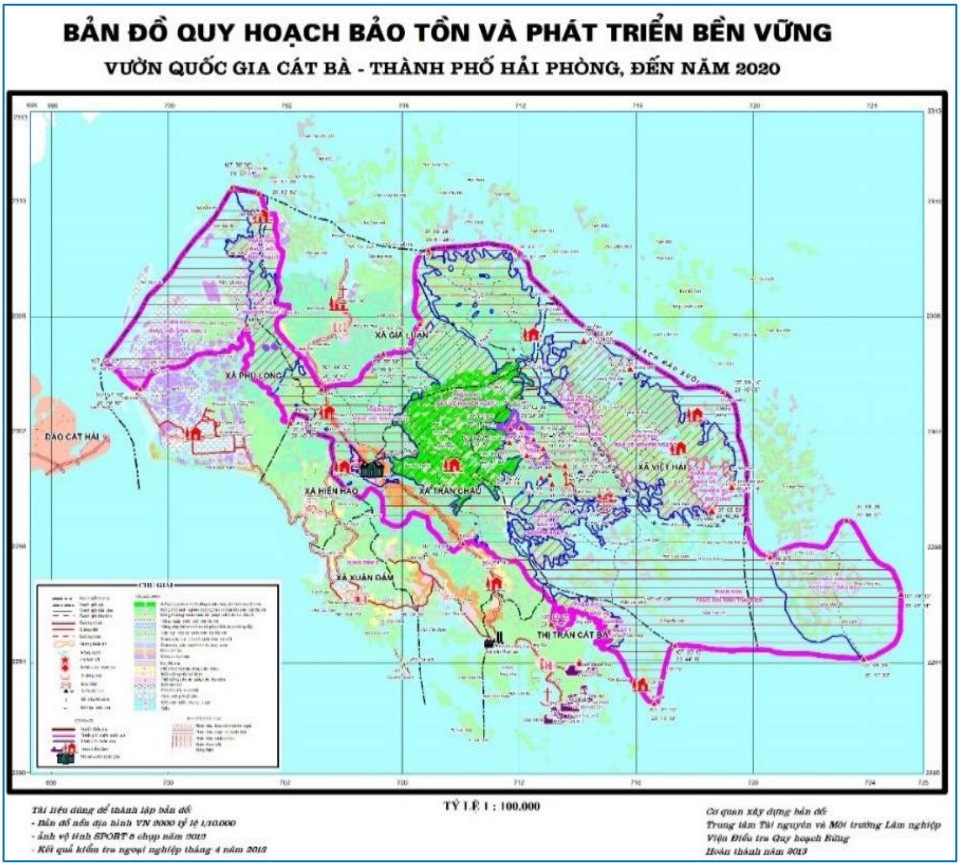


Figure 4.6: Map of Cat Ba National Park

(Source: Cat Ba National Park Management Board, 2018)

The Cat Ba National Park is distributed into three zones including strictly protection division (5,110.64 ha), ecological rehabilitation division (12,146.42 ha), and administrative and service division (105.90 ha) (Table 4.6). According to ecologists, Cat Ba National Park has 17 ecological typologies, in which sea cover the largest area (6,450.45 ha), followed by Secondary forest on the lime-stone mountain (3,396.74 ha), Bush and trees on lime-stone mountains (3,216.90 ha), etc.

Table 4.6: Ecological typology of Cat Ba National Park

According to the management division	**Area (ha)**
1. Strictly protected division	5,110.64
2. Ecological rehabilitation division	12,146.42
3. Administrative and service division	105.90
Sub-total	17,362.96
According to ecological typologies	**Area (ha)**
1. Bush, trees on limestone mountains	3,216.90
2. Bare mountains	1,619.80
3. Aquaculture	455.96
4. Coastal mudflat	237.86
5. Residential land	6.69
6. Submerged land areas	323.69
7. Permanent agricultural high-land area	0.00
8. Agricultural land (rice, short-term crops)	0.05
9. Fruit trees	57.31
10. Mangroves	258.88
11. Forest on a lime-stone mountain	1,030.18
12. Secondary bamboo forest (recovering after agricultural production)	30.39
13. Rehabilitation forest on the limestone mountain	8.08
14. Secondary forest on a limestone mountain	3,396.74
15. Plantation forest	208.32
16. Bare land (vacant land)	61.66
17. Sea	6,450.45
Total	**17,362.96**

(Source: Interview with Cat Ba National Park Management Board, 2018)

The buffer zone of Cat Ba National Park has a total area of 14,178.46 ha (Table 4.7). There are six communes and one town living both inside and adjacent to the park. Viet Hai, Gia Luan are two buffer communes that belong to the inner buffer zone because they locate inside the park. The inner buffer zone covers

155.05 ha. The remaining communes and towns (Phu Long, Gia Luan, Tran Chau, Hien Hao, Xuan Dam, Cat Ba town) are the outer buffer zone because they situate surrounding the park. The outer buffer zone has a total area of 14,023.40 ha. The agricultural and aquaculture in buffer zones cover moderate areas as compared with other areas.

Table 4.7: Land area of Cat Ba National Park's buffer zone

Buffer zone	Area (ha)
1. Inner buffer zone	**155.06**
1.1. Viet Hai commune	**145.55**
Bush, trees on limestone mountains	3.62
Bare mountains	12.78
Residential land	5.87
Agricultural land (rice, short-term crops)	96.23
Fruit trees	5.53
Mangrove	0.67
Plantation forest	20.85
1.2. Gia Luan commune	**9.51**
Agricultural land	4.2
Fruit trees and perennial crops	5.31
2. Outer buffer zone	**14,023.40**
Bush, trees on limestone mountains	4,919.50
Bare mountains	892,23
Aquaculture	519,18
Coastal mudflat	287,40
Residential land	147,32
Submerged land areas	241,80
Permanent agricultural high-land area	45,96
Agricultural land (rice, short-term crops)	266,96
Fruit trees	134,77
Mangroves	376,64
Secondary bamboo forest (recovering after agricultural production)	0,02
Secondary forest on limestones	1,416.34
Plantation forest	159,02
Bare land (vacant land)	430,87
Sea	4,185.39
Total	**14,178.46**

(Source: Interview with Cat Ba National Park Management Board, 2018)

- ***Tam Dao National Park***

Tam Dao National Park encircles the Tam Dao mountain range with 20 peaks and Tam Dao National Park is the highest at 1,592 meters above sea level. Tam Dao National Park extends from 21°21’ to 21°42’’ North latitude and from 105°23’ to 105°44’ East longitude. According to Decision number 1520/QD-BNN-TCLN of MARD, the park covers total of 32,877.3 ha as illustrated in detail in Table 4.8. According to administrative management, Tam Dao National Park has three zones: (1) strictly protected division (15,653.7 ha) to prohibit people from collecting timber, firewood and other forest product, illegal hunting animals and grazing, building huge roads and other infrastructure; (2) ecological rehabilitation division (14,594.4 ha) to replant the destroyed forest area to rehabilitate forest ecosystems and reduce human impacts on strictly protected division, enhance environment and water resources protection; and (3) service and administration division (2,628.2 ha) to develop eco-tourism following minimizing negative impacts to the environment. The buffer zone is 51,572 hectares in 23 communes locating along 5 districts of three provinces including Vinh Phuc, Thai Nguyen, and Tuyen Quang.

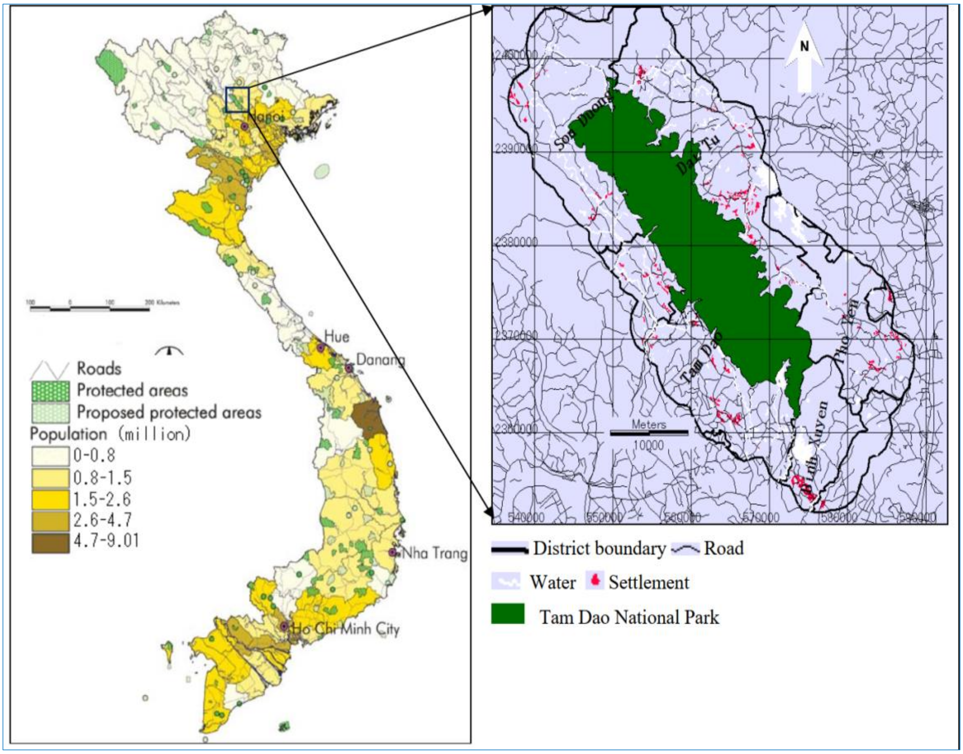


Figure 4.7: Map of Tam Dao National Park

(Source: Tam Dao National Park Management Board, 2018)

Table 4.8: Land area of Tam Dao National Park

Zones	**Area (ha)**
1. According to provinces	
- Vinh Phuc	15,207.7
- Thai Nguyen	11,446.6
- Tuyen Quang	6,160.0
2. According to management purposes	
- Strictly protected division	15,653.7
- Ecological rehabilitation division	14,594.4
- Service and administration division	2,628.2
3. According to ecological typologies	
- Forestry	32,753.1
- Others	124.2
Total	**32,877.3**

(Source: Tam Dao National Park Management Board, survey in 2018)

Table 4.9: Land area of Tam Dao National Park's buffer zone

Land area	**Area (ha)**
- Vinh Phuc (Binh Xuyen and Tam Dao district)	17,389
- Thai Nguyen (Dai Tu and Pho Yen district)	24,875
- Tuyen Quang (Son Duong district)	9,308
Total	**51,572**

(Source: Tam Dao National Park Management Board, survey in 2018)

- ***Tien Hai Nature Reserve***

Tien Hai Nature Reserve extends from 20^{0}24'14'' to 20^{0}22' North latitude and from 10^{0}60'31'' to 10^{0}60'37'' East latitude. According to Decision number 2159 of Nam Dinh PPC on September 26th,2014, the Tien Hai Nature Reserve covers 12,500 ha, in which a strictly protected zone is 9,000 and 3,500 ha of ecological rehabilitation zone. The buffer zone is the area of 1,700 ha of three communes including Nam Hung, Nam Phu, and Nam Thinh.

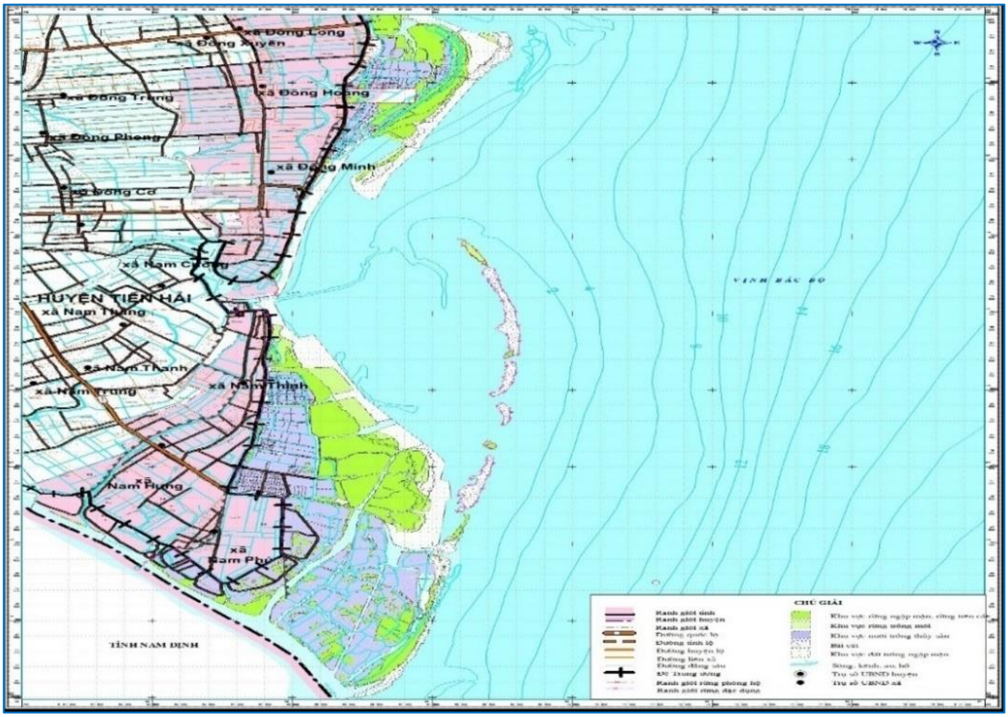


Figure 4.8: Map of Tien Hai Nature Reserve

(Source: Tien Hai Nature Reserve management board, 2018)

4.2.3 Flora and fauna

- ***Xuan Thuy National Park***

The flora is not as diverse as tropical humid forests in mountainous areas, and there are only 2 plant divisions represented, namely ferns (Pteridophyta) and flowering plants (Angiospermae). Nevertheless, the number of families and genera is much more varied than the number of species. Xuan Thuy National Park is home to 116 plant species in 42 families and 99 genera. Some dominant plant families are the dicotyledonous flowering plants (Ancanthaceae), including the marine coastal species (Acanthus ebracteatus) which are predominantly found in the lower level of the mangrove forests; The fauna is characterized by its delta and coastal wetlands fauna with an abundance of fish, water birds, and migratory birds, while mammals, reptiles and amphibians are not as rich in terms of composition and number of species. There are 9 species of mammals, 215 species of birds, 28 species of reptiles and amphibians, 107 species of fish and 138 species of benthos belonging to 39 families in 4 orders (polychaetes, crusta-ceans, gastropods, and bivalvias). Among these species,11 species are listed in the Vietnam Red Book and 21 species are listed in the World Red Data Book.

Annually around 150 species of water birds and migratory birds fly to Xuan Thuy National Park, attracted by the food source of amphibians, reptiles, fish and benthos.

- ***Bai Tu Long National Park***

By December 2012, there are 2,286 species of terrestrial and marine fauna and flora were recorded, of which 75 terrestrials and 33 marine species are listed in the Vietnam and World Red Books. There has been a significant decline in flora and fauna in Bai Tu Long National Park. There are 780 terrestrial flora species in 468 genera and 135 families in 5 tracheophyta divisions, of which, magnoliophyta accounts for the majority with 729 species. There are 1,243 marine species in Bai Tu Long National Park area.

- ***Cat Ba National Park***

Cat Ba National Park is home to 343 species of vertebrates, including 58 species of mammals, 205 species of birds, 55 species of reptiles and 25 species of amphibians.34 of these species are considered rare and are listed in the Vietnam Red Data Book and Decree No.32 CP/2006. Most importantly, Cat Ba National Park is home to the Cat Ba Langur (Trachypithecuspoliocephalus), which is endemic to Vietnam.

Cat Ba National Park is home to 1,588 species of plants in 850 genera,187 families and 5 divisions, including 245 species of popular agricultural plants and forest plants. The dominant plant division in Cat Ba is Magnolia with 1,494 species. The floraof the park comprises 81 rare and endangered species that are listed in the Vietnam Red Data Book, World Red Data list and Decree No.32/2006/ND-CP.

Many marine flora and fauna species have been recorded including 31 plants species of mangrove, 400 species of phytoplankton and phytobenthos, 43 species of seaweed,177 species of coral, 131 species of zooplankton, 340 species of zoobenthic, 120 species of mollusks and 124 species of fish,19 species of coral, 3 species of sea turtle, and 1species of marine mammal have been classified as rare and precious species.

- ***Tam Dao National Park***

Tam Dao National Park mountain range is covered by primary forest. There are two main forest types including tropical humid evergreen forest and subtropical humid evergreen low mountain forest. Tam Dao National Park’s flora consists of 1,247 species of 645 genera, 169 plant families, distributed across 5 divisions of vascular plants. There are 85 plant species found in Tam Dao National Park area that are rare and endangered. The fauna of the park is also extremely rich and diverse, with 1,299 species, including 93 species of mammals, 332 species of birds,136 species of reptiles and 62 species of amphibians. 651 insect species and 25fish species have that in Tam Dao National Park. Of these species, 11 are endemic to Tam Dao National Park including two reptiles, one amphibian, and 8 insect species. The endemic amphibian species is the Tam Dao salamander fish (Paramesotritondeloustali). The rare and endemic animals of Tam Dao National Park have distinct features.

- ***Tien Hai Nature Reserve***

Tien Hai Nature Reserve has 215 species of birds including 160 migratory birds and about 55 water-birds. There are seven species of birds that belong to the Red Book (grey pelican, spotted greenshank, and Asian dowitcher). The fauna has 113 insect species, 107 fish species, and 37 amphibian and reptile species. The flora has 100 plant species, in which 43 species are used for medicines.

4.2.4 Administrative structure and workforce

This part introduces the organization charts of protected area management boards. The management boards have legal entities with their own seals and accounts. The director of the management board is accountable to the PPC for all activities in protected areas. The management boards administer diverse departments.

Bai Tu Long National Park, Cat Ba National Park and Tam Dao National Park have their own department of forest protection because their sizes are greater than 15,000 ha. This department is equivalent to the Forest Protection Department of district and it includes forest ranger staff to check and examine the illegal activities of local people into the forests.

Xuan Thuy National Park and Tien Hai Nature Reserve do not have their own department of forest protection, thus they collaborate with forest rangers of communes and districts.

- ***Bai Tu Long National Park***

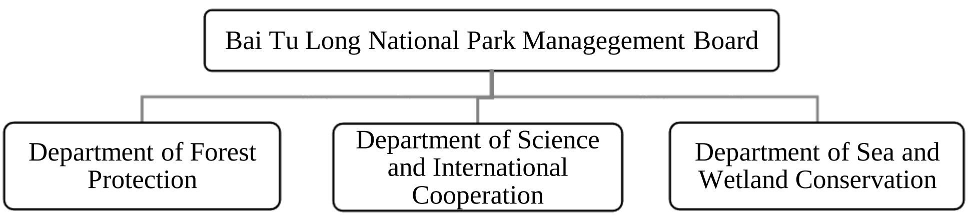


Figure 4.9: Organization chart of Bai Tu Long National Park
(Source: In-depth interview, 2018)

- ***Cat Ba National Park***

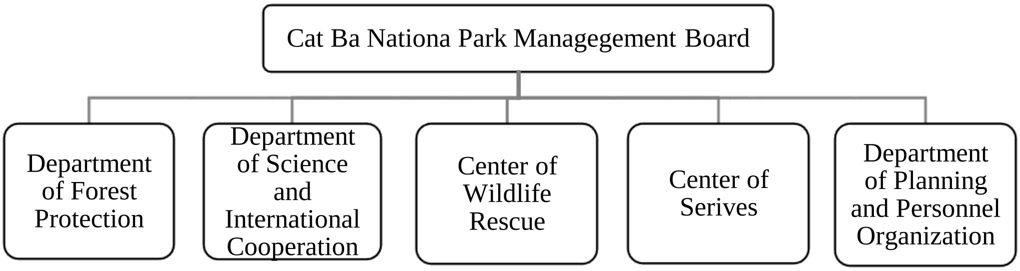


Figure 4.10: Organization chart of Cat Ba National Park
(Source: In-depth interview, 2018)

- ***Tam Dao National Park***

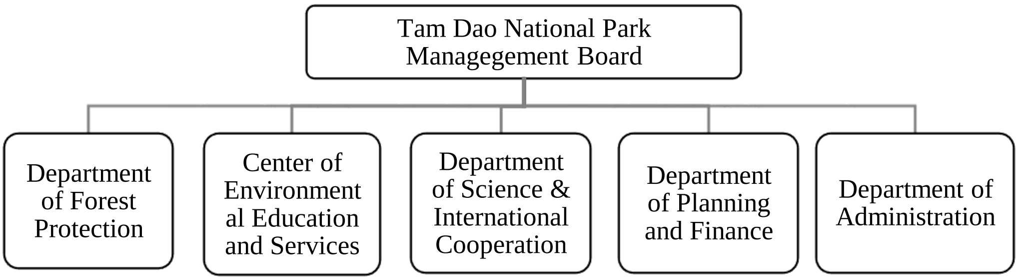


Figure 4.11: Organization chart of Tam Dao National Park
(Source: In-depth interview, 2018)

- ***Xuan Thuy National Park***

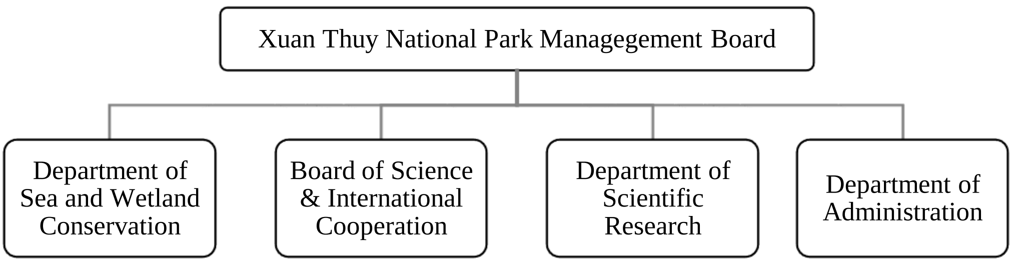


Figure 4.12: Organization chart of Xuan Thuy National Park
(Source: In-depth interview, 2018)

- ***Tien Hai Nature Reserve***

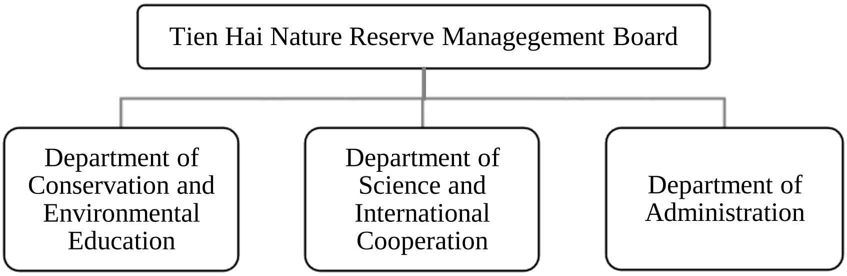


Figure 4.13: Organization chart of Tien Hai Nature Reserve
(Source: In-depth interview, 2018)

- **Workforce and educational background of staff**

Management boards of protected areas mainly include technical personnel. Cat Ba National Park has the highest workforce with 99 staff (including managers and technicians), followed by Tam Dao National Park (91 staff), Bai Tu Long National Park (53 staff), Xuan Thuy National Park (18 staff) and Tien Hai Nature Reserve (7 staff).

Regarding the specialty of employees, the dominance of the workforce in all surveyed protected areas has specialization in agriculture, aquaculture or forestry. Specialty in biology, ecology, environment protection, or conservation is moderate.

Cat Ba National Park and Bai Tu Long have employees holding qualifications in laws (three staff/ protected area).

Bai Tu Long National Park and Tien Hai Nature Reserve have personnel expertise in geography/geology (one staff/ protected area).

Among the five protected areas, Xuan Thuy National Park faces a shortage of staff holding three specializations in biology/ecology/environmental protection, laws, and geography.

Through in-depth interviews, it has found that the staff of protected areas mainly have a lack of skills in conservation (e.g. environmental impact assessment skills) and working skills with communities as well as other stakeholders in conservation programs.

The details of the workforce have been presented in Table 4.10 as below:

Table 4.10: Workforce and educational background of staff

Educational background	**Xuan Thuy**		**Bai Tu Long**		**Cat Ba**		**Tam Dao**		**Tien Hai**	
	Staff	%	Staff	%	Staff	%	Staff	%	Staff	%
1. Biology, ecology, env. protection	0	0.00	0	0.00	02	2.02	1	1.10	1	14.29

2. Economic, business mng.	1	5.56	0	0.00	14	14.14	11	12.08	2	28.58
3. Laws	0	0.00	03	5.67	03	3.03	0	0.00	0	0.00
4. Forestry, fishery, agriculture	13	72.22	39	73.58	66	66.67	75	83.51	3	42.84
5. Tourism	2	11.11	01	1.88	1	1.01	2	2.19	0	0.00
6. Geography, geology	0	0.00	01	1.88	0	0.00	0	0.00	1	14.29
7. Others	2	11.11	9	16.99	13*	13.13	2	2.19	0	0.00
Total	18	100.00	53	100.00	99	100.00	91	100.00	7	100.00

Note: (*) administrative, language, technician, driver, the boat driver
(Source: Management boards of protected areas, 2018)

4.2.5 Conservation and development activities of protected area management boards

- **The application of conservation and development policies**

In general, five protected areas have applied a wide range of legal instruments issued (Table 4.11). All of the laws promulgated by the National Assembly (Law on Environmental protection 55/2014/QH13, Law on Biodiversity 20/2008/QH12, Law on Forestry 16/2017/QH14, Law on Fishery 18/2017-QH14) have been enforced in five sites. However, policies on payment of forest environmental services (Decree 99/2010/ND-CP and its amended Decree 147/2016/ND-CP) have been applied only in Xuan Thuy National Park. In this park, clam aquaculture farmers pay fees for their use of brackish water. The payments then have been allocated for nature conservation projects on this site.

Table 4.11: The application of policies in five protected areas

Policies	Xuan Thuy	Tien Hai	Bai Tu Long	Cat Ba	Tam Dao
1. Biodiversity law 20/2008/QH12 issued in 2008, Decree 65/2010/ND-CP, Decision 1250/2013/QD-TTg	+	+	+	+	+
2. Environmental protection law 55/2014/QH13 and Decree 19/2015/ND-CP	+	+	+	+	+
3. Forestry law 16/2017/QH14 and Decree 156/2018/ND-CP: Guidelines of implementation articles of Forestry law	+	+	+	+	+
4. Decree 99/2010/ND-CP: Policies on payment of forest environmental services and amended Decree 147/2016/ND-CP	+	Not yet	Not yet	Not yet	Not yet

5. Fishery law 18/2017-QH14 & Decree 26/2019/ND-CP: Guidelines of implementation articles of Fishery law	+	+	+	+	+
6. Decision 24/2012/QD-TTg: Policies of investment and development of Special-use forest in 2011-2020	+	Not yet	+	+	+
7. Decision 218/2014/QD-TTG: Management strategy on Special-use forests to 2020, with a vision to 2030	+	+	+	+	+
8. Decree 117/2010/ND-CP: Organization and management of Special-use forests and Circular 78/2011/TT-BNNPTNT	+	+	+	+	+

Note: + signifies for having tasks
(Source: In-depth interview, 2018)

The policy on investment and development of Special-use forests (Decision 24/2012/QD-TTg) is enabled in four sites (Tam Dao National Park, Cat Ba National Park, Xuan Thuy National Park, Bai Tu Long except for Tien Hai Nature Reserve). This policy allows contracts between the parks and local communities to protect forests and natural resources. The contracts are re-signed every year. This management arrangement is formed when an owner of the forest (under State property) signs a contract with households to protect the forests. The ownership of the forests remains with the contractor. The contractee participates to go on patrol and protect the forest and they are entitled to a cash remuneration for the contracted area. Each household in Tam Dao National Park receives 200,000-400,000 VND/ha/year (equivalent 8-16 USD/ha/year) of the remuneration. Each household in Xuan Thuy National Park receives 100,000 VND/ha/year (equivalent to 4 USD/ha/year). The remuneration contributes to environment and biodiversity protection, livelihood improvement and awareness-raising among communities.

Moreover, 39 villages around Tam Dao National Park have received financial supports for infrastructure construction (water, electricity, information systems, road, public housing, etc.). The management board of Tam Dao National Park has the main responsibility for managing the subsidies and cooperating with CPC to decide which village is subsidized based on criteria assessment.

Around Bai Tu Long National Park, there are 22 villages (from the total of 38 villages) of the buffer zone have received financial supports for: (1) investing in capacity building for farmers (agricultural extension, forestry extension, seed, livestock, equipment); (2) hard infrastructure construction (water, electricity, information systems, road, public housing, etc.).

Management boards of protected areas play the main responsibility for managing the subsidies and cooperate with CPC to decide which village meets the criteria of subsidies. The policy on investment and development of Special-use forests contributes to the improvement of protected areas' infrastructure which helps to supply better environmental services for stakeholders and develop eco-tourism around the conservation areas. That also generates some additional sources of income for four protected area management boards to conserve the environment and ecosystem. Plus, the policy stimulates buffer communities to participate more in protecting natural resources through contracts.

Without the application policy on investment and development of Special-use forests, Tien Hai management board cooperates with private companies to provide mangrove seedling and technical consultations for farmers to grow more trees in aquaculture farms. In addition, farmers involved in going on patrol of the mangrove forests with Tien Hai Nature Reserve staff.

- **Assigned tasks and current activities of five protected areas:**

There are diverse responsibilities that have has for protected areas according to the decisions of the Establishment. In total, protected areas have eight tasks regarding conservative tasks for protected areas and development tasks for buffer zones (Table 4.12).

Table 4.12: Assigned tasks of five protected areas

Assigned tasks	Xuan Thuy	Tien Hai	Bai Tu Long	Cat Ba	Tam Dao
1. Managing, protecting and developing natural resources	+	+	+	+	+
2. Conducting scientific research activities	+	+	+	+	+
3. Conducting environmental education activities for communities	+	+	+	+	+
4. Organizing eco-tourism and entertainment activities	+	+	+	+	+
5. Cooperating with international organizations	+	+	+	+	+
6. Organizing environmental service payment					+

7. Developing livelihoods for buffer zones	+	+	+		
8. Providing and transferring AAS for the buffer zones					+

Note: + signifies for having tasks, AAS: Agricultural Advisory Services
(Source: Protected area management boards, 2018)

Most of the assigned tasks have been transferred into practical activities of protected area management boards through eight types of activities. Table 4.13 summaries current activities as follow:

- Natural resource management and protection within the protected areas (five sites);

- Scientific research activities (five sites);

- Environmental education (mainly through propaganda) for local communities (five sites);

- Organizing eco-tourism and entertainment activities for domestic and foreign visitors (five sites);

-Working with international organizations for environmental-related programs (five sites);

- Organizing environmental services: Xuan Thuy National Park, Tam Dao National Park;

- Developing livelihood for buffer zone: only in Tien Hai Nature Reserve. In policies, the investment and development plan for the buffer zones has to be developed at the same time as those in the protected areas for the enhancement of conservation (Decision 08/2001/QD-TTg). However, this policy has not been fully implemented nor integrated with the activities of protected area management boards. Only Tien Hai Nature Reserve has worked with private companies to provide mangrove seedling and technical consultations for farmers to grow more trees in aquaculture farms. In general, activities of socio-economic development or transferring economic models for buffer communities gain at "low" effectiveness at five sites.

- Providing agricultural advisory or agricultural models for buffer zone: Tam Dao National Park, Tien Hai Nature Reserve: providing seeds for crops and aquaculture production.

Table 4.13: Current activities of five protected areas

Current activities	Xuan Thuy	Tien Hai	Bai Tu Long	Cat Ba	Tam Dao
1. Managing, protecting and developing natural resources	+	+	+	+	+
2. Conducting scientific research activities	+	+	+	+	+
3. Conducting environmental education activities for communities	+	+	+	+	+
4. Organizing eco-tourism and entertainment activities	+	+	+	+	+
5. Cooperating with international organizations	+	+	+	+	+
6. Organizing environmental service payment	+				+
7. Developing livelihoods for buffer zones		+			
8. Providing and transferring AAS for the buffer zones		+			+

Note: + signifies for having activities; AAS: Agricultural Advisory Services

(Source: Survey, 2018)

- **Effectiveness of protected area management boards:**

Decision 156/2018/ND-CP of the Vietnamese Government assigns the management boards of protected areas to organize and cooperate with local authorities and communities to develop programs and projects for buffer zones. The management boards are in charge of applying laws on natural environmental protection and biodiversity conservation in protected areas.

As approved in the Decision 186/2006/QD-TTg, protected area management boards also have roles in organizing the participation of buffer communities in forest protection, conservation, wise utilization of natural resources, and environmental service provision.

However, park managers have the weak political power to deal with local people who break the laws on environmental protection and agricultural conservation because CPC is responsible for the management of protected area buffer zones.

Table 4.14 depicts the effectiveness of protected area management boards in transferring policies into practices. Managers were asked for the levels of effectiveness and their responses were rated as very low (1); low (2); medium (3); high (4); very high (5) and; not yet applied:

The application of the payment of forest services is considered as a financing mechanism to increase financial sources for the conservation of protected areas. This tool has been applied only in Xuan Thuy National Park at “medium effectiveness”, but “high effectiveness” in Tam Dao National Park because the payment provides higher additional income for more people in Tam Dao.

Practical activities for scientific research (i.e. conserving wild animals and plants belonging to endanger lists, forest replantation, observing fauna and flora, monitoring species, etc.) gain at a “high” level in five sites.

Environmental education programs were rated from “medium” (Xuan Thuy and Tien Hai) to “high” (Bai Tu Long, Cat Ba, Tam Dao).

Activities for environmental protection and biodiversity conservation within protected areas obtain at “medium” in the five sites.

Eco-tourism development can share park’s revenues. This effort is ranked at “very low” in Tam Dao, “low” at Tien Hai and Bai Tu Long. Only Xuan Thuy and Cat Ba achieve at the “medium” level.

Scientific research is mainly assessed at “high” effectiveness.

Activities for socio-economic development or transfer economic models for buffer communities gain at “low” effectiveness at the five sites: protected areas’ staff mainly focus on working with the natural environment inside protected areas (core zones) and providing environmental education for local people.

Table 4.14: Effectiveness levels of current activities of protected area management boards based on the application of policies

Activities	**Xuan Thuy**	**Tien Hai**	**Bai Tu Long**	**Cat Ba**	**Tam Dao**
1. Payment of forest services	3	Not yet	Not yet	Not yet	4
2. Environmental protection	3	3	3	3	3
3. Scientific research	4	3	4	4	4
4. Eco-tourism development	3	2	2	3	1
5. Environmental education for buffer communities	3	3	4	4	4
6. Socio-economic development for buffer zone	2	2	2	2	2

Note: Levels of effectiveness: very low (1); low (2); medium (3); high (4); very high (5)

(Source: In-depth interview, 2018)

Our further in-depth interviews show the major causes of the limited effectiveness from conservation managers including: (1) insufficient funding: a majority of funds received from government and international organizations are used for basic running costs or hard infrastructure; (2) limited capacity of staff; (3) pressures from economic development; (4) a dearth of specific relevant policies and operational mechanisms for large-scale participation of communities in conservation activities. That are explained as below:

Funding from the state government accounts for the majority of total financial sources of these protected areas to cover operational costs and conservative programs. The four provincial protected areas are funded mainly from the provincial budget approved by PPC, while Tam Dao National Park (inter-province) receives funds mainly from central sources. Provincial protected areas usually face limited financial sources for conservative activities because they depend on the budget distribution of provinces. PPCs have to balance the budget for numerous socio-economic activities within provinces. While the ecotourism in these protected areas cannot generate sufficient revenues for their operational costs. Tam Dao National Park has more potential than provincial protected areas in receiving supports and investment from both national and international organizations. The aims of national sources are different from international ones. While, national supports and investments focus on forest replantation, forest management, and infrastructure development, international sources focus on scientific research, environmental awareness improvement, community development, capacity building, and technological supports. Tam Dao National Park has more advantages in spending more on conservation than others. The Decision 08/2001/QD-TTg issues that the investment and development plan for the buffer zones has to be developed at the same time as those in the protected areas for the enhancement of conservation. However, this policy has not been fully implemented nor integrated with the activities of protected area management boards.

4.2.6 Characteristics of local communities around protected areas

- Population in the buffer zones

Table 4.15 demonstrates the population and its trend in buffer communes of surveyed site. Xuan Thuy National Park's buffer zone has the largest population (44,287 people in 2017) in comparison with others. A large population is recognized as one of the challenges in environmental protection and ecological conservation in protected areas including Xuan Thuy National Park.

Table 4.15: Population trend in the buffer zones

Protected area buffer zones	2015	2016	2017	Average growth rate
Xuan Thuy	43,959	44,210	44,287	0.37
Tien Hai	15,286	15,312	15,312	0.09
Cat Ba	17,571	17,802	18,101	1.50
Bai Tu Long	16,366	17,465	17,598	3.70

(Source: Interview with protected areas' management boards, 2018)

Table 4.16 shows the population density in the buffer zones. Among that, buffer communes of Xuan Thuy National Park have the densest population (1,108 people/km^2), while its buffer zone covers the smallest area in comparison with others (39.96 ha).

Table 4.16: Population density in the buffer zones

Protected area buffer zones	Population (people)	Land area (ha)	Population density (people/km^2)
Xuan Thuy	44,287	39.96	1,108
Bai Tu Long	17,598	328.03	53
Cat Ba	18,101	298.30	90
Tien Hai	15,312	50.79	301
Tam Dao	184,000	880.00	209

(Source: Interview with protected areas' management boards, 2018)

- Land use in the buffer zones

Table 4.17 illustrates the existing land use in the buffer zones for agriculture, aquaculture, forestry, residential land and specialized land. Land use for agriculture- aquaculture-forestry in this zone is distributed to households by communes with approval of District People's Committee in long-term periods (under 50 years with renewable use right).

Among these, Xuan Thuy National Park's buffer zone has the largest area of agriculture (2,188.71 ha of short-term crops, perennial crops and fruit trees) as well as aquaculture production (3,870.00 ha) as compared with other buffer zones. Bai Tu Long National Park's buffer zone has the largest area of forestry (22,781.40 ha).

Table 4.17: Land use in the buffer zones

Buffer zones	Agriculture (ha)	Aquaculture (ha)	Forestry (ha)	Resident land (ha)	Specialized land (ha)
Xuan Thuy	2,188.71	3,870.00	684.76	262.63	713.27
Bai Tu Long	318.60	1,274.00	22,781.40	160.70	1,420.30
Cat Ba	513.00	519.18	-	151.18	-
Tien Hai	890.10	2,883.00	454.00	135.80	716.30

(Source: Interview with protected areas' management boards, 2018)

4.2.7 Existing situation of agricultural development around protected areas

4.2.7.1 Cropping systems

The majority of people living adjacent to the protected areas depend on small-scale cropping systems including rice, maize, sweet potato, cassava, peanut (Table 4.18). Rice is the main crop that is grown widely in all buffer zones. Xuan Thuy National Park's buffer zone has the largest area of rice (1,872 ha), while Cat Ba National Park's buffer zone has the smallest area (19.9 ha). The rice yield in Xuan Thuy National Park's buffer zone also gained at the highest yield (6.6 ton/ha/crop) as compared with those in Bai Tu Long National Park's buffer zone (2.8 ton/ha/crop). In general, the buffer zones of Xuan Thuy National Park and Tien Hai Nature Reserve have better conditions for short-term crops. Other grains such as sweet potato, cassava, and peanut are not cultivated in all buffer zones. Rice has been cultivated with two crops per year (in the buffer zones of Xuan Thuy, Tien Hai, Tam Dao, Cat Ba) or one crop (buffer zone of Bai Tu Long). Seeds of crops were mainly from input dealers or agricultural cooperatives. Pesticides and chemical fertilizers have been used widely in buffer zones.

In the buffer zone of Bai Tu Long National Park, rice accounts for the largest area as compared with other cereals such as maize, sweet potato, cassava, and peanut. However, rice in this area is moderate (85 ha) in comparison with those in Xuan Thuy National Park's buffer zone (1,872 ha) and Tien Hai Nature Reserve's buffer zone (805.5 ha). Among the communes in the buffer zone of Bai Tu Long National Park, Ban Sen commune has the most fertile soil for rice production. Rice is cultivated by individual families and used for subsistent consumption and animal feed. Each household owned an average of 1,000-2,000 m^2 of rice and the yield gained at an average of 2.8 ton/ha/crop. The yield has been increased in recent years following the application of fertilizers and pesticides but the yield is much lower than in other inland areas

Table 4.18: Farm size and outputs of main crops around protected areas

Buffer zones	Rice		Maize		Sweet potato		Cassava		Peanut	
	Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)
Xuan Thuy	1,872.0	6.6	114.0	4.7	150.0	4.0	-	-	52.7	1.5
Bai Tu Long	84.5	2.8	23.7	2.9	35.2	6.7	11.0	6.6	36.3	1.2
Cat Ba	19.9	4.4	25.0	1.6	14.0	3.3	11.5	6.0	-	-
Tien Hai	805.5	6.2	84.6	5.1	-	-	-	-	-	-
Tam Dao	-	4.8	-	3.7	-	-	-	-	-	-

(Source: Survey, 2018)

Agricultural land in the buffer zone of Cat Ba National Park is the smallest among five buffer zones that have 19.9 ha of rice, 25 ha of maize, 14 ha of sweet potato, 11.5 ha of cassava, and 37 ha of peanut. The buffer zone of Cat Ba National Park does not have favorable conditions for agricultural production due to lime soil and a shortage of fresh water. Therefore, local people mainly buy foods and vegetables from the inland of Hai Phong province. According to Cat Ba National Park management board, the application of agrochemicals from these crops and waste from cropping systems are not recognized as serious problems for the ecosystems of Cat Ba National Park.

4.2.7.2 Aquaculture systems

The buffer zone of Xuan Thuy National Park has integrated aquaculture-mangrove and intensive shrimp system (Table 4.19). The integrated aquaculture-mangrove culturists apply poly-culture with various cultured species include black tiger shrimp (penaeusmonodon), greasybock shrimps (metapenaeusensis), crabs, fish, and seaweed. The average size of one farm is 6.45 hectares but there is no standard design for integrated aquaculture-mangrove ponds. Dikes around the shrimp ponds are constructed as boundaries to indicate pond size and shape. Mangroves are integral to natural ecosystems, protecting against tidal waves and storm surges, and providing vital fish nursery grounds. Farmers stocked shrimp at a density of 5.47 seeds/ m². Shrimps' food is mainly ephemera, but some bivalves and miscellaneous fish are mixed with rice bran are used at the beginning of the crop. None of the fertilizers or chemicals are applied in rearing.

Table 4.19: Main aquaculture systems in Xuan Thuy National Park's buffer zone

Issues	**Integrated aquaculture-mangrove**	**Intensive shrimp**
Production system	Black tiger shrimp – Crab (co-products: wild-caught shrimp/fish, seaweed)	White legged shrimp– White legged shrimp– Fallow
Diversity of species	Polyculture	Monoculture
Farm size (ha)	6.82	1.60
Stocking density (seeds/m^2)	5.47	76
Seed sources	Hatchery and wild	Hatchery
Number of crop/year	1	2
Chemical used	None	Widely used
Feed used	Bivalves, miscellaneous fishes	Artificial
Aeration	None	Frequently

(Source: Survey, 2018)

The intensive shrimp culturists apply monoculture with two raising cycles per year. Farmers construct ponds near coastal rivers or Integrated aquaculture-mangrove farms where ponds can be completely drained and dried before stocking. White-legged prawns (Penaeus vannamei) are conducted with a stocking rate of fries of about 76 seeds/m^2. This system depends heavily on aeration to circulate water for oxygen for shrimps. After harvesting the second production crop, farmers clean ponds and leave them fallow in about three months.

In Tien Hai Nature Reserve's buffer zone, there is 100 ha of intensive shrimp farming located only in Nam Thinh commune. This farming has been culturing by the Thai Binh Import-Export Limited company. In buffer communes, there are a total of approximately 40 ha of semi-intensive shrimp farming (Table 4.20).

In comparison with those in Xuan Thuy National Park's buffer zone, intensive shrimp around Tien Hai Nature Reserve is cultivated by Thai Binh Import-Export Limited company. With much higher stocking density (200-300 PLs/m^2), the yields of intensive shrimps are much higher in Tien Hai Nature Reserve's buffer zone.

Table 4.20: Main aquaculture systems surrounding Tien Hai Nature Reserve

Characteristics	**Integrated aquaculture-mangrove**	**Semi-intensive shrimp**	**Intensive**	**Clam**
Production system	Black tiger shrimp, crab (Co-products: wild-caught shrimp/fish, seaweed)	White legged shrimp - White legged shrimp - Fallow	White legged shrimp - White legged shrimp - White legged shrimp	Clam
Diversity of species	Polyculture	Monoculture	Monoculture	Monoculture
Farm size/farm owner (ha)	1-30	0.5-3	0.5-2	2-8
Mangrove coverage in farm	Yes	None	None	None
Stocking density (PL/m^2)	5-10	60-100	200-300	-
Seed source	Hatchery and wild	Hatchery	Hatchery	Hatchery
No. of crop/year	1	2	3	-
Chemical used	None	Widely used		None
Survival rate of shrimps (%)	40-60	50-80	90	-
Feed used	Bivalves, miscellaneous fishes	Artificial	Artificial	None
Water exchange	Tidal (6-7 times/month)	Pumping (1-2 times/week)	Pumping	Tidal
Aeration	None	Every hour	Every hour	None
Labor (person/ha)	0.2	1	1-2	0.5
Yield	50-100 kg/ha/crop (shrimp)	3-5 ton/ha/crop	20-30 ton/ha/crop	-

(Source: Group interview and in-depth interview, 2018)

In the buffer zone of Cat Ba National Park, Phu Long commune is a unique place that has intensive shrimp aquaculture. The production system started in 2011 with a total area of 120 ha located adjacent the park. It has been organized and cultivated by Son Truong limited company. The company has assigned four technicians and 63 workers working full-time in the shrimp farms and check shrimps daily. They work and live in the farms. Supports from aquatic technicians contribute to reducing disease occurrence and improving the survival rate of shrimps. No antibiotics are used in intensive shrimp ponds. Technicians use garlic as bio-antibiotics to improve the health of shrimps. Son Truong company connected with other companies to distribute shrimp products to markets. Thus, there is no price-squeeze at harvest seasons.

In 2018, Cat Ba National Park management board and Cat Hai DPC eliminated 20 fish cages (397m^2) in the strictly protected division of Cat Ba National Park that made pollution for the water surface of the park.

The technical features of intensive aquaculture and integrated aquaculture-mangrove in Cat Ba National Park's buffer zone are demonstrated in Table 4.21 and Table 4.22 as follows:

Table 4.21: Intensive shrimp system in Cat Ba National Park's buffer zone

Characteristics	**Intensive shrimp**
Farm size (ha)	120
Area of one pond (m^2)	1,500
Name of post-larvae (PL)	White-legged shrimp
Stocking density (PL/m^2)	100-120
Seed source	Hatchery
Number of crop/year	2
Diversity of species	Monoculture
Formulated complete feed (times/day)	04
Antibiotics	None
Probiotics	Widely used
Minerals use	Widely used
Water exchange	Pumping
Aeration	Widely used
Employment (person/ha)	2
Disease problems	Frequent
Operation cost	Extremely high
Productivity (ton/ha/crop)	4.5

(Source: In-depth interview with technicians of Son Truong limited company, 2018)

Table 4.22: Integrated aquaculture-mangrove system surrounding Cat Ba National Park

Characteristics	Integrated aquaculture-mangrove
Farm size (ha/household)	2-40
Mangrove coverage (%)	20-30%
Stocking diversities	Black tiger shrimp, crab, tilapia
Stocking density (PL/m^2)	1.0
Seed source	Hatchery
No. of crop/year	1.0
Duration of one crop	6 month
Diversity of species	Polyculture
Feed (the first 20 days of a crop)	Egg mixed with clam, fish
Antibiotics	None
Probiotics	None
Minerals use	None
Water exchange	Tidal
Aeration	None
Productivity (kg/ha)	
- Black tiger shrimp	18.7
- Tilapia	90.0
- Wild-catch fish	17.5
- Wild-catch shrimp	35.5
- Crab	15.0
Land fee	0.0

(Source: In-depth interview, 2018)

4.2.6.3 Issues of agricultural production around protected areas

We have asked headers of agricultural cooperatives in five protected area buffer zones about the differences between farming practices of buffer communes and outer ones. Results show that farmers in the buffer zones are not allowed to destroy mangroves inside integrated aquaculture-mangrove ponds. However, in intensive shrimp farms, farmers can use a diverse range of aquatic drugs and discharge farm effluent without testing environmental standards. In crop cultivation, farmers can use chemical pesticides and fertilizers. In general, there are not many differences between farming activities in buffer zones and outer regions.

The perception of park managers on issues of agriculture on the natural environment is presented in Table 4.23. Respondents were asked for their assessment of the problematic issues of agriculture production. The levels of issues were ranked at “very low seriousness-1”, “low seriousness-2”, “moderate-

3”, “high seriousness-4”, “very high seriousness-5”. Likert scale was used to determine the mean scores of the assessment:

Overall, three emerging problems have been recognized at “high seriousness” in all buffer zone sites including Dependency on agrochemicals, Low economic performance of crops and, Lack of incentives for conservation farming.

In particular, farming practices surrounding Xuan Thuy National Park have created more serious pressures in comparison with other surveyed zones. The pollution from surrounding crop farms on Xuan Thuy National Park was assessed individually as “high seriousness” in comparison with the mean score. This is because Xuan Thuy National Park buffer zone has the largest area of cropland as compared with other sites and farmers adopt synthetic fertilizers and chemical pesticides widely but lack regulations and enforcement for conservation.

Table 4.23: Issues of agricultural development around protected areas

Issues	**Xuan Thuy**	**Cat Ba**	**Bai Tu Long**	**Tam Dao**	**Tien Hai**	**Mean score**	**Meaning**
1. Dependency on agrochemicals	4	3	3	3	4	3.4	High
2. Pollution from surrounding aquaculture farms	4	4	3	-	4	-	-
3. Pollution from surrounding crop farms	4	2	2	1	3	2.4	Low
4. Low economic performances of crops	5	3	3	4	4	3.8	High
5. Low economic performances of aquaculture	3	2	2	-	2	-	-
6. Farming encroaches on natural ecosystems	1	1	1	1	1	1.0	Very low
7. Un-regulation in farm production	3	2	2	3	2	2.4	Low
8. Lack of regulations and enforcement	4	3	3	2	3	3.0	Moderate
9. Low awareness of farmers	3	3	3	3	3	3.0	Moderate
10. Lack of incentives for conservation farming	4	3	4	3	4	3.6	High

(Source: In-depth interview, 2018)

4.3 Conclusion of the chapter

This chapter provides two main contents: Part 4.1 provides an overview of protected areas systems in Vietnam; Part 4.2 provides natural-socioeconomic-institutional characteristics of five protected area cases as well comparative features between them. We conclude by emphasizing some main points:

- *The establishment and institutional management of protected areas in Vietnam:*

National parks are placed at the top priority for conservation and protection, nature reserves come at the second in the national strategy.

PPCs have roles in implementing strategies on environmental protection for provincial national parks (parks located entirely within one province), nature reserves and other forms of special-used forests.

DARD and DoNRE are two specialized departments working under the administration of PPCs and reporting to PPCs. DARD and DoNRE are responsible for disseminating and enforcing laws on environmental protection and agricultural development to communes, consulting resource users. Through the professional works of DARD and DoNRE, PPCs manage their protected areas.

Currently, DPC has not participated much in the environmental management of protected areas.

CPCs, the lowest hierarchical level of administration, manage socio-economic development programs of protected area buffer zones.

The protected area management boards are in charge of applying laws on natural environmental protection and biodiversity conservation within protected areas. Moreover, the boards are responsible for organizing and cooperating with local authorities and communities to develop programs and projects for buffer zones (Decision 156/2018/ND-CP). However, park managers do not have political authority for their buffer zones.

- *Policy framework for protected areas*

Since the 1960s, the Vietnamese government has issued and reformed a range of laws and policies for the foundation of managing and monitoring protected areas and their buffer zones. From the highest legislative organization (national-level), the National Assembly issued Environmental protection law, Biodiversity law, Forestry law, and Fishery law. MARD, MoNRE, and provincial government organizations have issued lower legal documents including Decisions, Circulars, and Decrees for applying and monitoring the laws issued by the National Assembly.

- *Characteristics of five protected area cases*

Five cases of protected areas that belong to the system of special-use forests provide comparative features:

Most of the assigned tasks have been transferred into practice: Natural resource management and protection within the protected areas (five sites); Scientific research activities (five sites); Environmental education (five sites); Eco-tourism and entertainment activities (five sites); Working with international organizations for environmental-related programs (five sites); Organizing environmental services (two sites); Developing livelihood for buffer zone (one site); Providing agricultural advisory or agricultural models for buffer zone (two sites).

According to policies, the investment and development plan for the buffer zones has to be developed at the same time as those in the protected areas for the enhancement of conservation. However, these policies mainly have not been fully implemented nor integrated with the activities of protected area management boards. The in-depth interviews reveal the low effectiveness in the works of park managers in economic development activities for buffer zones.

There are plentiful land-use systems around the five sites. In general, there are not many differences between farming activities in protected area buffer zones and outer zones: In intensive shrimp farms, farmers can use a diverse range of aquatic drugs and discharge farm effluents to the surrounding environment without testing environmental standards. In crop cultivation, farmers can use chemical pesticides and fertilizers. In integrated aquaculture-mangrove, farmers in the buffer zones are not allowed to remove mangroves inside as compared with outer ones.

A wide range of problematic issues arise from agricultural production practices around the five sites have been reported especially the case of Xuan Thuy National Park. While intensive shrimp aquaculture around Cat Ba National park has not adopted antibiotics, farmers around Xuan Thuy National Park use antibiotics widely. The other emerging issues among sites have been pointed out such as heavy dependency on agrochemicals, low economic performance of crops and, lack of incentives for conservation agriculture, etc.

5

Agricultural development toward agroecology around Xuan Thuy National Park

The agricultural production surrounding Xuan Thuy National Park has the largest areas as compared with the other five case sites, but it creates many obstacles in the line of sustainable development. In this chapter, we analyze the current situation of agricultural development nearby Xuan Thuy National Park through the application of the systemic approach of agroecology: objectives – practices – outputs. Chapter 5 aims to clarify the objectives of farmers and local authorities, whether farmers nearby the park respect environmentally-friendly methods, what are outcomes from the farms and, what are barriers of good practices?

5.1 Objectives of local authorities and farming communities

5.1.1 Objectives of Xuan Thuy National Park

As declared in Decision 01/2003/QD-TTg which change Xuan Thuy Wetland Nature Reserve to Xuan Thuy National Park on January 2nd 20013, this protected area has three main goals: (1) to preserve typical wetland ecosystems of the Red River estuary and typical plant and animal species of wetland ecosystems, especially aquatic animals, water-birds and migratory birds; (2) to serve scientific researches, environmental education and ecotourism development for people; (3) to build infrastructure for training, scientific research, and environmental education, ecotourism development, contributing to socio-economic development and job creation for local communities.

In addition, Decision 2714/2016/QD-UB of the Nam Dinh PPC promulgates more goals for the park: (1) to conserve natural landscapes and biodiversity for Xuan Thuy National Park area; (2) to manage and use aquatic resources in a sustainable manner with more involvement of local people; (3) to regulate water for the region; (4) develop scientific research programs of environmental assessment, biodiversity; (5) to develop the buffer zone toward sustainability and strengthen the participation of local people in monitoring the environmental protection programs; and (6) to develop ecotourism.

The function of Xuan Thuy National Park management board are assigned as: (1) to help Nam Dinh province to formulate long-term, medium-term and annual plans and investment projects for the construction of the national park, buffer zone, ecotourism development based on current regulations; (2) to manage, conserve and develop the typical wetland ecosystems of the Red River estuary, including the typical animals and plants of wetland ecosystems, waterfowl and migratory birds; (3) to organize scientific research as well as serve for scientific research and environmental education; (4) to carry out and coordinate with related departments and Giao Thuy District People's Committee to exploit available products and develop eco-tourism on the principle of encouraging activities that do not to create negative impacts on nature and environment, contributing to socio-economic development and creating jobs for local communities.

Following goals and functions assigned by the Vietnamese Government and Nam Dinh PPC, Xuan Thuy National Park managers have worked for environmental protection within core protected areas and support for its buffer zone. The primary objectives and interests of park managers for their buffer zone are reduction use of chemical fertilizers, pesticides and agricultural waste/sludge through the protecting of mangroves in the buffer zones, supplying environmental education, maintaining eco-tourism (14 households), supporting growing mushroom (20 households), forming beekeeping groups (5 households), supporting earthworm raising group (5 households). The secondary interests are profits and farm yields (Table 5.1).

Table 5.1: Objectives and interests of local authorities and farmers

Objectives/interests	Farmers	Buffer communes	Park managers
Increase yield	Primary	Primary	Secondary
Increase profit	Primary	Primary	Secondary
Maintain employment	Primary	Primary	Primary
Reduce chemical fertilizers	Secondary	Secondary	Primary
Reduce chemical pesticides	Secondary	Secondary	Primary
Reduce agricultural waste or sludge	Secondary	Primary	Primary
Improve environmental quality	Secondary	Secondary	Primary

(Source: Survey, 2018)

5.1.2 Objectives of communes and farmers

Buffer zones of protected areas are established to protect and enhance the conservation value of the core protected sites (Lynagh & Urich, 2002). The functions of buffer zones are discussed during the Buffer Zone Workshop held in Ha Noi in 1999 as follows: contribute to the conservation of core protected areas, enhance the conservation values within the buffer zones, and provide benefits from the protected areas to the adjacent communities (Gilmour & Van San, 1999). The buffer zone of Xuan Thuy National Park has main goals of (1) preventing threats from surrounding areas for the core zone, protecting forest trees, ecosystem and biodiversity; (2) conservation of culture, indigenous knowledge, local gene, and local breed and; (3) heightening awareness of local managers and communities toward sustainable natural resource management and improving livelihood for residents. In the legal documents, buffer communes generally aim at developing agriculture simultaneously ensuring biodiversity conservation for the park and for the buffer zone itself. Our results reveal that through propagation, communes remind farmers to dispose of agricultural waste such as containers, plastic bags or farm tools in the right places. Due to economic pressures, communal authorities take yield and profits for their priority work, but the reduction of chemical pesticides and fertilizers comes secondary.

We also explore the information on the objectives of farmers in the connection with the goals of Xuan Thuy National Park. Being the beneficiary of ecosystem services provided by on-farm agricultural biodiversity, the roles of farmers in its sustainable utilization and conservation is vital. Objectives have influences on decisions and responsiveness of farmers on production methods and technique applications. How much expected they are with the conservation of agricultural biodiversity is crucial to improve farm performance. We have asked farmers for their objectives of the cultivation including profits, yield, environmental protection activities. Farmers concerned for agricultural development is how to gain profit or yield firstly. The profit from farming, without any doubt, is the most priority of smallholder farmers in this area. While smaller numbers of farmers have objectives on environmental conservation (preservation of trees, birds, farm biodiversity, soil, water quality, etc.). In other words, primary farmers enjoy their own needs of profit and sell surplus products rather than feeling responsible for long-term maintenance.

5.2 Agricultural production practices toward agroecology

5.2.1 The diversity of farming systems

The diversity of farming systems including farmland characteristics, farming practices, financial outcomes, and water conflicting between user groups are presented in the articles: *"Dynamics of farming systems under the context of coastal zone development: the case of Xuan Thuy National Park, Vietnam"*. Agriculture, 9(7), 138. Groups of authors: Nguyen, T. T. N., Tran, H. C., Ho, T. M. H., Burny, P., & Lebailly, P. (2019). In this article, we explained the typologies of farming systems were classified according to the availability of natural resources, patterns of farm activities and intensity of production management, farm outputs, and environmental issues. Three main farming systems were identified with a substantial cropping focus and aquaculture production focus.

In the article: *"Economic analysis of different aquaculture systems in coastal buffer zones of protected areas: a case study in Xuan Thuy National Park,* *Vietnam".* Ecology, Environment and Conservation, 26(2), 44-52. Group of authors: Nhung, N. T. T., Cuong, T. H., Burny, P., Hop, H. T. M., Dogot, T., & Lebailly, P., we analyze economic indicators and highlight that the incomes of farmers are influenced by impacts of polluted sources from the surrounding environment.

- ***Integrated aquaculture – mangrove system:***

The common characteristics of the integrated aquaculture–mangrove (IAM) system are low intensification with low production cost, low stocking density, available wild-caught marines but high market prices of farmed products. This production is based on culturing aquaculture species within mangrove trees. IAM culturists around Xuan Thuy National Park started employing the polyculture since 1986s. Target products including hatchery black tiger shrimps (Penaeus monodon) and crabs (Scylla serrata) were reared inside mangrove ponds together with the recruitment of wild captured species including wild-caught shrimps (Greasybock – Metapenaeus ensis), wild-caught milkfish, etc. Seaweed also exists naturally in the farms and farmers collect this plant at the end of the grow-out season. Prevailing laborers are individual owners and few laborers are tenants in large farms (about 10 ha or more). The production is cultivated between April and November yearly (8 months of culture period). Ephemera from Ba Lat coastal estuary are the main food for this system but some bivalves and miscellaneous fish are mixed with rice bran are used at the first 15-20 days of shrimps.

Month	Rice – based	Intensive shrimp	Integrated aquaculture - mangrove
1	Plough Sowing land with rice varieties	Emptying	Emptying
2	Transplanting		
3	Pesticide and fertilizer application	Pond preparation, Releasing shrimp PLs, Feeding and water mgt.	
4	Pesticide and fertilizer application	Feeding and water mgt.	Releasing shrimp PLs, crabs Feeding and water mgt.
5	Harvesting	Feeding and water mgt.	Feeding and water mgt.
6	Plough Sowing land with rice varieties	Feeding and water mgt., Harvesting	Feeding and water mgt.
7	Transplanting	Emptying	Feeding and water mgt.
8	Pesticide and fertilizer application	Pond preparation, Releasing shrimp PLs	Harvesting shrimp, crabs
9	Pesticide and fertilizer application	Feeding and water mgt.	Harvesting crabs, fish
10	Harvesting	Feeding and water mgt.	Harvesting crabs, fish
11	Emptying	Feeding and water mgt. Harvesting	Harvesting seaweed
12		Emptying	Emptying

1st crop (green) 2nd crop (orange)

Note: PL: Post-larvae

Figure 5.1: Agricultural calendar of farming systems

(Source: Survey, 2018)

The other months from December to March, farmland is dried in several weeks depending on the location of farms, then water control gates are opened for intake brackish water with some wild marine based on the tidal (about 7 times per month). Black tiger shrimps and crabs are the farmed products that are harvested prior after about 3.5 – 4 months of the grow-out cycle in July and August. Then, farmers continue to collect wild-caught habitats and seaweed until November. Marine products are harvested about 6-7 times per month a fortnight by draining ponds at low tides through a bag net at the outlet sluice gate. Marines follow the water flows and are then trapped in nets attached to the gate. IAM farming is based on family labor and it does not utilize heavily mechanized techniques. IAM mainly uses local resources as well as local production methods.

- ***Intensive shrimp system:***

The high shrimp production target imposed by local government agencies is the reason to change 150.37 ha of the rice-shrimp system to an intensive shrimp system (ISH). ISH has been in operation in Xuan Thuy National Park's buffer zone since 2014. Shrimp culturists apply intensive monoculture with two raising cycles per year. The first cycle usually starts in March and ends in June with an average culture period is around 80 – 90 days. The second cycle often lasts from August to November with some rainy days with a longer average culture period (100 –105 days) than the first one. ISH production relies on aeration to provide oxygen for shrimps and phytoplankton and shrimps need various inputs including pellet feeds, supplements (minerals and vitamins), probiotics, antibiotics, veterinary drugs, etc. This cultivation requires stricter management skills and capital investment than IAM. Shrimp are harvested with large scoop nets when required for selling. After the harvest of the second crop, farmers leave pond emptying in three months from December to February. Emptying ponds can contribute to the reduction of disease proliferation. ISH farming requires more complicated management skills than IAM does. ISH generates more employments than IAM, but more immigrants from outer communes move to the buffer zone for culturing.

- ***Rice-based farming system:***

Rice-based (RB) farming system has been cultivating largely with almost households around Xuan Thuy National Park since the 1960s. Rice is grown by two mono-crops per year. The winter-spring crop starts from the middle to the end of January when rice varieties are sown or transplanted then harvested at the end of May. The land is dried for about two weeks before starting the second crop (summer-autumn) in the middle of June then harvested around the end of October.

Rice straw is mainly burned in fields. After the second crop, local cultivators dry and fallow land for about eight weeks then starts preparing land with plow by machines for the next crop. There are two varieties including pure-line and high-yielding. This production is a low-intensive technological application. Only machines are used to plow land and harvest grains. Various inorganic fertilizers and pesticides are widely utilized in rice plots. Our further results reveal that there is no special training or different farm management skills for rice farmers in the buffer communes of Xuan Thuy National Park in comparison with outer communes. The guidelines for rice cultivation have been disseminated similarly in the whole district by Giao Thuy district DARD.

- **Distribution of farm area and characteristics of farmland**

IAM culture is practiced in the field with an average of 6.82 hectares per farm, with an average of 24.28% of mangrove trees inside the farms (based on respondents' estimation). These farms situated closely to Ba Lat coastal line. Before 1995, land prior to the aquaculture farms was mangroves and sedge. Since the 1980s, the government allowed residents to remove some mangroves and sedges for IAM. According to Beland et al. (2006), 63% of mangrove trees in 1986 had been replaced by aquaculture ponds in 2001.

Table 5.2: Land area and characteristics

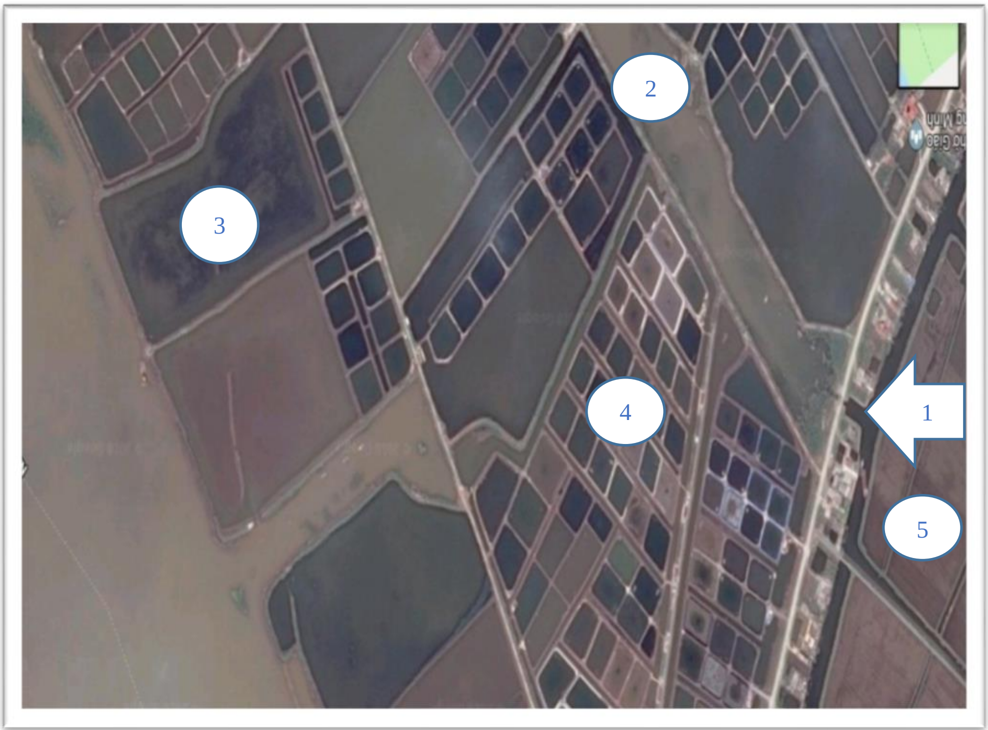
Characteristics	IAM	ISH	RB
Land holding per farm owner (ha)	6.82	1.60	0.18
% mangroves	24.78	0.00	0.00
Land prior	Natural mangrove, sedge	Shrimp - rice	Rice fields
Land tax (mil.VND/ha/year)	0.00	1.5-6.0	1.0
Ecosystem fee	0.00	0.00	0.00
Water source	Sea flow to Vop, Tra and other rivers	Sea flows to Vop and Tra river	Freshwater & rain
Frequency of water change (times/crop)	Base on tidal regime (48 times)	7.2 times	30 times
Distance from farms to:			
- the coast	6,071.43	8,879.63	8,937.50
- the core zone	4,019.07	10,333.33	9,958.33
- agri. sluice gates	3,050.60	1,943.52	1,020.21
- Park office	3,140.50	1,923.61	3,560.42

(Source: Survey, 2018)

ISH culturists own smaller farms with an average of 1.6 hectares per farm, in which pond surface account for 60% and the remaining is 40% with intake water ponds, drainage area, and tent or warehouse. Land prior to ISH farms was aquaculture-rice because since 2014 DPC of Giao Thuy district issued the decision 4803/QD-UBND to change 150.37 hectares of the aquaculture-rice farming system to ISH. Currently, 100% of ISH farmers have to hold land tenures. Rice is cultivated in the area with a size of 0.18 ha per household on average.

The paddy fields situated near ISH farms (two areas are separated by a national dike (10-meter width). The inland flows including freshwater and drainage from RB run to Ba Lat estuary or river channels where mariculture farms located through a large system of agricultural sluice gates. IAM farms closely to ISH rearing ponds. Many ISH farms drain their pond sludge into nearby supply canals or rivers where is the intake water source for IAM.

Since 2016, IAM farms have not under land rent fees, meanwhile, ISH and RB cultivators must pay land fee for the government. The production of IAM, ISH and RB do not cover the cost of ecosystem services.



1:	*Agricultural sluice gate*	*3:*	*Integrated aquaculture-mangrove farms*	*5:*	*Rice-based farms*
2:	*Supply canal/river*	*4:*	*Intensive shrimp farms*		

Figure 5.2: Farm location and design

5.2.2 Farming practices toward agroecology

5.2.2.1 Rice-base system

5.2.2.1.1 Knowledge of farmers and the application of agroecological-based practices

Based on the guidelines of FAO for Best Farm Management Practices of irrigated lowland rice cultivation in Asia which are presented by Joint (2018), we have asked farmers if they know and apply eco-friendly practices in previous cropping seasons.

Table 5.3: Knowledge of farmers and the application of agroecological-based practices in RB

Methods	Percent of farmers know	Percent of farmers applied
1. Soil fertility management		
- Incorporate residues from previous crops into the soil during land preparation	100.0	30.2
-Incorporate organic manure and compost with chemical fertilizers	100.0	32.3
2.Site specific integrated nutrient management		
- Use leaf color chart as a mean to assist farmers to use proper dose of N fertilizer in different plots	17.7	0.0
3. Integrated pest management (IPM)		
3.1 Agronomic tactics		
- Crop rotation/mixed crop/intercropping/ trap crops	81.2	0.0
3.2 Mechanical tactics		
- Collecting eggs of harmful pests by screens/barriers	100.0	25.0
- Trapping insects by suction devices (light, nets, etc.)	93.8	24.0
- Removing affected rice plants to prevent spread of diseases	42.7	30.2
3.3 Biological tactics		
- Conservation of natural enemies	45.8	25.0
- Do not use preventive insecticides	52.1	27.1
- Do not use early preventive spraying (before the first 40 days after transplanting)	20.0	20.0
- Growing legumes or broad leaf weeds on rice field bunds for natural enemies	17.7	0.0
- Growing grass and other vegetation near rice fields for natural enemies	0.0	0.0
-Conserve insect predators (frog, toad, birds) by preventing their capture from rice fields	0.0	0.0
3.4 Chemical tactics		
- Used chemical pesticides as the last methods when all of non-chemical methods are fail to control	19.8	16.7

(Source: Survey, 2018)

Table 5.3 reveals percentages of farmers reporting knowledge about conservative methods and their actual use in rice fields. Few techniques are recognized by the high rate of farmers (incorporate residues from previous crops into the soil during land preparation/ 100% of respondents; incorporate organic manure and compost with chemical fertilizers/100%; collecting eggs of harmful pests by screens or barriers/100%; trapping insects by suction devices/93.8%; crop rotation/mixed crop/intercropping/ trap crops/81.2%; do not use preventive insecticides/52.1%; removing affected rice plants to prevent spread of diseases/42.7%). However, the knowing rates of all other methods are very low (0-19.8%). Farmers have never heard about two biological IPM techniques (growing grass and other vegetation near rice fields for natural enemies/0%; conserving insect predators by preventing their capture from rice fields/0%). Table 5.3 also shows that all conservative methods are implemented by very limited percentage of farmers (0 – 32.3%).

The technical knowledge and actual practice toward conservation of farmers around Xuan Thuy National Park are **similar low** as compared with those in non-buffer regions. According to Rodriguez et al. (2009), farmers in Southern US states rarely adopt biological IPM control (15.33%), IPM-pesticide management (21.60%), crop rotation (26.48%), and soil testing (29.27%). In the research of Nakano et al. (2018), the adoption rates of farmers in improved rice production technology in Tanzania range from 26.67 - 46.15%.

Barriers to adoption of agroecological-based practices:

The most frequently barriers to the limited use of agroecological-based methods in this area have been reported:

- Soil fertility management methods: Farmers have limits on their own energy and time. Soil fertility management methods require for more labour and time consuming as compared with conventional ones. If they use hired labour, it could reduce their profitability. Poor economic situation of local farmers as well as and high incentive for profits are barriers to the adoption of environmental friendly practices.
- Site specific integrated nutrient management: Farmers face unavailability as well as inaccessibility of conservation equipment to test soil fertility. There are no public and private shops or other places to sell and provide the tools for farmers.
- Integrated pest management:

- First, integrated pest management practices need longer time between treatment and effect than chemical pesticides. However, farmers lack understanding of long-term benefits of these methods. In this area, there are no demonstration farms to convince farmers to follow the good practices.

- Second, ongoing habits limit the involvement of farmers in good practices. Farmers feel convenient with things that their parents and neighbours do. New things become unfamiliar for farmers. Farmers also perceive complexity when changing current activities.

- Third, lack of institutional supports for sustainable practices: Shortage of environmental friendly programs as well as agricultural advisors restrains to learning process and application of farmers. Farmers wonder the practices will work in their soil/farms without reduction of yield?

5.2.2.1.2 Current practices

Land preparation	Sowing land with rice	Transplanting rice	Pesticide spraying	Harvesting rice grains	Burning straw

Figure 5.3: Main activities of RB cultivation

1. Land preparation

The RB system depends mainly on irrigation and some rainfall with low application of intensive technology. Farmer use machines in two stages (plow land and harvest grain). Animals are no longer used in production (Figure 5.4). Four-wheel motorized tractors or hand-pulled tractors are used in soil tillage by all of the respondents. A small number of residues from previous crops and organic manure are incorporate in the plowing. Soil is plowed to become puddle and levelled. Farmers do not apply the non-tillage method.

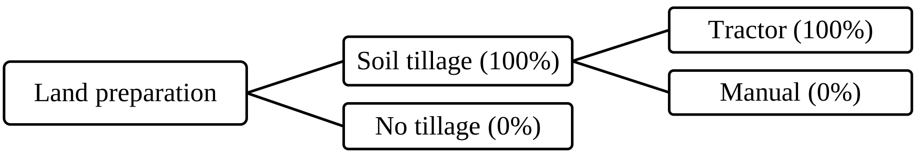


Figure 5.4: Land preparation stage of RB cultivation
(Source: Survey, 2018)

2. Seedling preparation and transplanting

Rice seedlings were manually transplanted (90% respondents) or direct seeded (sa lua) (10% respondents) with plentiful varieties. The majority of farmers (70%) bought seeds from communal agricultural cooperative and local traders in villages, while a small number of respondents used self-produced varieties (Figure 5.5). Farmers carried rice seedlings from the nursery into fields and transplant by manual with the density of 2-3 seedling/hills. Seedlings were grown at a 1-2 cm depth. The distance from the hill to the hill was ranged from 20 x 20 cm to 25 x 25 cm.

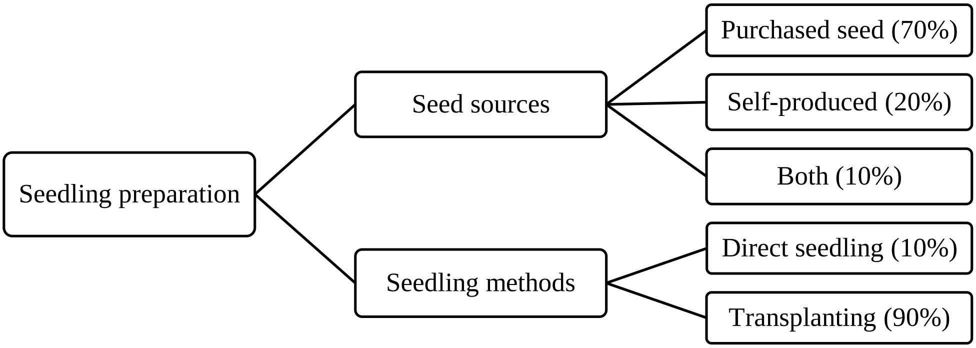


Figure 5.5: Seedling preparation stage of RB
(Source: Survey, 2018)

3. Fertilizer application

Figure 5.6 shows the fertilizer utilization during rice growth. Farmers expect for increasing productivity through fertilizers. Farmers in the buffer zone of Xuan Thuy National Park combined blend NPK (nitrogen – phosphorus – potassium) with single N (nitrogen) and K (potassium) for grain yield improvement. All of the surveyed rice farms were cultivated with compound NPK (100% respondents), N (100% respondents), and K (96.8% respondents). The problem is that majority of farmers are applying only chemical fertilizer to land, while only 32.3% of farmers still used organic sources (compost and manure).

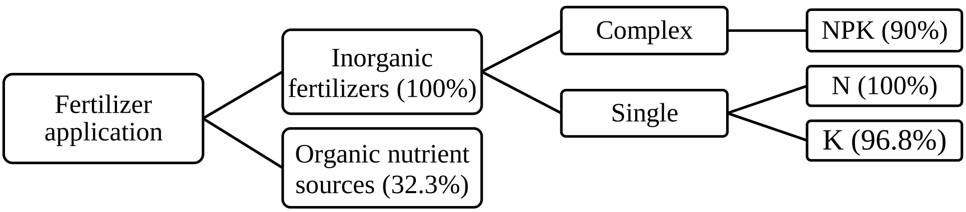


Figure 5.6: Application of fertilizers in RB
(Source: Survey, 2018)

There were diverse kinds of NPK fertilizers with different ratios of pure N-P-K that were used in this area such as NPK (16-16-8), NPK (5-10-3), or NPK (5-12-3), etc. However, most farmers were unable to understand the meanings of the ratios.

4. Weed control

Weeds are one of the most serious constraints to rice because weed competes with rice for light, water, nutrients, and space. Figure 5.7 shows two methods of weeding in Xuan Thuy National Park's buffer zone including chemical weed control (herbicides) (80.21% of our respondents) and manual weeding (19.79% of our respondents). Farmers preferred herbicides because this method needs less labor and has faster effectiveness. A small percentage of farmers recognized the negative impacts of herbicides for grain quality, they, therefore, applied hand weeding. They removed weed manually after about 20-25 days after transplanting time or about 30-35 days after direct seedlings.

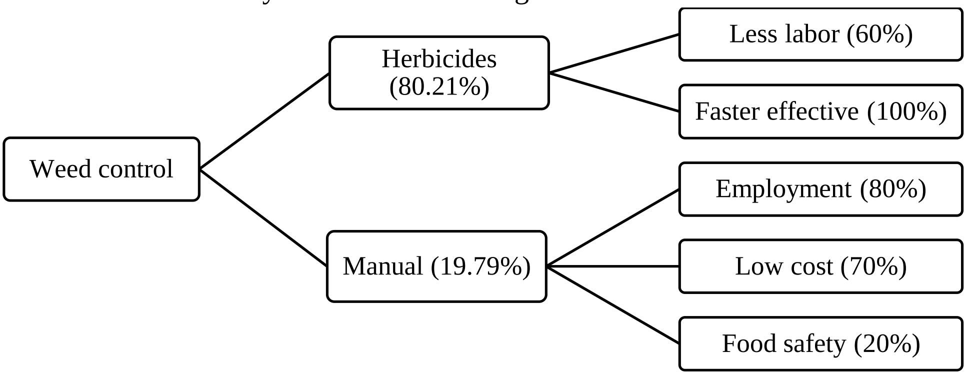


Figure 5.7: Weed control of RB
(Source: Survey, 2018)

There are a few numbers of farmers (10% of respondents) removed weeds by hand after about 20 days since transplanting or about 30 days after direct seedlings. Farmers repeated weeding the second time or more. Manual weeding provided employment and lower cost for farmers, especially poor farmers. However, several farmers recognized the negative impacts of herbicides for rice quality; thus, they apply hand weeding.

5. Pest and disease control

There were 100% of our respondents often applied chemical methods to eliminate pests, snails, or funguses when receiving announcements of communal authorities instead of basing on field observation. They did not consider environmentally-friendly methods before spraying chemical pesticides (Figure 5.8). Besides chemical inputs, a moderate proportion of farmers destroyed eggs of caterpillars and snails (20.8%) or protecting insect predators such as toads and birds (10.4%).

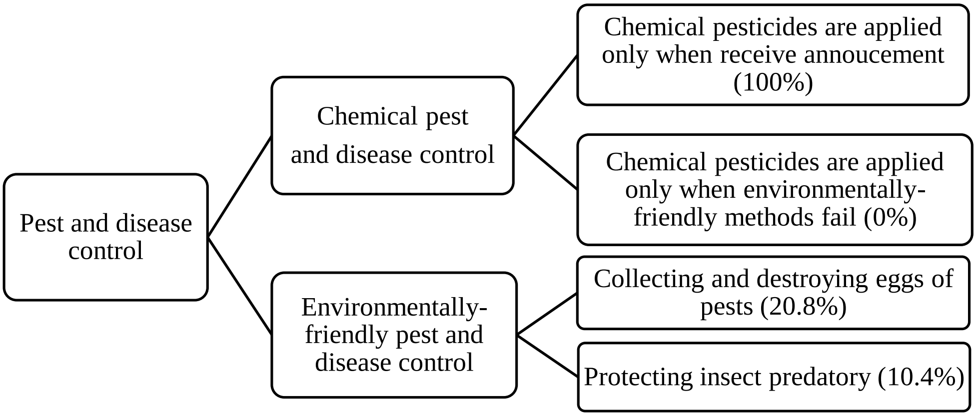


Figure 5.8: Pest and disease control of RB
(Source: Survey, 2018)

6. Residue management

As the intensive level has increased in rice cultivation, the yields have increased but the using area of straw has decreased rapidly. Farmers in the surveyed site mainly consider rice straw a form of waste, so burning straw is very common practices of almost farmers (84.3% of respondents), whereas, the moderated percent of the residue were composted with household wastes (6.2% of respondents) or carried home to use as fodder for animals (9.5% of respondents) (Figure 5.9). Farmers prefer to burn the disposal because this practice is cheap and quick before starting the next crop, whilst farm residue has not regulated by local authorities and Xuan Thuy National Park management board.

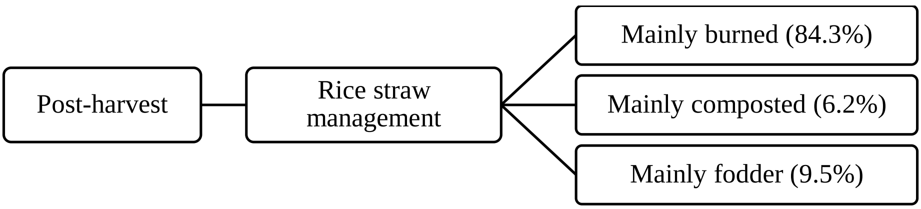


Figure 5.9: Crop residue management (% of respondents)
(Source: Survey, 2018)

Rice straw burning is concerned not only for public health hazards but also for the environment. We have asked a total of 96 RB farmers about whether they got negative effects from rice straw burning practices. Levels of the effects ranged from very low to very high. There were the majority of RB growers claimed the high effect from burning smoke for the air quality (58.3% of total respondents) and directly for their daily activities (70.8% of total respondents) due to the close distance between resident areas and fields, meanwhile, 81.3% farmers did not recognize the effect of burning straw on the soil due to lack farm management knowledge and soil analysis. According to many authors, the burning of crop residue causes damage to other micro-organisms in the upper soil layer as well as its organic quality. The solubility capacity of the upper layers of soil has also been reduced. On average, 1 kg of rice straw burning on the field releases 1.46 kg CO_2, 34.7 gm CO, and 56 gm of dust (Gadde et al., 2009). For the harms on the environment, stubble burning is prohibited in many countries but not in this area.

Table 5.4: Problems of rice straw burning (% of respondents)

Effects	Do not know	Very low	Low	Medium	High	Very high
Polluted air	-	-	-	41.7	58.3	-
Impacts on the soil property	81.3	-	-	-	17.7	-
Impacts on the daily life activities	-	-	-	29.2	70.8	-

(Source: survey, 2018)

7. Post-production and marketing

Post-production includes harvesting, bundling, hauling, threshing, drying, cleaning, storage, milling, and grading of rice (Figure 5.10). Farmers harvested grain when the majority of them became mature. There were 97.9% of farmers hired machines to harvest rice and 2.1% of the harvested rice by hand. Then farmers quickly shreshed rice grain by machines (100% of respondents) on the fields to prevent the attacks of rats, insects, or pathogenic fungi. Rice grains were dried in open sunlight to remove moisture content. When the moisture rate was low, farmers removed unfilled grains by fan winnowing. At the following stage, farmers stored grains and seeds in woven plastic sacks or airtight containers to prevent absorbing moisture from outside and damages by rats during months.

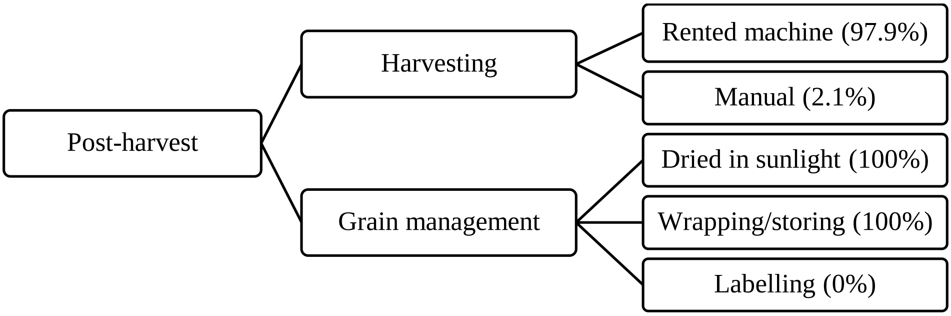


Figure 5.10: Post-production of RB cultivation
(Source: Survey, 2018)

Most of RB growers sell about 40% of the harvested products annually to local private shippers at their farms or final customers in local markets in buffer communes. None of the below activities in marketing were done by RB farmers except preservation (drying in sunlight then wrapping). Rice products have not approved by third-party certification such as Global Good Agricultural Practices, Vietnam Good Agricultural Practices.

Table 5.5: Marketing activities of RB farmers

Marketing activities	RB (% of respondents)
Preservation	100.00
Processing	None
Packaging	None
Labelling	None
Registering and being approved a patent to the Vietnamese Office of the Intellectual Property	None
Product safety approval	None

(Source: survey, 2018)

5.2.2.2 Intensive shrimp system

5.2.2.2.1 Knowledge of farmers and application of agroecological-based practices

Based on the Manual of Best Management Practices for White Shrimps (Penaeus Vannamei) Farming guided by Fisheries and Aquaculture Organization of Central American (OSPESCA) (Cuellar-Anjel et al., 2010). It has control points related to quality management, water monitoring and chemical use. We have investigated the levels of knowledge of eco-friendly practices and their application in this study site. Likewise RB, the results show the low level of knowledge and application of eco-friendly practices in ISH among the communities.

Table 5.6: Knowledge and application agroecological-based practices in ISH

Methods	Percent of farmers know	Percent of farmers applied
1. Farm design and building		
- Having separate canals for water input and output	100.0	100.0
- Avoid discharges to sensitive environments	100.0	29.6
- Maintaining riverside vegetation/buffer zone between ponds and adjacent water bodies for restoration of natural habitats	0.0	0.0
- Maintaining vegetation buffer zones among the mangroves/rivers	0.0	0.0
2. Water quality monitoring		
- Pond water monitoring should be done at the water pond gates	100.0	100.0
- Pond water monitoring should be done at the water outcoming pond gates	81.2	0.0
- Evaluating effluents (water used and discharged) with reference to the quality of receiving water bodies	79.6	0.0
3. Water exchange		
- Minimize water exchange without affecting shrimp production	46.3	38.9
4. Veterinary drugs and chemical products		
- The use of veterinary drugs and other chemicals should be recorded well	40.7	29.6
- The use of veterinary drugs and other chemicals should follow the manufacturers' recommendations (doses, store, disposal, etc.)	76.0	61.1
- Antibiotics should not be used for preventive plans	42.6	35.2
- Expired veterinary products should be removed under a not environmental contaminating way	100.0	100.0
- Waste and sludge after the treatment should not be used/discharge to the water bodies until these compounds have had enough biodegradation time	44.4	37.0
5. Disease management		
- Cooperating and communicating with neighboring farms for common problems of disease spread	64.8	31.5
- Testing diseases for new shrimp PLs before stocking	46.29	0.0
- Dead or sick shrimps must be handle to avoid disease spread to other farms	63.0	53.7
- Use recycle water instead of water exchange during disease occurrence	0.0	0.0

- Giving adequate times for degradation of disease before discharging into water bodies	44.4	33.3
6. Pond effluent management		
- Implement water circulation system to reduce water consumption and effluents	33.0	0.0
- Sedimentation and reservoir ponds store sufficient volume of anticipated water for daily used	31.5	0.0
- Using sedimentation ponds/traps to reduce suspended material and increase effluent quality	74.0	33.3
- Wastewater should be treated under environmentally responsible manner before discharging to the water bodies	100.0	40.7
- Mangroves should be planted on discharge channels as natural filters	9.3	9.3

(Source: Survey, 2018)

Barriers to adoption of agroecological-based practices:

- Farm design and building: Some of farmers face limited land and capital for designing canals for wastewater treatment and low perception of environmental protection lead to the discharging of pond sludge to the common rivers.
- Water quality monitoring: Tests and treatment for farm effluents incur higher production costs. So, farmers do not prefer this kind of "extra" work which leads them to lower profits. In addition, water quality assessment is not compulsory in this area. The standards for farm effluents are existing but lack of implementing and monitoring.
- Water exchange: Most farmers believe that more frequency of water exchange provides the cleaner condition for shrimps. So, they exchange water daily which resulting in more dependency on water quality from outside.
- Veterinary drugs and chemical products:
  - The old habits and time-consuming prevent farmers to record the use of chemical products daily.
  - Belief in antibiotics' effects: Most farmers believe that antibiotics can ensure a stable yield of shrimps in unfavorable environments. So, they often apply antibiotics as a preventive method.
  - More farmers lack pond ecology knowledge, so a small number of them can wait until compounds of waste have enough biodegradation time.
- Disease management:
  - Farmers only communicate with their neighbors to build the electricity system at the starting stage of farm preparation. After that, they work individually in their ponds. Lack of common interest groups leads to low

cooperation and communication among communities when disease occurrence and spread in the region.

- Farmers buy PL shrimps from companies in the central or south of Vietnam. They do not own equipment to test the shrimp quality before releasing point. When shrimps get diseases, farmers increase the frequency of water exchange to pump cleaner water from rivers.

- Pond effluent treatment:
  - The dearth of land and shortage of financial sources are barriers to build reservoir ponds for water circulation and sedimentation ponds for effluent treatment in this area.
  - Limited land and lack of knowledge on farm ecology prevent farmers grow mangroves on discharge areas as filters.
  - The majority of farmers resist applying standard treatment methods for farm effluent because it causes higher expenses for their own production. Plus, low awareness of environmental preservation and lack of law enforcement hinders famers from responsible treatment of waste before releasing to the water bodies.

5.2.2.2.2 Current practices

Pond preparation | PL releasing | Feed preparation | Harvesting | Emptying

Figure 5.11: Main activities of ISH culture

1. Selection of species culture

White-legged shrimp (Litopenaeus vannamei or Penaeus vannamei), is also known as Pacific white shrimp, live in tropical areas (Figure 5.11). Eggs (spawns) of shrimps have diameter sizes less than 1/64 inch and alive in high salinity oceanic water. The lauplius are plankton in the ocean and they have limited swimming ability. Protozoea has sizes from 1/25 to 1/12 inch and they have mouth and abdomen parts. Mysis stages have sizes ranging in 1/8-1/5 inch with their early development of legs and antennae. Postlarvae have sizes from 1/6-1/4 inch with walking and swimming legs. Shrimp adults have a length of 5-8 inches.

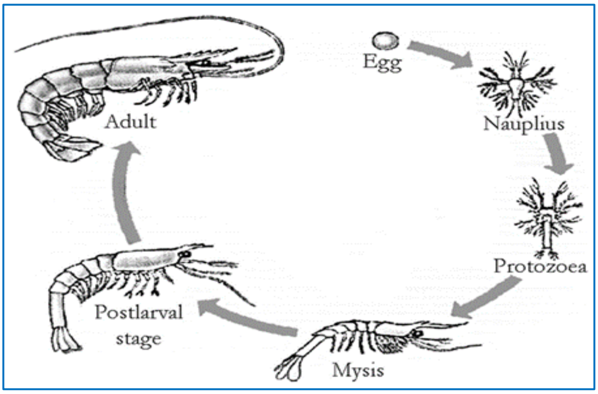


Fig 5.12: The life cycle of white-legged shrimps

Shrimp seeds firstly imported from Hawaii and Thailand but currently, hatcheries in Vietnam can produce and supply around the country. Farmers in Xuan Thuy National Park's buffer area do not have nurseries or hatcheries for producing white-legged PLs, so the PLs are transported from other Southern Vietnam provinces. White-legged shrimps were introducing to stock in this area firstly since 2014.

2. Pond design and preparation

Shrimp farms in the buffer zone situated in non-mangrove areas along Vop and Tra rivers and Ba Lat estuary or nearby integrated mangrove-aquaculture farms. All of ISH farms were previously rice-shrimp production system. Farms have an average size of 1.6 ha and their rearing ponds can be drained, dried before stocking. A farm normally consists of several rearing ponds, supply canals for inlet water, drainage canals for outlet water, and support facilities (living quarters, warehouses, road, etc.). The supply reservoir canal is constructed separately with an effluent treatment canal to avoid contamination for intake water sources. All of the surveyed farms have a supply canal, but 20% of respondents do not design farms with an effluent treatment area due to the shortage of capital investment, limited land, or low awareness of farmers.

Rectangular or square ponds were built for ISH shrimp culture. Each rearing pond has a size of 1,000-1,500 m^2 and an average depth of 1-1.2 m containing around 1,200 – 1,500 m^3 of water. Ponds are square or rectangular. Between two crop cycles, the bottom of ponds was dried for several weeks for cleaning. Pond embankments are constructed by concrete and covered with nylon to avoid leakage. In the middle of the pond, the bottom is served as wastes and residues collecting.

Pumps are also used in this pond. Two sluice gates for water exchange are located in the two corners of the ponds. Two aeration device systems are available for daily water circulation in each pond.

There were 80% of ISH farms reported the difficulties in access to electricity for aeration operation inside shrimp ponds. Due to the lack of available low voltage grid in this area, farmers have to invest a huge capital for building low voltage poles and lines. There were no supports for improving infrastructure for starting ISH farming from the government.

Many farms (70% of farms) locate nearby the area of garbage which flows from resident zones and upstream and settles there.

In the preparation stage, ponds were treated by cleaning the bottom and embankment. Intake brackish water was pumped into ponds. Farmers used aquaculture chemicals for brackish water with treatment methods to eliminate algae, grass and predatory, adjust pH and disinfect pathogens.

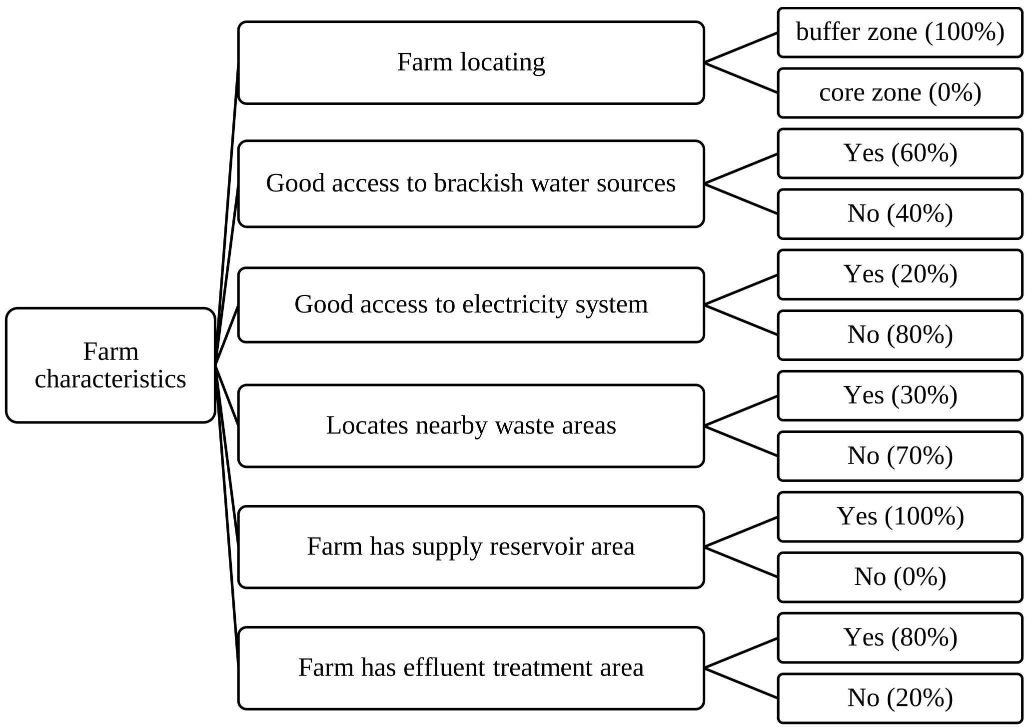


Fig.5.13: Farm characteristics of ISH cultivation
(Source: Survey, 2018)

3. Seed supply

There were 100% of ISH farms relied solely on hatchery-raised seeds. Farmers bought quality-control seeds from hatcheries in Nha Trang and Ben Tre southern provinces of Vietnam. Farmers stocked white-legged PLs with size PL12-15 (PL12 has 9-11 mm in length), which were screened for viruses before stocking. The hatchery transported PL shrimps in plastic, fiberglass, or tanks with seawater, aeration, and low temperature (about 22-25^oC) in about 10 hours of traveling. While-legged PLs were stocked at the rate of fries about 75 PLs/m^2.

4. Feed supply and drug use

The grow-out takes about 90-100 days for the first season and 110-120 days for the second season. Farmers used formulated complete feed which is provided by various companies in the market such as Beyer Vietnam,Vinh Thinh Biostadt, or Newkeys Vietnam. Farmers provide large amounts of pellet feed and feed supplements meet the nutrition requirements and maximize the growth of shrimps.

The feed is in pelleted forms with main ingredients from soybean, wheat flour, and fishmeal for the needs of energy as well as protein. Feeds are prepared about three times per day and given into pond surface by broadcasting. Feeding trays (feed check trays) are used in separated ponds to check food consumption and prevent feed wastage. Trays are simply made from bamboo strips or polyethenlene screen. Each pond is placed with one tray. In this area, farmers apply hand feeding. Automatic feeding devices (feeders) have not been applied to check feed in interval time. The feed conversion ratio (FCR) is estimated by the total weight of pellet feed consumed (ton) divided by the total yield (ton). The FCR of ISH in this area was estimated at 1.17 which implied that 1.17 tons of pellet feed are needed to produce 1 ton of shrimp body live weight.

Pelleted feed, additives (hormones, minerals, vitamin), disinfectant (chlorine) and their usage are guided and pushed mainly by private traders. Farmers used both probiotics and antibiotics for the cultivation. All of the pellets, drugs and additives are stored in small rooms to minimize insect infestation. This production stage requires a high degree of specialized managerial skills of farmers, technical supports as well as advanced infrastructure.

Aquaculture chemical is a substance, pure or mixed, with a distinct molecular composition that is produced by or used in a chemical process. The drug is any chemical compound used in the diagnosis, treatment or prevention of disease or other abnormal conditions. Aquaculture chemicals and drugs available on the market in this area have a wide variety. Farmers used chemicals and drugs for pond preparation, pest control, water quality management, disease treatment and control, shrimp health improvement. High yield and profitability incentives have led farmers in this area to use an extensive range of chemicals and medicines due to the immediate effects.

Table 5.7 summaries the main aquaculture chemical and medicines in the buffer zone of Xuan Thuy National Park. They can be categorized into five groups based on the purpose of uses including disinfection (bactericide), disease prevention and control, supplement, pond water management, and antibiotics.

Table 5.7: The use of main aquaculture chemical and medicines in ISH

Categories	Tradename	Purpose of use
1. Disinfection (bactericide)	Clear 88	Killing bacteria and viruses. Curing diseases of white spot, yellow-head, a disease in antennae and tails, black gills. Controlling glowing algae, killing toxic algae. Cleaning shrimp effluent in pond bottoms. Cleaning viscosity, suspended and reducing foam in pond water.
	Key Din 90	Killing bacteria and viruses. Curing diseases of black gills and yellow-head. Cleaning sludge and residues in pond water.
	BKC (Benzalkonium Chloride)	Cleaning ponds and tools, intake water. Curing diseases by bacteria of Edwardsiella**,** Vibrio**,** Staphylococcus**,** and Aeromonas.
	Chlorines	Cleaning ponds, tools, and water of ponds. Curing algae and diseases by bacteria or viruses.
2. Medicines for disease prevention and control	All lacto	Balancing and developing intestines of shrimps. Strengthening the immune system and digestion of shrimps. Reducing Feed conversion ratio (FCR).
	Key big	Strengthening liver and pancreas of shrimps. Curing infections and restraining oxidants.
	New plex	Hardening the shell and meat of shrimps. Controlling water quality. Preventing muscular cloudiness and curved. Curing parasitic diseases.
	C-plus	Improving the immune system of shrimps when water changes of pH, salinity, and temperature, reducing the stress of shrimps, curing shock when being released into ponds.
	Osamet shrimp	Curing the atrophy liver of shrimps.
3. Supplement	Top bill	Stimulating shrimps to eat food and gain weight. Providing vitamins, minerals, and protein.
	Megabic	Providing calcium, phosphorus to harden shrimp's shell. Improving shrimp's intestines and digestion.
	Oli-mos	Strengthening natural immunes and livers of shrimps. Providing beta-glucan and vitamin E for shrimps
4. Pond water management	Oxy gene	Providing oxygen for shrimps especially in the bottom of ponds and weather changes.
5. Antibiotics	Baymet	Eliminating bacteria of shrimps

(Source: In-depth interview with the aquatic technician in Xuan Thuy National Park's buffer zone, 2018)

However, tradenames and ingredients of the aquaculture chemicals were not always clear to farmers. Most of the respondents were unable to understand the ingredients of veterinary medicines or classify them into the five groups. Most of users do not have basic knowledge of the microbial, virus, or aquatic disease, either. Private companies' technicians visit farms frequently to guide farmers to use inputs until practices become habits.

Farmers use chemicals based mainly on consultation from input traders or technicians and veterinarians of input companies. Not many farmers have practiced record-keeping on the application such as dosage, species treated, methods of application, etc. Users have not tested indicators of water, wastewater and after using. This leads to the unavailability of documents for chemical residues in this area. There is no traceability, either. Proper dosages help to control water quality and disease and improve the growth of aquatic species. But usages without an understanding of pond ecology and drugs' runoff can kill beneficial organisms or non-target habitats and cause other negative consequences on habitat networks in non-farmed areas.

Antibiotic is a substance produced by or derived from a certain fungus, bacteria or another microorganism, that can destroy or inhibit the growth of other microorganisms. Antibiotics have been applied in aquaculture for treating bacterial infection. In the first year of ISH cultivation (the end of 2014), there were 100% of aquaculturists applied antibiotics to prevent and disease treatment. In the following years, more farmers experience low effectiveness in disease treatment and increasing costs of antibiotic use; therefore, they reduce the dosage.

The proportion of farms fed by antibiotics was 87.04% as preventive measures (in 2018). Antibiotics are recognized as environmental hazards because they are toxic to microorganisms and phytoplankton. They also are potential long-term exposure and this can disrupt reproduction. Antibiotics disrupt the basis of the food web, local bacterial communities, and ecosystem functions such as nitrification. As mentioned earlier by FAO (2002), the selection of appropriate inputs should be based on solutions that combine traditional knowledge and modern technology and assist farmers in investing in the maintenance of natural resources.

5. Intake water and wastewater treatment

This stage requires skills in remaining pond water quality and exchange, mechanical aeration, and disease control. The water level is maintained at a depth of 1-1.3 m throughout the culture period by pumping water into ponds. Most ponds exchanged their water on a regular basis because farmers believed that the frequent exchange provides cleaner water for a high stocking density of shrimps. The proportion of water exchange was 20% of total water in ponds. There are two aerators in a 1,500 m^2 pond. The aerators operate for about 10-14 hours per day depends on the stages of shrimps to increase oxygen in the water column and accumulation of waste in the bottom of ponds. Waste and other shrimp effluents in center bottom ponds were removed daily. Farmers release the waste into drain canals or surrounding rivers depend on the location of farms.

In this area, ISH culture adopted the open water exchange system. Water is essential for shrimps and farmers to have to exchange water daily to maintain appropriate conditions. Farmers then have to drain 20% water from culture ponds and acquire make-up water for replenishment. For this reason, ISH needs a large amount of brackish water during the grow-out period.

Giao Thuy district DARD consults the standards for intake water for white-legged shrimps as distinguished in Table 5.8. Initial treating ponds were applied by all of ISH farmers to ensure suitable intake water standards and remove predatory or unwanted organisms before releasing shrimps into ponds. However, not all of the suggested indicators were tested due to the lack of investment in testers or testing tools.

Table 5.8: Intake water quality standards for white-legged shrimps

Indicators	Value range
DO	> 6 mg/l
pH	7.5 – 8.5
Salinity	5-25‰
Alkaline	120 - 150 mg/l
Water clarity	30 - 40 cm
NH_3	< 0,1mg/l
H_2S	≤ 0,01 mg/l

(Source: DARD of Giao Thuy district, 2018)

Waste and pond effluent are uneaten feed, shrimp shells, or organic and inorganic matters were discharge daily to drainage canals of farms or to common rivers. After harvesting, a large amount of pond sludge was released to these places. In the farm visits, there were only 40.7% of farmers applied the several techniques of wastewater treatment such as use lime or dry the waste before releasing into the natural environment (Figure 5.15). ISH farms in this area were often criticized by locals for the disposal of wastewater and sludge, but they did not know how to tackle this problem in the long-term.

In this area, there are no models of “zero water exchange” or “recirculation” to release less potentially damaging effluents (organic and inorganic) into the surrounding rivers and ruduce disease effects from outside environment. Figure 5.14 presents the use of clean water for intake ISH ponds and the disposal of pond effluents to rivers.

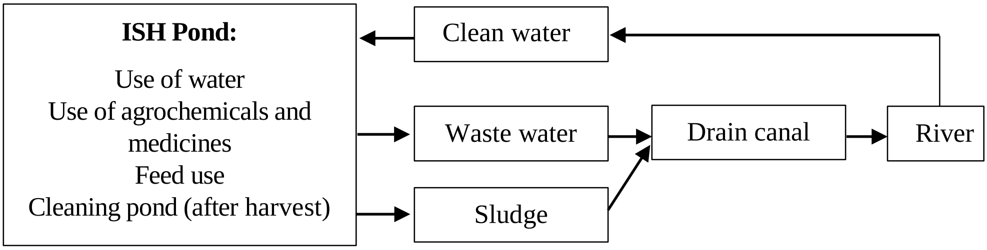


Figure: 5.14: Water use and discharge of ISH farm effluent
(Source: Survey, 2018)

Regulations of farm effluents and water quality standards issued by MARD requires every individual and organization working in aquaculture raising in Vietnam to apply (Table 5.9)

Table 5.9: Wastewater quality standards for brackish shrimp aquaculture

Indicators	Value range
pH	5.5 – 9
BOD_5	≤ 50 mg/l
COD	≤ 150 mg/l
Suspended solids	≤ 100 mg/l
Coliform	≤ 5000 MPN/100 ml

(Source: Decree 22: QCVN 02-19: 2014-BNNPTNT: National technical regulation on brackish water shrimp aquaculture - Conditions for veterinary hygiene, environmental protection, and food safety, issued by MARD in 2014).

The treatment methods require technique and facilities such as drainage ponds, inoculation, algae and probiotics. Nevertheless, none of IAM and ISH respondents used toolkit to test indicators for wastewater and sludge. The majority of ISH farmers were reluctant to apply treatment methods for sludge and sewage before draining to rivers.

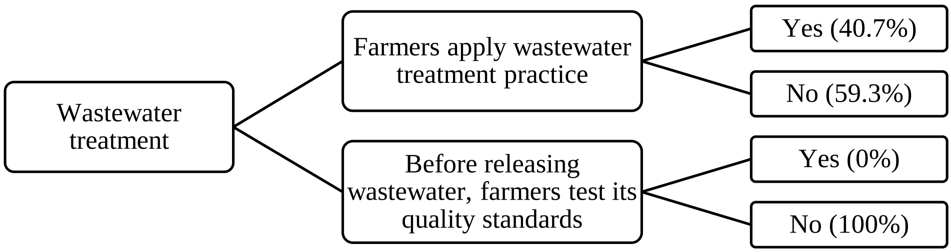


Figure 5.15: The application of wastewater treatment in ISH cultivation
(Source: Survey, 2018)

The regulations on the effluent treatment of the government were not strictly enforced by organizations in this site. There was neither commitment to treat wastes nor incentives for the treatment in this area. Since shrimp ponds use water from rivers, more disposals of untreated effluents to the environment leads to higher rates of disease infection and pollution through intake water. According to the DARD of Giao Thuy district, they lacked sufficient facilities, laboratories, and staff to monitor and enforce aquaculture production in this area.

6. Harvesting and marketing

Shrimps are harvested one time or when a lot of stocks reach the marketable size (about 70-80 pieces/kg). The harvesting net is installed in the pond with a mesh size to retain all of the shrimps. After harvesting, shrimps are placed immediately in chilled water (10–15°C) in the styrofoam box provided by middlemen for transportation by trucks to northern provinces such as Ha Noi, Hai Phong, Quang Ninh, etc. None of the below activities regarding marketing were done except preservation by ISH farmers. Shrimp products have not been approved by third-party certification.

Table 5.10: Marketing activities of ISH farmers

Marketing activities	**ISH (% of respondents)**
Preservation	100.00
Processing	None
Packaging	None
Labelling	None
Registering and being approved a patent to the Vietnamese Office of the Intellectual Property	None
Product safety approval	None

(Source: survey, 2018)

5.2.2.3 Integrated aquaculture-mangrove system

Farm preparation | PL releasing | Water management | Harvesting | Emptying

Figure 5.16: Main activities in IAM culture

1. Selection of species culture

Black tiger shrimp (Penaeus monodon) has other common names as giant tiger prawn or Asian tiger shrimp (Figure 5.17). These shrimps mature and breed in tropical marine habitats. Larvae, juveniles, and sub-adults occupy coastal estuaries and mangrove areas. They were introducing to stock in Xuan Thuy National Park's buffer area since the 1986s.

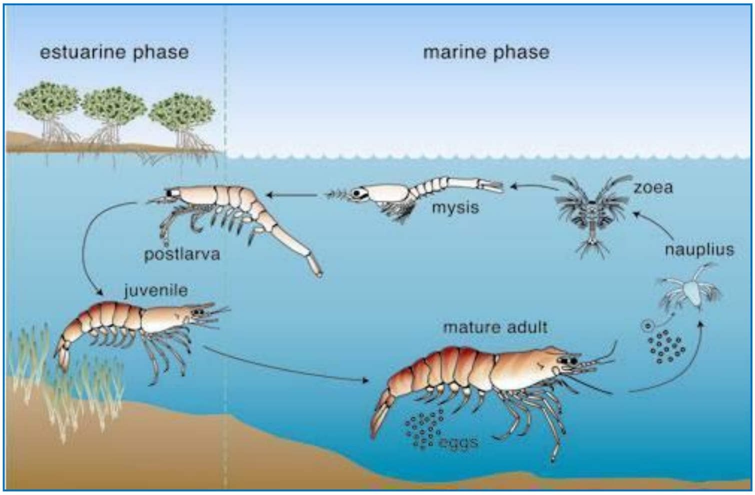


Figure 5.17: The life cycle of black tiger shrimps

2. Pond design and prepareasing

The system combines extensive aquaculture species farming with mangrove trees. All of IAM farms were previously mangroves. Since 1986s, mangroves were cut to provide space for aquaculture raising. The average farm size was 6.82 ha/farm owner, in which scattered mangroves were maintained with about 24.28%

total area, as self-reported by respondents. Farm ranged in size from 2.2 to 20 ha with its bund. There is no standard design for an IAM pond. Earthen embankment around farms is constructed as boundaries to indicate the size and shape of farms. The boundaries (bund) are constructed through digging and ponding of earth by mainly man-power. Mangroves are integral within ponds and on dike inside ponds to protect against storm surges and provide wild feedstock, organic waste for food, shade, and root structures for marine stocks. Mangrove cutting and harvesting are not legally permitted. Water control gates (sluice gates) were constructed from concrete and wood. Concrete gates were built to have adequate capacity for the required amount of water to be taken in or drained out. A gate has several grooves for harvest nets to reduce the risk of escape. A net is attached to a gate for harvesting. Farmers dig trenches (ditches) through machines with a depth of approximately 2 m inside farms to prevent hot temperatures during summers.

(a) (b)

Figure 5.18: Mangrove density: (a) in Xuan Thuy National Park, (b) in IAM ponds in the buffer zone

3. Seed supply

In IAM culture, black tiger seeds are hatchery-raised transporting from Ben Tre and Nha Trang provinces. However, 100% of crab seeds were bought from farmer harvesters who involved in the exploitation of natural resources around Xuan Thuy National Park wetland area. Besides, wild-caught shrimps (greasyback – Metapenaeus ensis) and diverse wild-caught fish species are captured from rivers into the mangrove ponds base on the tides with the operation of sluices. This system is cultured with the co-existence of hatchery-raised seed (black tiger shrimp) and wild-caught seeds (crabs, greasyback shrimps, and fish). Farmers stocked black tiger PLs with size PL15- PL20 (PL15 has 12 mm in length). Black tiger shrimp PLs were reared at a stocking density of 5.47 PLs/m^2.

4. Feed supply

The IAM system is operated mainly with wild food and little use of supplemental feed. In the first 20 days from the shrimp releasing point, farmers keep PLs in a small pond area (0.2-0.3 ha) which is built inside their farms. Post-larvae shrimps are provided supplement feeds in case tidal water supply insufficient food. Supplemental foods are wet feeds or dry pelleted feeds. Wet feeds (moist) were freshly prepared by using locally available ingredients including rice bran mixed with miscellaneous fish or bivalve. Sometimes, garlic is mixed with feeds to provide natural antibiotics for the health improvement of habitats. Dry pelleted feeds were bought from input traders in the commune to provide shrimps various nutrient sources at a certain time. Supplemental food was given to shrimps by broadcasting. After the 20 days, farmers release shrimps into the whole farms and they depend on natural food such as small crustaceans, mollusks, polychaetes, and other slow-moving benthic organisms through frequent exchanges with tidal water bodies. There is no use of fertilizers, drugs, chemicals or antibiotics that were applied in this system. Mangroves and frequent exchanges of natural water play important roles as serving nurseries and natural foods as well as a living environment for shrimps and other marine species.

5. Water management

Various indicators for intake water standard has been introduced and recommended by DARD of Giao Thuy district (Table 5.11). However, all of IAM farms have not been equipped with testers. At the point of PL releasing, some of IAM farmers asked the current salinity of brackish water from nearby ISH farmers. The other times of opening the sluice gate for intake water, farmers based on their experience and observation.

Table 5.11 Intake water quality standards for black tiger shrimps

Indicators	Value range
Dissolved oxygen (DO)	> 4 mg/l
pH	7.5 – 8.5
Salinity	5-25‰
Alkaline	80 - 120 mg/l
Water clarity	30 - 40 cm
NH_3	< 0,1mg/l
H_2S	≤ 0,01 mg/l

(Source: DARD of Giao Thuy district, 2018)

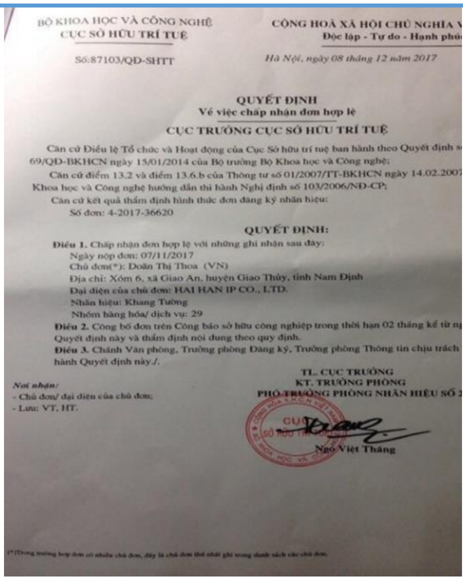
6. Harvesting and marketing

The stocks are harvested when reaching the marketable size (black tiger shrimps are at about 40 pieces/kg). Harvesting is usually done several times per month in the period from June-November. Aquaculture stocks are harvested by the use of a bag net installed at the drainage gate. Habitats that go with the drained water are collected at the bag net. The majority of IAM farmers does not involve in the standard development process. **There is only one IAM household registered and approved a patent to the Vietnamese Office of Intellectual Property**. The farmer (account for 1.19% of respondents) applied several marketing activities including conservation, processing, and designing packages. Many buyers in the whole country recognized these products as traceable signs. Besides, he approached final customers and sold online through customer groups and food-safety interest groups with hundred thousands of members from the north to the south of Vietnam. Accompanying these changes in marketing, buyers of these groups appreciate his products as organic and natural tasty. However, shrimps and co-products in this area have not approved by third-party certification such as Global Good Agricultural Practices, Vietnam Good Agricultural Practices, Best Aquaculture Practices, or HACCP which cover the aspects of ecosystem protection, food safety regulations and standards, and social responsibility.

Table 5.12: Marketing activities of IAM farmers

Marketing activities	IAM (% of respondents)
Preservation	1.19
Processing	1.19
Packaging	1.19
Labelling	1.19
Registering and being approving a patent to the Vietnamese Office of the Intellectual Property	1.19
Product safety approval	1.19

(Source: Survey, 2018)



BỘ KHOA HỌC VÀ CÔNG NGHỆ
CỤC SỞ HỮU TRÍ TUỆ

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA V
Độc lập - Tự do - Hạnh phú

Số:87103/QĐ-SHTT

Hà Nội, ngày 08 tháng 12 năm 2017

QUYẾT ĐỊNH
Về việc chấp nhận đơn hợp lệ
CỤC TRƯỞNG CỤC SỞ HỮU TRÍ TUỆ

Căn cứ Điều lệ Tổ chức và Hoạt động của Cục Sở hữu trí tuệ ban hành theo Quyết định s 69/QĐ-BKHCN ngày 15/01/2014 của Bộ trưởng Bộ Khoa học và Công nghệ;
Căn cứ điểm 13.2 và điểm 13.6.b của Thông tư số 01/2007/TT-BKHCN ngày 14.02.2007 Khoa học và Công nghệ hướng dẫn thi hành Nghị định số 103/2006/NĐ-CP;
Căn cứ kết quả thẩm định hình thức đơn đăng ký nhãn hiệu:
Số đơn: 4-2017-36620

QUYẾT ĐỊNH:

Điều 1. Chấp nhận đơn hợp lệ với những ghi nhận sau đây:
Ngày nộp đơn: 07/11/2017
Chủ đơn(*): Doãn Thị Thoa (VN)
Địa chỉ: Xóm 6, xã Giao An, huyện Giao Thủy, tỉnh Nam Định
Đại diện của chủ đơn: HAI HAN IP CO., LTD.
Nhãn hiệu: Khang Tường
Nhóm hàng hóa/ dịch vụ: 29
Điều 2. Công bố đơn trên Công báo sở hữu công nghiệp trong thời hạn 02 tháng kể từ ng Quyết định này và thẩm định nội dung theo quy định.
Điều 3. Chánh Văn phòng, Trưởng phòng Đăng ký, Trưởng phòng Thông tin chịu trách hành Quyết định này./.

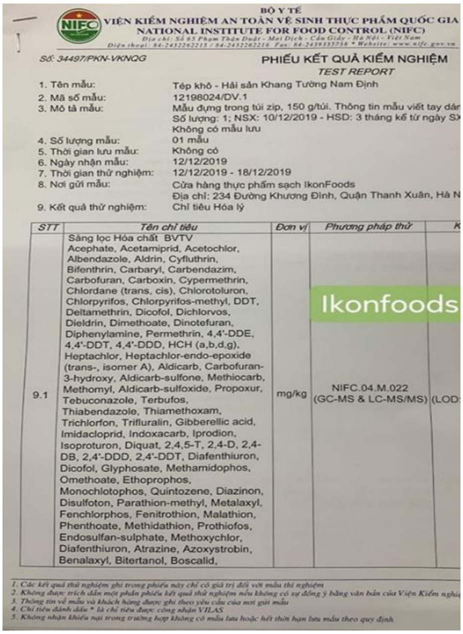
Nơi nhận:
- Chủ đơn/ đại diện của chủ đơn;
- Lưu: VT, HT.

TL. CỤC TRƯỞNG
KT. TRƯỞNG PHÒNG
PHÓ TRƯỞNG PHÒNG NHÃN HIỆU SỐ 2

Ngô Việt Thắng

Registering and Approved for Khang Tuong brand name by the Vietnamese Office of Intellectual Property

Package and brand name of IAM shrimps



BỘ Y TẾ
VIỆN KIỂM NGHIỆM AN TOÀN VỆ SINH THỰC PHẨM QUỐC GIA
NATIONAL INSTITUTE FOR FOOD CONTROL (NIFC)

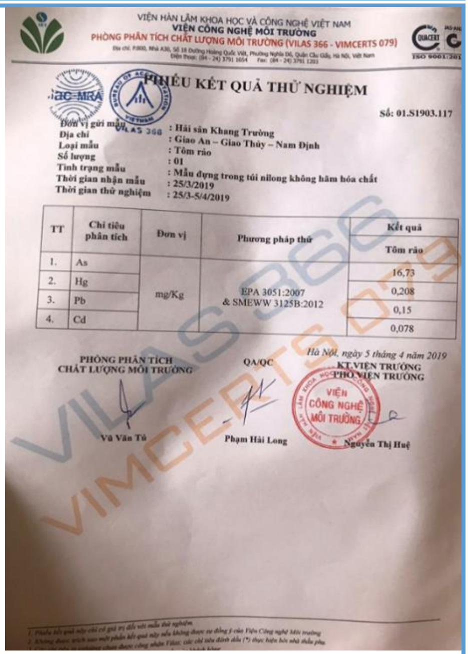
Số: 34497/PKN-VKNQG

PHIẾU KẾT QUẢ KIỂM NGHIỆM
TEST REPORT

1. Tên mẫu: Tép khô - Hải sản Khang Tường Nam Định
2. Mã số mẫu: 12198024/DV.1
3. Mô tả mẫu: Mẫu đựng trong túi zip, 150 g/túi. Thông tin mẫu viết tay dán Số lượng: 1; NSX: 10/12/2019 - HSD: 3 tháng kể từ ngày SX Không có mẫu lưu
4. Số lượng mẫu: 01 mẫu
5. Thời gian lưu mẫu: Không có
6. Ngày nhận mẫu: 12/12/2019
7. Thời gian thử nghiệm: 12/12/2019 - 18/12/2019
8. Nơi gửi mẫu: Cửa hàng thực phẩm sạch IkonFoods Địa chỉ: 234 Đường Khương Đình, Quận Thanh Xuân, Hà N
9. Kết quả thử nghiệm: Chỉ tiêu Hóa lý

STT	Tên chỉ tiêu	Đơn vị	Phương pháp thử	K
9.1	Sàng lọc Hóa chất BVTV Acephate, Acetamiprid, Acetochlor, Albendazole, Aldrin, Cyfluthrin, Bifenthrin, Carbaryl, Carbendazim, Carbofuran, Carboxin, Cypermethrin, Chlordane (trans, cis), Chlorotoluron, Chlorpyrifos, Chlorpyrifos-methyl, DDT, Deltamethrin, Dicofol, Dichlorvos, Dieldrin, Dimethoate, Dinotefuran, Diphenylamine, Permethrin, 4,4'-DDE, 4,4'-DDT, 4,4'-DDD, HCH (a,b,d,g), Heptachlor, Heptachlor-endo-epoxide (trans-, isomer A), Aldicarb, Carbofuran-3-hydroxy, Aldicarb-sulfone, Methiocarb, Methomyl, Aldicarb-sulfoxide, Propoxur, Tebuconazole, Terbufos, Thiabendazole, Thiamethoxam, Trichlorfon, Trifluralin, Gibberellic acid, Imidacloprid, Indoxacarb, Iprodion, Isoproturon, Diquat, 2,4,5-T, 2,4-D, 2,4-DB, 2,4'-DDD, 2,4'-DDT, Diafenthiuron, Dicofol, Glyphosate, Methamidophos, Omethoate, Ethoprophos, Monochlotophos, Quintozene, Diazinon, Disulfoton, Parathion-methyl, Metalaxyl, Fenchlorphos, Fenitrothion, Malathion, Phenthoate, Methidathion, Prothiofos, Endosulfan-sulphate, Methoxychlor, Diafenthiuron, Atrazine, Azoxystrobin, Benalaxyl, Bitertanol, Boscalid,	mg/kg	NIFC.04.M.022 (GC-MS & LC-MS/MS)	(LOD

IAM product was checked by the National Institute, Vietnam for Food Control



VIỆN HÀN LÂM KHOA HỌC VÀ CÔNG NGHỆ VIỆT NAM
VIỆN CÔNG NGHỆ MÔI TRƯỜNG
PHÒNG PHÂN TÍCH CHẤT LƯỢNG MÔI TRƯỜNG (VILAS 366 - VIMCERTS 079)

PHIẾU KẾT QUẢ THỬ NGHIỆM

Số: 01.S1903.117

Đơn vị gửi mẫu: Hải sản Khang Trường
Địa chỉ: Giao An – Giao Thủy – Nam Định
Loại mẫu: Tôm rảo
Số lượng: 01
Tình trạng mẫu: Mẫu đựng trong túi nilong không hàm hóa chất
Thời gian nhận mẫu: 25/3/2019
Thời gian thử nghiệm: 25/3-5/4/2019

TT	Chỉ tiêu phân tích	Đơn vị	Phương pháp thử	Kết quả Tôm rảo
1.	As	mg/Kg	EPA 3051:2007 & SMEWW 3125B:2012	16,73
2.	Hg			0,208
3.	Pb			0,15
4.	Cd			0,078

Hà Nội, ngày 5 tháng 4 năm 2019

PHÒNG PHÂN TÍCH CHẤT LƯỢNG MÔI TRƯỜNG — Vũ Văn Tú
QA/QC — Phạm Hải Long
KT.VIỆN TRƯỞNG PHÓ VIỆN TRƯỞNG — Nguyễn Thị Huệ

IAM product was checked by the Institute of Environmental Technology, Vietnam

Figure 5.19: Marketing activities and certified products of IAM

5.3 Outcomes toward agroecology

5.3.1 Socio-economic dimension

The socioeconomic outcomes of farms are presented in the articles: "Dynamics of farming systems under the context of coastal zone development: the case of Xuan Thuy National Park, Vietnam". Agriculture, 9(7), 138. Groups of authors: Nguyen, T. T. N., Tran, H. C., Ho, T. M. H., Burny, P., & Lebailly, P. (2019). In this article, diversity of farm products and yields, financial performances, dependency of farmers on external inputs are analyzed.

- **Diversity of farm products and farm yields**

In the monoculture production, farmers receive one kind of product: white-legged shrimps in ISH and rice grains in RB (Figure 5.20). In the polyculture production, IAM farmers receive various aqua-products including farmed products or target products (black tiger shrimps and crabs) and co-products (wild-caught shrimps: Metapennaus ensis, wild-caught fish: Mugil nepalensisreus, Bostrichthys sinénsi, Taius tumifrons, wild-caught bivalve, and seaweed). This form of aquaculture generates a range of outputs that work more with local ecosystems than being managed for production of one single product. The diversity of farm products increases farm productivities, reduces the viability of farm incomes, and diversifies sources of income for households (Makate et al., 2016). The cropping diversification helps farmers cope with declined profits if the price of one crop is lower than average in a season. In this coastal area, natural disasters occur very often (storms are usually from July-August) and climate change has effects on farms, cropping diversification help farmers to mitigate risks from natural hazards in the case of failure or damages one crop.

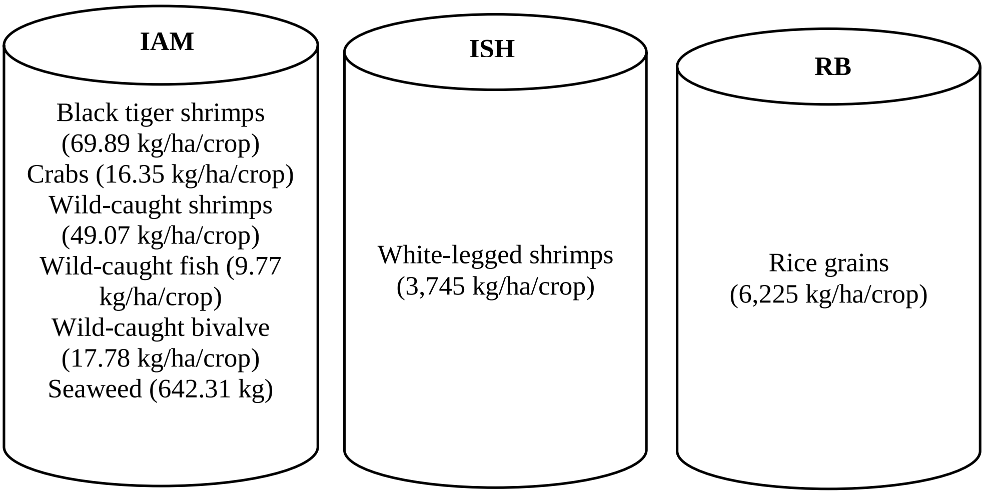


Figure 5.20: Products and yields of farming systems (Survey, 2018)

Farm yields measure the physical productivity of land in crops or aquaculture farming. It is an indicator of agricultural productivity expressed as the amount of farm outputs given a certain area and during a certain period. ISH has the most attractive cultivation for Nam Dinh PPC and local communities in terms of production volume. However, the farmed yield of ISH obtained 3,745 kg/ha/crop (with the stocking density of 75 PL/m^2) was at a medium level as compared with average Vietnam yield (3,469 kg/ha/crop with the stocking density of 31 PL/m^2) and Thailand (3,483 kg/ha/crop with a stocking density of 62.5 PL/m^2) (Engle et al., 2017).

RB yield was 6,225 kg/ha/crop, which was much higher than the Vietnam national average (5,547 kg/ha) (FAO, 2017).

IAM provided 69.89 kg of black tiger shrimp per ha per crop, which was considered as lower yields than 300-400 kg/ha in Ca Mau province, Vietnam (Seafood Trade Intelligence Portal, 2018) and 175-139 kg/ha/crop in Mekong Delta, Vietnam (Bosma et al., 2016; Jonell & Henriksson, 2015; Ha et al., 2012; Binh et al., 1997).

- **Costs of production**

The total cost of ISH was the highest (696.39 mil. VND/ha/year), followed by RB (104.31 mil.VND/ha/year), and IAM (13.29 mil. VND/ha/year), respectively. IAM has the lowest production cost system in comparison with others because this system depends more on natural resources and no use of aquatic chemicals. Mangrove trees and tidal play an essential role in supporting the natural input food, wild feedstock and other favorable conditions for IAM marines. Moreover, the IAM system brings advantages for smallholder farmers who have limited access to capital. Whereas, ISH requires farmers the highest capital investment.

In RB cultivation, the cost of renting machines are tractors, harvesters, and threshing. IAM and ISH culturists have to pay interests on their loans from formal and informal credit sectors. Meanwhile, the smallholding RB production (0.18ha/household) does not cover the interest costs.

Table 5.13: Costs of production (Unit: mil.VND/ha/year)

Costs	IAM	ISH	RB
Variable cost*	**10.70**	**643.66**	**103.20**
Family labor	4.37	43.79	58.34
Hired labor	0.11	30.19	3.32
Post-larvae shrimps	2.79	96.89	-
Post-larvae crabs	2.48	-	-
Rice varieties	-	-	3.15
Feeds	0.41	243.11	-
Miscellaneous	0.34	0.00	-
Lime	0.20	11.20	-
Sand	0.00	17.53	-
Chlorine	0.00	10.85	-
Bacteria/virus drugs	0.00	6.46	-
Antibiotics	0.00	42.33	-
Pro-biotic	0.00	39.78	-
Supplement	0.00	37.24	-
Electricity	0.00	57.32	-
Oil	0.00	6.97	0.00
Fertilizers	-	-	15.68
Pesticides	-	-	6.21
Rented machinery	-	-	16.50
Fixed cost*	**2.59**	**51.73**	**1.11**
Land annual rental	0.35	1.5	1.11
Interest on loans	0.40	16.93	0.00
Repairs	1.21	0.00	0.00
Depreciation	0.63	33.30	0.00
Total costs	**13.29**	**695.39**	**104.31**

(Source: Compiles from data survey, 2018)

- **Technical efficiency of farming systems**

Table 5.14 exhibits the physical inputs and outputs of the estimation of technical efficiency of different farming systems:

Table 5.14: Summary statistics of inputs and outputs of farming systems

Variables	Unit	Mean	Std.Dev	Min	Max
1. ISH					
Inputs					
Labour	mil.VND/ha/crop	25.22	9.53	9.33	60.50
Postlarvae	mil.VND/ha/crop	47.46	19.21	15.37	123.00
Pelleted feed	mil.VND/ha/crop	106.75	61.12	7.78	364.00
Chemical and drugs	mil.VND/ha/crop	70.31	46.79	16.00	330.00
Electricity	mil.VND/ha/crop	28.18	13.17	2.78	100.00
Oil	mil.VND/ha/crop	3.43	1.42	0.00	10.00
Sand	mil.VND/ha/crop	8.56	4.91	2.67	40.00

Lime	mil.VND/ha/crop	5.52	2.02	1.50	15.00
Farm size	ha	1.62	0.85	0.70	5.00
Outputs					
Shrimps	ton/ha/crop	3.25	1.93	0.06	10.00
2. IAM					
Input					
Labour	hours/ha/crop	314.34	212.06	64.00	1600.00
Postlarvae shrimp	10,000 PL/ha/crop	5.47	1.70	8.75	1.85
Postlarvae crab	PL/ha/crop	410.25	331.69	0.00	2000.00
Rice bran	ton/ha/crop	0.02	0.07	0.00	0.49
Miscellaneous feed	ton/ha/crop	0.11	0.37	0.00	2.25
Lime	ton/ha/crop	0.08	0.34	0.00	3.00
Farm size	ha	6.83	4.89	1.20	29.00
Outputs					
Farmed shrimps	ton/ha/crop	0.07	0.04	0.00	0.26
Farmed crabs	ton/ha/crop	0.01	0.02	0.00	0.10
Wild-caught shrimps		0.05	0.03	0.00	0.13
Wild-caught fish	ton/ha/crop	0.01	0.02	0.00	0.13
Wild-caught bivalve	ton/ha/crop	0.02	0.07	0.00	0.47
Seaweed	ton/farm/crop	0.64	1.35	0.00	8.00
3. RB					
Inputs					
Labour	day/sao/crop	7.00	0.00	7.00	7.00
Seed	kg/sao/crop	1.09	0.16	0.90	2.00
N	kg/sao/crop	13.76	3.17	5.00	20.00
NPK	kg/sao/crop	15.05	5.00	5.00	25.00
K	kg/sao/crop	3.90	2.57	0.00	20.00
Pesticides	1,000 VND/sao/crop	94.25	30.38	30.00	250.00
Farm size	sao	4.17	2.16	1.00	11.00
Output					
Rice	kg/sao/crop	202.54	41.34	100.00	300.00

Note: Labor: family and hired. Source: comply from survey data
(Source: Survey, 2018)

Table 5.15 measures the efficiency estimates of the three farming systems through Data Envelopment Analysis (DEA) method. Technical efficiency is the ratio of actual to best practice production. The technical inefficiency offers an opportunity to reduce inputs without reducing output (input-reducing orientation) or to increase output from the same amount of input (output-increasing orientation) (De Koeijer et al., 2002). Efficiency related to specific inputs that cause environmental impacts. The calculation of technical efficiency explains the possibility of enhancing the environment by reducing environmentally damaging inputs (Piot-Lepetit et al., 1997). The results reveal average values of technical (CRS), pure technical (VRS) and scale efficiency. The CRS efficient value of IAM is highest (0.923), followed by ISH (0.867) and RB (0.761). Overall, the efficiency values of three farming systems are below 1.00 which illustrate that there is a considerable scope for minimizing the inputs for given outputs and improving the sustainability.

Table 5.15: Efficiency score of farming systems in Data Envelopment Analysis

Score	ISH	IAM	RB
Technical efficiency score (under CRS)	0.867	0.923	0.761
Pure Technical efficiency (under VRS)	0.932	0.970	1.00
Scale efficiency	0.930	0.948	0.761

CRS: constant return to scale; VRS: Variable return to scale
(Source: Comply from survey data,2018)

The efficiency under CRS of ISH was 0.867 illustrating that farms produced shrimps at 86.7% of the potential frontier production levels at the existing category of technology and inputs or these operators could reduce their inputs by 13.3% while still obtain the same level of shrimp outputs. Pure Technical efficiency under VRS of ISH was 0.932 referring that farmers could potentially increase shrimp outputs by 6.8% by making better use of existing technology.

The efficiency under CRS of IAM was 0.932 illustrating that farms produced various products at 93.2% of the potential frontier production levels at the existing category of technology and inputs or these operators could reduce their inputs by 6.8% while still obtain the same level of farm outputs. Pure Technical efficiency under VRS of IAM was 0.97 referring that farmers could potentially increase shrimp output by 3% by making better use of existing technology.

The efficiency under CRS of RB was 0.761 illustrating that farms produced rice at 76.1% of the potential frontier production levels at the existing category of technology and inputs or these operators could reduce their inputs by 23.9% while still obtain the same level of rice outputs.

- **Farmed gate price**

As presented in Table 5.16, the average prices of shrimps from IAM were 260,000 VND/kg (equivalent 11 USD), while ISH shrimps were 135,500 VND/kg (equivalent 6 USD). All of the respondents reported that IAM shrimps were sold with a nearly double price higher than ISH shrimps. The IAM crabs have also been pricing high as not many local people are affordable to buy. The other IAM co-products (wild-caught shrimps, fish, and seaweed) have lower market prices because farmers do not have to purchase seeds. Our further results show the majority (72.6%) IAM farmers reported a price squeeze at the main harvest seasons in July and August when natural disasters (storms, heavy rains) occur annually. There are nearly one-quarter (24.08%) of ISH farmers have faced difficulty in price bargaining with the collectors or middlemen. The other aquaculturists do not bargain prices but most of the farmers reported that the farm gate prices were low. All of the RB farmers complained about the low price because of the low and homogenous value of rice grains.

Table 5.16: Farm gate prices of farmed products

Products	Unit	IAM	ISH	RB
1. Farmed product	1,000 VND/kg	260	136.5	10
2. Co-products	1,000 VND/kg			
Crab		339	-	-
Wild-caught shrimp		129	-	-
Wild-caught fish		30	-	-
Wild bivalve		5	-	-
Seaweed		4.8	-	-

(Source: Survey, 2018)

- **Net Farm Income**

The values of net farm income of ISH gains at 321.17 mil. VND/ha/year which is 15.7 times higher than those in RB and 16.3 times higher than those in IAM. ISH farming is attracted to farm owners due to higher opportunities for short-term profits especially in rural areas where monitoring and control of environmental standards are limited. However, the income of ISH production in this area was assessed at a medium level of economic performance in the intensive white-legged shrimp production in other coastal provinces of Vietnam (Engle et al., 2017).

Table 5.17: Net farm income of farming systems (unit: mil.VND/ha/year)

Indicators	IAM	ISH	RB
1. Total revenue*	**32.99**	**1,017.00**	**124.79**
2. Total cost*	**13.29**	**695.39**	**104.31**
2.1 Variable cost*	**10.70**	**643.66**	**103.20**
Labor (hired and family)	4.48	73.98	61.66
Seeds	5.72	96.89	3.15
Feeds	0.41	243.11	-
Miscellaneous	0.34	0.00	-
Lime	0.20	11.20	-
Sand	0.00	17.53	-
Chlorine	0.00	10.85	-
Bacteria/virus drugs	0.00	6.46	-

Antibiotics	0.00	42.33	-
Pro-biotic	0.00	39.78	-
Supplement	0.00	37.24	-
Electricity	0.00	57.32	-
Oil	0.00	6.97	0.00
Fertilizers	-	-	15.68
Pesticides	-	-	6.21
Rented machinery	-	-	16.50
2.2 Fixed cost*	**2.59**	**51.73**	**1.11**
Land annual rental	0.35	1.5	1.11
Interest on loans	0.40	16.93	0.00
Repairs	1.21	0.00	0.00
Depreciation	0.63	33.30	0.00
3. Net Farm Income*	**19.70**	**321.17**	**20.48**

Different superscripts (*) from Kruskal–Wallis test denote a significant difference between mean within rows ($p < 0.05$).

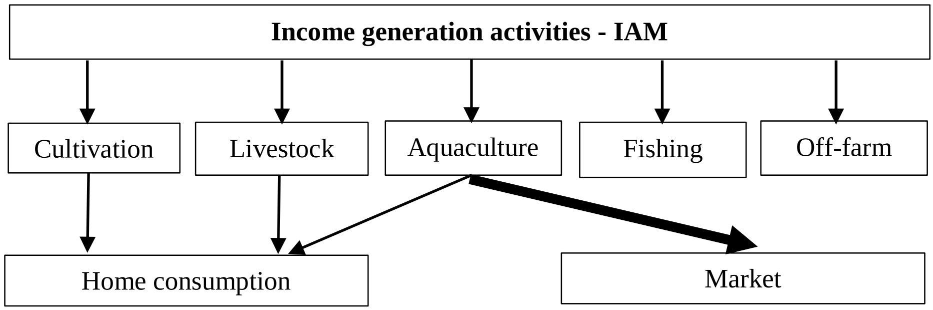
(Source: Compiles from data survey, 2018)

- **Home consumption, sale, and marketing**

Figure 5.21 - Figure 5.23 visualizes activities of income generation of households regarding home consumption and market access.

IAM has a limited contribution to the total black tiger shrimp count due to the low yields as compared with ISH, but the market demand for quality and taste of IAM products has increased tremendously. IAM system also has a high potential to provide steady food for locals with diverse co-products. Local households prefer IAM food to ISH ones due to the antibiotic-free of IAM. One indication that IAM households have sufficient food from their ponds in about 06 months/year, additionally they still have more than 50% of total farm produced for markets. Farmers sold black tiger shrimps and crabs firstly due preference of consumers for their remarkable sizes, good taste and high prices. All of ISH products are distributed to the outside markets and there were almost no local markets for while-legged shrimps because local people do not prefer “industrial products”.

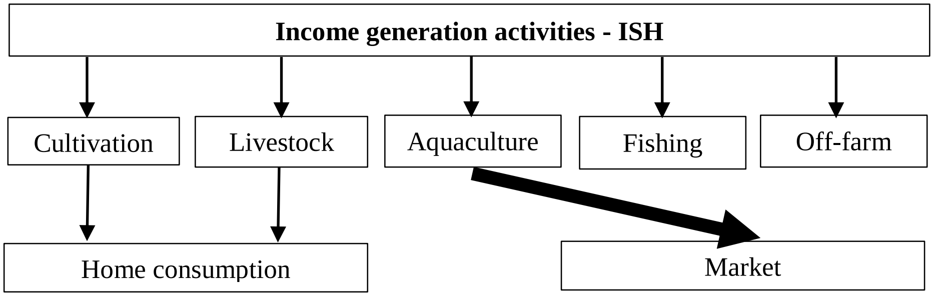
The majority of RB grains are firstly used to fulfill household food and livestock raising and the remaining (below 50% of total farm produce) are sold to the local markets or local collectors who travel from village to village to buy farmed products at the farm gate. RB farmers can earn some small income from the amount of surplus rice grain and this earning mostly is spent on buying other daily necessities such as vegetables, fish, shrimps, meat, etc. but it is limited. Most of RB farmers have sufficient rice grains for 12 months/year and this is an indicator of food security.



Note: IAM cultivation generates 60-70% of total income

Figure 5.21: Income generation activities of IAM households

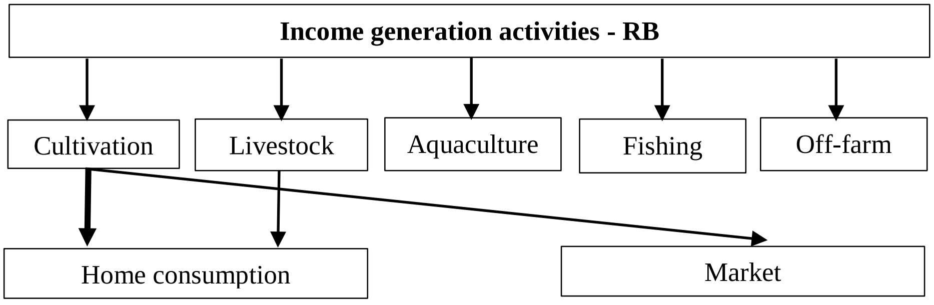
(Source: Survey, 2018)



Note: ISH cultivation generates 80-90% of total income

Figure 5.22: Income generation activities of ISH households

(Source: Survey, 2018)



Note: RB cultivation generates 20-30% of total income

Figure 5.23: Income generation activities of RB households

(Source: Survey, 2018)

Food security at farm households is a matter of a household is able to meet the daily food needs from their own production or means to obtain food from off-farm sources. However, in the opinions of Rasul & Thapa (2004), farmers should have the ability to meet the balanced diet from their own farms or other sources. So, IAM farmers have been able to meet the requirement of diverse kinds of nutrients, including proteins, vitamins, and fat required to keep them healthy rather than RB and ISH.

According to Gafsi et al. (2006), diversifying farm and non-farm activities help to improve the economic autonomy of households. The authors also emphasize the importance of marketing channels for farmed products in stimulating their economic sustainability. Farmers in this area have several channels for sales including conventional and short-channel (Table 5.18):

Table 5.18: Sale and marketing

Sale and marketing	Unit	IAM	ISH	RB
1. Channels of sale	% of respondents			
Conventional channel		98.81	100.00	100.00
Short-channel		1.19	0.00	0.00
2. Types of markets	% of total sale volume			
Sale through local markets		20.00	0.00	100.00
Sale through outside markets		70.00	100.00	0.00
Sale through restaurants		5.00	0.00	0.00
Sale through ethical purchasing groups		5.00	0.00	0.00
3. Farm produce sold in markets	% of total farm produce	> 50	100.00	< 50
4. Farm products preserving	number of products	4	1	1
5. Farm products processing	number of products	4	0	0
6. Farm products packaging	number of products	4	0	0
7. Farm products labeling	number of products	4	0	0
8. Eco-labeling products	number of products	0	0	0
9. Agri-tourism	% of respondents	0	0	0

(Source: Survey, 2018)

In general, three groups of farmers sold their products through conventional channels through direct sales. Besides, the small number of IAM culturists sold their aqua-products through both conventional and short-channel. The short-channel is established by using social media (online sales) such as Facebook and Zalo (Zalo is a popular social network among 40 million Vietnamese users). IAM generates more opportunities for diversified markets since its products were distributed to plenty of markets including outside and local markets, restaurants, and ethical purchasing groups. ISH farmers sold the dominant white-legged shrimp products through outside markets, there were almost none of the local markets from this shrimp. RB sold rice grains mainly through local markets. Food production includes not only traditional agricultural products but also other livelihoods such as ecotourism. Ecotourism is tourism activities that are directly related to the recreation of the natural landscape in non-extractive ways with sustainable use of land but none of the farmers participated in agri-tourism even though the buffer zone of Xuan Thuy National Park has been recognized with high potential for tourism especially IAM farms themselves are an attraction for many visitors.

5.3.2 Environmental dimension

5.3.2.1 Rice-based system

- ***Fertilizer usage, soil fertility and sustainability***

Tables 5.19 and Table 5.20 present amounts of N, P, and K used in surveyed plots after the conversion of authors from farmers' practice. Currently, all of our respondents use inorganic fertilizers and the majority of cultivators apply compound NPK with supplement single N and K. The ratio of N-P-K ingredients is mentioned on the packages, which requires users to convert into a specific amount of N, P and K for each unit of rice land. Based on natural characteristics, DARD of Giao Thuy district recommended farmers to apply fewer fertilizers in the 2^{nd} season than 1^{st} season for both kinds of varieties because the 2^{nd} season has more favorable weather with more rain and shorter growth duration (about 12 - 20 days) than 1^{st} season. The instructions were informed to farmers through agricultural extension personnel of communal agricultural board and communal agricultural cooperative. However, the Mann-Whitney U tests demonstrate the similarity in fertilizers employed between two seasons according to different varieties. The specific amount of N, P, and K was converted from diverse utilizations of various kinds of NPK fertilizers in the commune including NPK (16-16-8), NPK (5-10-3), NPK (5-12-3), N, and K.

Table 5.19: Application rate of fertilizers for hybrid varieties in different growing seasons

Fertilizers (kg/sao/crop)	**Hybrid varieties**	
	1st season	2nd season
N	14.17[a]	14.0[a]
P	9.13[a]	7.11[a]
K	4.22[a]	3.31[a]

The same alphabet characters after mean denote the similarity between two seasons ($p > 0.05$) from the Mann-Whitney test. Significance at 1%.

(Source: Compiles from data survey, 2018)

Table 5.20: Application rate of fertilizers for inbred varieties in different growing seasons

Fertilizers (kg/sao/crop)	**Inbred varieties**	
	1st season	2nd season
N	15.74[a]	15.65[a]
P	9.27[a]	9.36[a]
K	4.85[a]	4.86[a]

The same alphabet characters after mean denote the similarity between two seasons ($p > 0.05$) from the Mann-Whitney test. Significance is at 1%.

(Source: Compiles from data survey, 2018).

Table 5.21 and Table 5.22 demonstrate that farmers tend to use more amounts of commercial fertilizers for inbred varieties than the hybrid in both seasons. The practice is opposite with instructions of Giao Thuy district's DARD. According to extension staff, hybrid rice has a higher capacity of branching, so it requires more fertilizers than the inbred one. On the other side, farmers usually grow hybrid rice with less transplanting density (30 hills/m^2) than those in inbred plots (35-40 hill/m^2) and they observe that hybrid rice adapts better with alkaline tolerant soil as well as climatic condition. Farmers, therefore, decided to utilize fewer fertilizer amounts for hybrid rice.

Table 5.21: Application rate of fertilizers according to rice varieties of the first season

Fertilizers (kg/sao/crop)	**1st season**	
	Hybrid	Inbred
N	14.17[a]	15.74[b]
P	9.13[a]	9.27[a]
K	4.22[a]	4.85[b]

The same alphabet characters after mean denote the similarity between hybrid and inbred ($p > 0.05$) from the Mann-Whitney test. Different alphabet character denotes the difference between hybrid and inbred ($p < 0.05$) from the Mann-Whitney test. Significance is at 1%.

(Source: Compiles from data survey,2018)

Table 5.22: Application rate of fertilizer according to rice varieties of the second season

Fertilizers (kg/sao/crop)	2nd season	
	Hybrid	Inbred
N	14.10[a]	15.65[b]
P	7.11[a]	9.36[b]
K	3.31[a]	4.86[b]

The same alphabet characters after mean denote the similarity between hybrid and inbred ($p > 0.05$) from the Mann-Whitney U test. Different alphabet character denotes the difference between hybrid and inbred ($p < 0.05$) from the Mann-Whitney test. Significance is at 1%.

(Source: Compiles from data survey, 2018)

Results also highlight the overloading of N fertilizer. Farmers applied at the average of 14.0 kg/sao/season for high-yielding rice (equivalent 388.9 kg/ha) and 15.7 kg/sao/season (434.8 kg/ha) for inbred. The rate is higher than local standards suggested by DARD (maximum 12 kg/sao/season or 333.36 kg/ha/season)and other tropical regions such as China (360 kg/ha) (Liu et al., 2016), Philippines (60-120 kg N/ha) (Peng et al., 2004), and West Africa (90-120 kg) (Djaman et al., 2016). The reasons hide misuse practices are various. Firstly, farmers used to manage rice with single-nutrient fertilizers (before the 1990s) which normally required a total of 10-12 kg/sao of N. Since 1992, NPK started to be used in fields and it is combined with supplement single N and K. However, farmers still keep adopting the rate of 10-12 kg of N per sao even though they already used the proper amount of NPK in plots. Along with experience that farmers have developed from overtime, they do not often adhere to directions on packages. This results in the inordinate use of nitrogenous fertilizers. Secondly, promotion programs, especially advertisements of agro-companies party stimulate farmers to assure that rice needs more nitrogen inputs to achieve better pest resistance and crop yield. While farm-gate prices and returns of rice are low value-added in this area, farmers appreciate higher yield and profit as awards of their cropping (100% of our respondents). They subsequently acted on the assumption of profit or yield driven. Some more kilograms are added year after year as an accustomed activity along with the reduction of manure. Lastly, most of the respondents are not able to understand the meaning of the N-P-K ratio mentioned on packages nor convert from compound NPK into single N, P, and K required for paddy plots. There are 80.2% of farmers perceived the term of NPK ratio on labels is abstract or complicated for them. Instructions from producers are considered as references, not for their final decisions. And thus result in applying an inappropriate range of diverse chemical fertilizers. Although intensify production, RB farmers do not own any farm equipment to check the current status of soil or rice plant. Hence, farmers do not know whether the rates are imbalance or not because they lack chemical application equipment.

Chemical fertilizers help to double the rice yield from a base level of 2.0-2.5 ton/ha expected for unfertilized plots (Joint, 2018). However, the wrong uses can harden the soil, degrade its fertility, and cause other side-effect environmental problems. High use of fertilizer increases nutrients entering the water which leads to the eutrophication of rivers or estuaries and causes decreased fish yields (Scialabba, 1998). According to Lichtenberg (2000), fertilizers that are not taken up completely into finished crop products are disposed into environmental, where this nutrient runoff becomes pollution. As warned by Zhen & Routray (2003), the overuse of these inputs can lead to leaching fertilizers and expanding nitrate contents into the soil, groundwater, crops, and human health. Thus, the authors recommended that the dosage of synthetic fertilizers should be based on soil fertility status. FAO (2018) suggested that fertilizers must be managed in a sustainable way including eight criteria: (1) not exceed dosages; (2) use organic nutrient sources; (3) use leguminous plants to reduce chemical fertilizers; (4) distribute fertilizers in several times over the growing period; (5) consider soils and climate conditions; (6) use soil sampling at lease every five years to calculate nutrient budget; (7) apply precision farming; (8) use buffer strips along watercourses. Results highlight 32.30% of farmers applied two of the above measures to reduce associated environmental risks including number 2 (use organic nutrient sources) and number 4 (distribute fertilizers several times over the growing period). For those who applied at least two of the above measures, the sustainable level of fertilizer utilization is assessed at acceptable (32.3% respondents), and the remaining (67.70% respondent) belongs to unsustainable level because they apply none of the measures to restraint the environmental risks from fertilizers (Table 5.23).

Table 5.23: Sustainable level of fertilizer utilization in RB

Fertilizer usage	Percent (%)	Levels of sustainability
-No fertilizers/acquire at least four measures to reduce fertilizer-related risks	0.00	-
-Use fertilizers and acquire at least two measures to reduce fertilizer-related risks	32.30	Acceptable
-Use fertilizers but do not apply measures to reduce fertilizer-related risks	67.70	Unsustainable

(Source: Survey, 2018)

Constant or increasing soil fertility is a vital resource for sustainable agriculture. The functioning of agricultural systems depends on a large extent on soil fertility. Soil fertility is an ecological indicator that is partly due to the utilization of chemical fertilizers. States of soil are easily aware of by farmers. We have asked farmers the proportion of their farms which are reduced in soil fertility. The reference proportion of affected farmland due to soil degradation is estimated based on recommendations of FAO (2018). There were a huge number of farm owners (88.84% respondents) claimed that the soil fertility of the whole-farm is reduced gradually over the years (unsustainable), while the small percent of growers (11.45% respondents) have been impaired from 10%-50% total area by the similar threat (acceptable). There were no farmers got affected less than 10% of farmed land. Table 5.24 indicates that the prevailing surveyed farms (88.54% respondents) obtained at an unsustainable level of soil fertility, while a moderate proportion of farmers gained at acceptable. None of the farms achieved sustainable soil fertility status.

Table 5.24: Sustainable level of soil fertility in RB

Soil fertility	**Percent (%)**	**Levels of sustainability**
-Below 10% of farmland get affected	0.00	-
-From 10%-50% of farmland get affected	11.45	Acceptable
-Above 50% of farmland get affected	88.54	Unsustainable

(Source: Survey, 2018)

- ***Pesticide usage and sustainability***

Pesticides help to kill the spread of pests and eliminate grain-eating species and diverse diseases, but inappropriate utilization can harm people and the natural ecosystem as well. According to Scialabba (1998), the high use of pesticides causes toxic pollution of estuaries and inshore waters which leads to decreased fish yields. Most RB farmers have experienced disease occurrence every crop, so many of them consider pesticides as a preventive resort rather than disease treatment. Interviews with farmers and locals reveal the growing doses of pesticides due to more disease occurrence in rice plants recently.

Discussion with extension staff revealed that the increasingly large amount of pesticides helps to maintain yield due to the gradual deterioration biodiversity caused by monoculture and unwise use of other chemicals. Farmers also believe that higher doses would control diseases better. Farmers focus on immediate effectiveness rather than environmental consequences. They sprayed about 5 times in the first season and 6-7 times in the second season. While preparing pesticides, they always mix 3-4 different pesticides to heighten its effectiveness and reduce spraying times working in fields. The mixture of various pesticides without an understanding of ingredients can reduce the effects because the different pesticides might have similar functions. Farmers consider the instructions on packages but they do not always follow all of the listed instructions such as ensure uniform sprays, spray only on calm days, ensure field conditions when spraying such as humidity, moist soil, etc.

According to FAO (2018), user health-related risks incorporated with pesticides can be minimized through obeying three measures including: (1) following label recommendations; (2) cleansing equipment after use, and; (3) safe disposal of waste. By following these recommendations, health and well-being are assured. Environmental–related risks can be reduced by applying eight measures including: (1) following label recommendations; (2) applying good agricultural practices (crop rotation, mixed cropping, inter-cropping, crop spacing, etc.); (3) adopting biological pest control or bio-pesticides; (4) Adopting pasture rotation to suppress livestock post population; (5) applying pest resistant/ tolerant rice varieties/disease resistant/certified seeds; (6) removing rice plant attacked by pest and disease; (7) cleansing equipment after use; (8) using less than two times for each pesticide in a season to restraint pesticide resistance. Results indicate farmers follow two criteria of health-related measures (numbers 1-following label recommendations and 2-cleansing equipment after use).

However, there is a large number of farmers released packages, bottles, and wastewater after use into common rivers and fields. There were four measures of environmental-related usage of pesticides followed by RB growers including numbers 1 (considering instructions on labels), number 3 (protecting toads and birds), number 5 (growing certified rice varieties) and, number 7 (cleansing equipment after spraying). According to FAO (2018), for farmers who applied pesticides and followed at least two health-related measures and at least two environmental-related measures have been evaluated at an acceptable level but this needs to be improved.

As summarized in Table 5.25, the sustainable level of pesticide utilization of RB around Xuan Thuy National Park is acceptable. However, all of the RB farmers reported the growing dose in recent years incorporated with the dramatic reduction of biodiversity in paddy fields, frequently disease occurrence, and serious outbreak of exotic snails (Pomacea canaliculata). Based on in-depth interviews with local extension personnel and farmers, there is a reduced existence of earthworms which are beneficial organisms for soil structure.

Other aquatic life in rice fields such as toads, frogs, fish, shrimps and crabs are dying pretty much due to pesticide concentrations. Even leeches and grasshoppers are disappearing due to the pesticide residues. The loss of insect and pest predators in paddy fields has also become critical. The application of environmentally-friendly pest and disease control methods (e.g. agronomic, mechanical, biological or botanical methods) helps to increases pest control efficiency simultaneously reduce environmental damages, but the knowledge and adoption of farmers around the protected area are very limited.

Table 5.25: Sustainable level of pesticide utilization in RB

Pesticide usage	**Percent (%)**	**Levels of sustainability**
-No pesticides, follow three health-related measures and at least four environmental-related measures	0.00	-
-Use pesticides, follow at least two health-related measures and at least two environmental-related measures	100.00	Acceptable
-Use pesticides without applying any health-related and environmental-related measures	0.00	-

(Source: Survey, 2018)

- ***Irrigation use and sustainability***

Freshwater used in cropping is a measurement to evaluate environmental sustainability. Water withdrawal from natural sources can lead to unsustainable issues such as reduction of groundwater amount, drying out of water resources, and water conflicting between groups of users. Erik (2001) concerned that expanded irrigation impair groundwater stocks as well as surface water flow, dry up rivers and wetlands, destruct fishery resources, and downstream farming.

The RB in this area relies mainly on the irrigation. Water is managed by private limited companies. Irrigation calendars for farming were informed to locals. Farmers were accessible to intake water and their farms were not waterlogging, so the irrigation in RB was at acceptable sustainability (Table 5.26). Nonetheless, none of the respondents apply methods for water-saving or low volume such as drip. There are no limits for access to irrigation water such as pricing, quotas, priority usage, etc. Large volumes of irrigated water used for an intensive RB system might leach more chemicals into nearby ecosystems.

Table 5.26: Sustainable level of irrigation use in RB

Irrigation	Percent (%)	Levels of sustainability
-Use irrigated water below 11% of farmland	0.00	-
-Use irrigated water above 10% of farmland	100.00	Acceptable
-Other cases	0.00	-

(Source: Survey, 2018)

- ***Adoption of biodiversity-friendly practices and sustainability***

Agriculture has interactions with biodiversity. Agrobiodiversity is one of ecosystem service which is beneficial for farm productivity. The adoption of biodiversity-friendly practices can influence the agrobiodiversity and quality of natural ecosystem including: (1) leaving at least 10% total area for natural or various vegetation; (2) non-pesticides and antimicrobials application; (3) at least two of the following contribute to the production: crop/pasture; trees; animal products; fish (each of them account at least 10% value of the holding production); (4) applying crop rotation at least 3 crops on at least 80% of farm area over 3 years; (5) using at least two different varieties for above 2ha farmland; apllying monoculture for below 2 ha farmland; (6) at least 50% of livestock population use local breeds (FAO, 2018). RB in the surrounding Xuan Thuy National Park acquired criterion number 4 only when farm owners grow several kinds of varieties including inbred and hybrid. Without some forms of intervention, short-term financial incentives lead to the limited application of environmental protection practices in this area. The whole of surveyed RB farms was at unsustainable in the application of biodiversity-friendly measures (Table 5.27). That is an emerging concern in this site because most of its requirements were not adopted.

Table 5.27: Sustainable level of adoption of biodiversity-friendly practices in RB

Biodiversity-friendly practices	Percent (%)	Levels of sustainability
Above 3 measures	0.00	-
From 2-3 measures	0.00	-
Below 2 measures	100.00	Unsustainable

(Source: Survey, 2018)

The **"Traffic light" approach** was used as an analytical technique to evaluate and visualize the environmental sustainability of RB cultivation. Farms perform badly results are signified with unsustainable (marked with red), while others achieved preferable outcomes are highlighted with desirable (marked with green). For those performances obtain at neutral are being rated acceptable (but need to be improved) (marked with yellow). The ranking varies differently for different indicators. Indicators for assessing the environmental sustainability of rice cultivation in this study site were elaborated based on concepts of the Inter-Agency and Expert Group on Sustainable Development Goals of FAO (2018).

Figure 5.24 illustrates a range of environmental indicator risks regarding soil health, water use, fertilizer pollution risks, pesticide risks, and application of biodiversity-friendly practice. It can be seen that none of the environmental indicators gain at a desirable or sustainable level. In particularly, biodiversity-friendly methods were emerging concerned in this site when most of its requirements were not adopted. Pesticides and water use were mainly evaluated as acceptable, but they are required to adjust for higher performance. Soil fertility has been degraded in recent years partly due to improper fertilization.

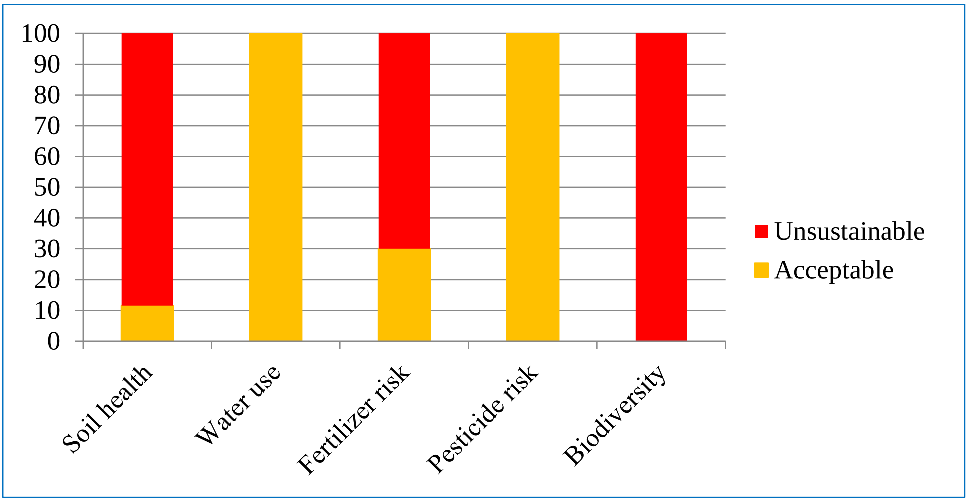


Figure 5.24: Environmental sustainability assessment of RB cultivation (Source: Survey, 2018)

5.3.2.2 Aquaculture systems

- **Biodiversity loss rate**

Preservation of wildlife habitats is crucial to maintain farm productivity. We have asked two groups of aquaculturists about their collection of wild marine habitats for culture production including spawns and fries of fish, shrimps, crabs, and mollusks. The capture of wild species for aquaculture farming was ranged into three levels including above 50%, above 25% to below 50%, below 25%, and no use of wild fries (Table 5.36). In IAM cultivation, there were 100% of farm owners trapped and harvested wild marines through frequent exchanges of brackish water from rivers, canals, or estuary. Moreover, wild crab seeds (size 3-5 cm/crab) were used in most of IAM ponds and they were also bought from crab harvesters living inside and outside the communal buffer zone. The techniques of this cultivation has not changed as much from its origins in 1986s.

Xuan Thuy National Park staff reported that at the seasons of crabs (May-June and September-October), there were hundreds of people captured crabs in rivers and wetland areas of the park. This activity is partly responsible for the degradation of critical aquatic species around the park as well as the disruption of living environment of water-birds especially when people use flash-lamps at night time. The lower biodiversity loss rate (BDL) of IAM (0.28) demonstrates the higher level of wild fries was captured which corporate the risk of natural aquatic resource degradation in regional rivers. The biodiversity degradation in turn decreases yields of IAM farms because this system still depends much on wild fisheries.

ISH production used hatchery-produced seeds (no collection of wild shrimp PLs), therefore, the BDL ratio of this farming system was 1.0. However, all of ISH farmers adopted aquanone drugs while preparing inlet water for culture ponds to remove unwanted species such as predatory fish, shellfish, crabs, and other undesirable habitats that enter the ponds and compete for feeds and living environment with target white-legged shrimps. The wide use of drugs from shrimp farms might create unpredictable external impacts incorporated on the surrounding environment.

Table 5.28: Biodiversity loss rate of aquaculture systems

Wild-caught use	**IAM** (number of respondent)	**ISH** (number of respondent)
>50%	72	0
From 25-50%	12	0
< 25%	0	0
No use	0	54
Biodiversity loss rate	0.28	1.00

(Source: Survey, 2018)

5.3.2.3 Water use conflict

In the article *"Dynamics of farming systems under the context of coastal zone development: the case of Xuan Thuy National Park, Vietnam".* Agriculture, 9(7), 138. Groups of authors: Nguyen, T. T. N., Tran, H. C., Ho, T. M. H., Burny, P., & Lebailly, P. (2019), we analyze the problems of water conflict:

Farmers were asked about the serious problems related to their farming systems. Out of the responses, 90.47% of IAM and 77.78% of ISH culturists reported that their water intake was impaired in months in which pesticides were applied in rice fields (March–April, and August–September). The two aquaculture system suffered from the same problems related to pesticide contaminants because their farms are exposed than other areas where aquaculture takes place and farmers did not adopt the close-water system. This might cause direct losses from aquaculture. The paddy fields were situated closely to the ISH farms and separated by a national dike (10 m width) as visualized in Figure 5.25.

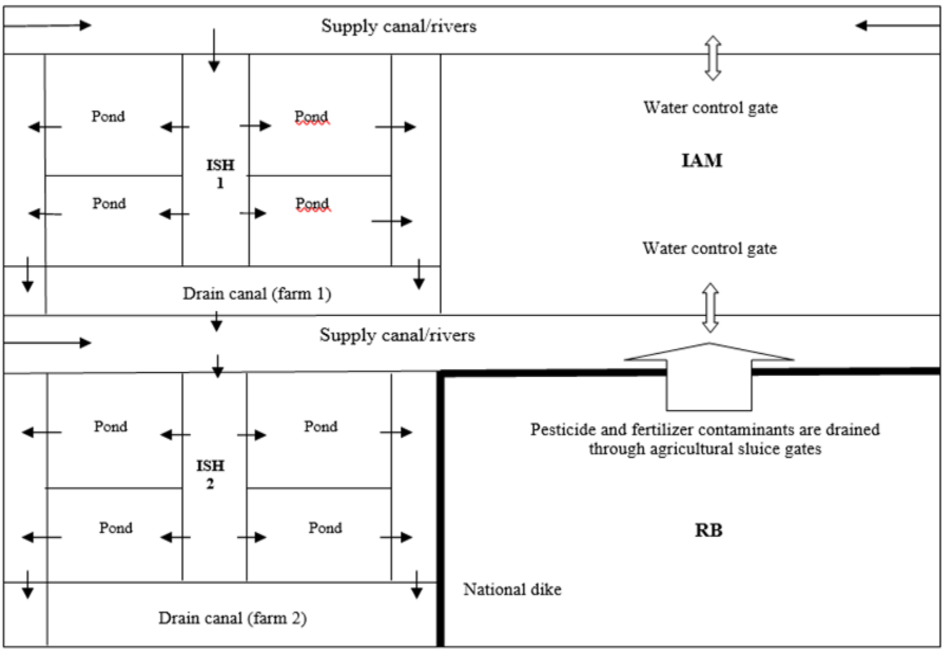


Figure 5.25: Interrelation between farming systems
(Source: Survey, 2018)

Hoanh Dong and Number 10 sluices belong to four drainage sluice systems around five buffer communes. They are responsible for directly draining water from rice fields in buffer communes to Tra and Vop rivers where provide intake brackish water for IAM and ISH aquaculture. The statistics of the Giao Thuy Irrigation limited company recorded that each sluice had dimensions of 4 m × 7 m (B × H) (B: width of the sluice; H: the difference between river water level and canal design water level). Two of them covered a total of 1,700 ha of drained area. Both of the two gates are controlled to open during the time of chemical applications. RB production has irreversibly environmental impacts. Pesticides, toxic pollution of estuaries and inshore water lead to the reduction of fish yield in rivers. Fertilizers increase the amounts of nutrients, eutrophication, and pollution of estuaries, leading to a reduction of fish yield and coral.

The frequency of water exchange in the aquaculture corporate in close proximity to the IAM (3 km) and ISH (1.9 km) with agricultural sluices might incur more effects from external pollution which is illustrated in Figure 5.26. According to Mai & Nguyen (2003), the concentration of pesticides and herbicides was higher than allowed ranges in the Xuan Thuy National Park area. Pesticides cause toxic pollution to the estuaries and inshore water, killing fish, and leading to a reduction in fish yield, as mentioned by Scialabba (1998). However, almost all of the rice practitioners were unaware of this alarming sign from their fields for aquaculture. They have used diverse pesticides for the control of weeds, pests, and exotic snails (Pomacea canaliculata) with a limited understanding of the ingredients. Both farmers and officials claimed that more pesticides have been adopted in recent decades due to increasing farm labor costs and disease occurrence.

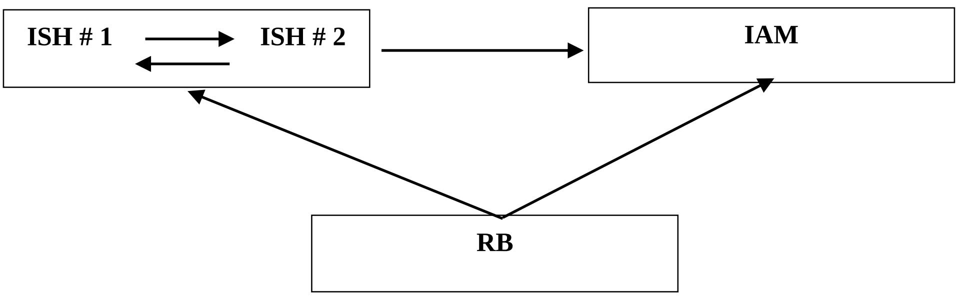


Figure 5.26: Conflicts between farming systems
(Source: Survey, 2018)

There is an additional risk related to shrimp effluents. Shrimp farming interacts with the environment across spatial scales regarding resource inputs and the production of waste. The disposal of sludge and effluents from ISH ponds created pollution not only for themselves but also for some IAM farms nearby. The surveyed data indicates that intake water of 100% of ISH and 33.3% of IAM farms have been affected by effluents from ISH ponds since the majority of ISH farmers were reluctant to treat sewage before releasing it to the surrounding rivers. Water pollution impacts from shrimp production in the Xuan Thuy National Park area have also been indicated earlier by Beland et al. (2006). They concluded that the surface water in rivers near the effluent disposal of shrimp ponds had higher values of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) pollutants than national standards. Currently, farmers are not responsible for reporting water standard indicators for permitted organizations.

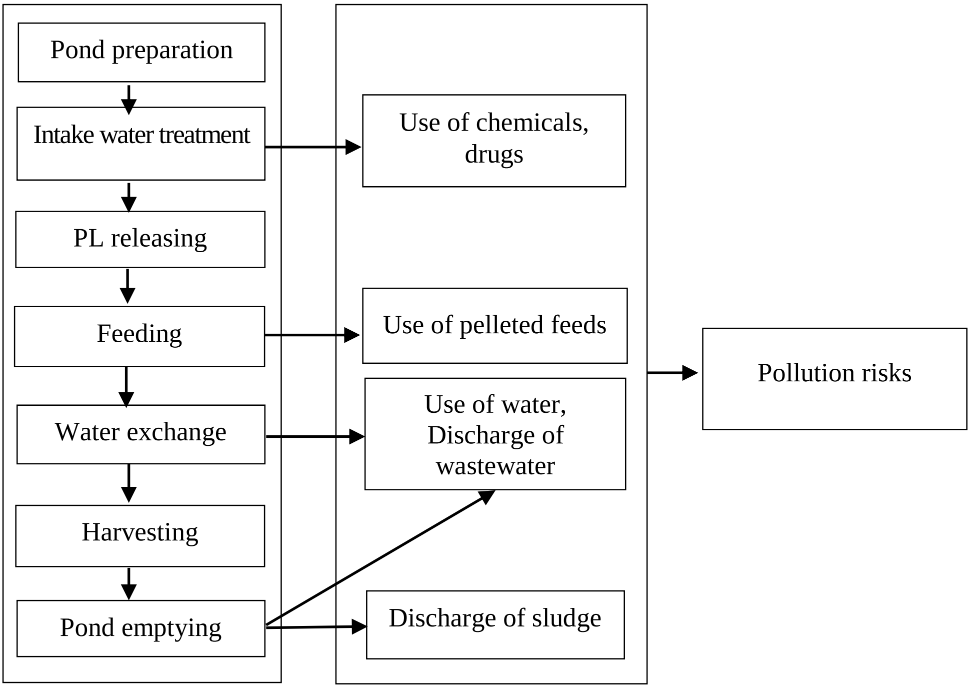


Figure 5.27: Pollution risks of ISH
(Source: Survey, 2018)

In our article namely *"Economic analysis of different aquaculture systems in coastal buffer zones of protected areas: A case study in Xuan Thuy National Park, Vietnam"* 2020. Ecology, Environment and Conservation, we estimated the factors influencing net farm income of farming systems. We found that polluted effluents and pesticide contaminants from the outside environment have an inverse influence on the net farm income of IAM and ISH (Nhung et al., 2020).

Water quality regulations in terms of effluent standard and permits issued by the MARD, but they are implemented as advice for practitioners. Unregulated production of RB and ISH in this area creates many frictions between farmers who derive their livelihoods from rice farming, those who depend on aquaculture systems and those whose livelihood may be adversely affected by environmental impacts. Chand et al. (2015) emphasized that a sustainable farming system should have linkages with other systems without destructing the ecological integrity. The clamour against RB farming causing for neighboring aquaculture production and ISH causing for nearby aquaculture ponds may refer to unsustainable issues.

The water conflicts from agriculture sector become more common recently. It not only exists among groups of farmers as my study explained but also between farmers and local government in other researches. Hang (2018) asserts that local farmers experience a high death rate of clam aquaculture because their water is polluted from outside environment. Thus, farmers blamed for the low effective monitoring of local government. On the other side, the local government complains that the water source is impaired by unwise cultivation practices of farmers: farmers increase higher stocking density for more profits and that contributes to self-pollution. They have not yet found the resolutions for the conflicts between farmers and governors.

5.4 Conclusions of the chapter

Chapter 5 aims to clarify the objectives of farmers and local authorities and how farmers nearby the park perceive and adopt environmentally-friendly practices, what are the outcomes from the farms and barriers to good practices?

There are different priorities in the work of Xuan Thuy Nation Park managers, buffer communes and farmers: The primary objectives of park managers are reducing uses of chemical fertilizers, pesticides and agricultural waste/sludge through providing environmental education, maintaining eco-tourism groups, encouraging alternative farming activities to reduce the usage of agrochemicals. However, communes and farmers tend to be ambitious for immediate profits. Communal authorities take yields and profits for their prior objectives due to economic pressure. Likewise, primary farmers enjoy their own needs of profit and sell surplus products rather than feeling responsible for long-term maintenance.

Our results reveal that farmers lack necessary knowledge and adoption of agroecological-based methods. Many obstacles restraint farmers' learning process and application: Farmers lack understanding of long-term conservation benefits and farm ecology; while authorities lack institutional supports, policy enforcement and subsidies for conservation agriculture. Limited financial sources and commitment for wastewater treatment, issues on land planning and high incentive for profits are also mentioned challenges.

In the monoculture production, farmers receive one single product: white-legged shrimps in ISH and rice grains in RB. In the polyculture production, IAM farmers produce a rage of aqua-products including farmed products and wild-caught habitats and a few of these products have been preserving, processing, packaging, and labeling. ISH and RB farmers sold farmed products through the conventional channel (direct sales), while IAM products were sold through both conventional and short-channel (online sales). The IAM aqua-products were preferred by the local and distant markets and some of the amounts were checked for food safety by the National Institute for Food Control (the application was done by an individual farmer) but there were no eco-labeling regimes for further promotion.

Regarding farmed yield, different systems obtained different levels. ISH aquaculture is considered as an incentive for economic development by Nam Dinh PPC and local communities in terms of production volume. But its yield was obtained at a medium level as compared with the average Vietnam yield. IAM yield achieved considerably lower than those in other places of Vietnam. Among the three systems, only RB acquired higher than the national average yield.

The technical efficiency score of all production systems reveals that there is considerable scope for minimizing the inputs for given outputs, or these systems produced less than the potential frontier production levels at the existing category of technology and inputs. Therefore, these operators could reduce inputs while still obtain the same level of outputs.

Inordinate cultivation activities create a range of environmental issues. In RB production, none of the indicators for environmental risk assessment were sustainable or desirable. The utilization of fertilizers in rice fields was improper. Local advisory providers recommended farmers to apply fewer fertilizers in the 2^{nd} season than 1^{st} season for both kinds of varieties (inbred and hybrid) because the 2^{nd} season has more favorable weather with more rain and shorter growth duration. However, results demonstrate the similarity in fertilizers employed between two seasons according to two rice varieties. Plus, farmers used more amounts of synthetic fertilizers for inbred varieties than the hybrid in both seasons which is opposite with local instructions. The dose of N fertilizer was excessive because it was higher than the dose suggested. Instructions from producers were complicated for farmers and the recommended doses were considered as references, not for decisions. Although intensified production, RB farmers did not own chemical application equipment to check the current status of soil or rice plant. Hence, farmers did not know whether the rates are imbalanced or not. The usage of fertilizers for the majority of RB farmers was evaluated as unsustainable. Prevailing surveyed farms obtained unsustainable level of soil fertility, while none of them gained sustainable. The utilization of pesticides in RB production was acceptable but most farmers have experienced disease occurrence. That lead to growing doses of pesticides recently incorporated with the biodiversity degradation in fields. Biodiversity-friendly methods were emerging concerned in this site when most of its requirements were not adopted.

In ISH, pollution risks have been concerned from the use of aquatic chemicals, drugs, pelleted feeds, and the disposal of wastewater and pond sludge into common rivers. Water reuse or recirculation water system were not adopted in this area. Most of farmers applied frequent exchange regimes to supply inlet water, while water from outside rivers is impaired by contaminants of chemical and diverse polluted sources. The reluctance of wastewater treatment before releasing it to the water bodies is stressing the environmental quality around the park. However, there was neither commitment to treat wastes nor incentives for the treatment in this area. ISH production faces environmental risks including disease occurrence, self-pollution and external pollution.

In IAM, the co-culture of diverse aquatic species gained several environmental and economic benefits, but the biodiversity loss rate was concerning due to this system depends on the capture of wild fries and the reduction of mangroves inside farms. This activity is partly responsible for the degradation of critical aquatic species around the park as well as the disruption of living environment of water-birds especially when people use flash-lamps at night time to collect wild marines.

Unregulated production practices of different groups of farmers contribute to the conflicting between local communities that no individual farmers can tackle alone. Aquaculture farmers claimed for water pollution from RB plantation. Unregulated production of RB and ISH creates frictions between farmers who derive their main livelihood from rice and those who rely on aquaculture.

6

Constraints and causes of sustainable agricultural development around Xuan Thuy National Park

6.1 Overview of constraints and the underlying causes

Constraints and challenges in agricultural production limit its performance. This part will describe some of the constraints facing farmer producers of rice and aquaculture sectors, as well as the main responses from the government. Stakeholders identified pressing constraints and interlinked causes affecting agricultural work in their sector. The constraints of addressing problems include mismanagement practices, economic and infrastructure dimensions. The underlying causes of the constraints include policies and enforcement, roles of agricultural advisory services, and personal characteristics of farmer-decision makers. The analysis of constraints and the causes of agricultural development are undoubtedly brought about the understanding and management of problematic issues for the protected area.

- *Intensive shrimp system*

Table 6.1: Constraints and underlying causes of ISH system

Questions	Answers
Identify pressing constraints affecting your agricultural activities	**1. Mismanagement practices** Application of antibiotic and diverse drugs Discharge of wastewater Discharge of sludge **2. Economic constraints** Disease occurrence Unstable yields/incomes High dependency on external costs Limited marketing activities Low on-farm diversification Limited access to credits A high rate of land tax **3. Environmental constraint** Water conflicts
Identify the underlying causes of the constraints	**1. Policies and enforcement** Policies on agriculture and the environment exist but improper enforcement High yield orientation **2. Roles of agricultural advisory services** Low performance of agricultural advisory services **3. Awareness and objectives of farmers** High incentives for profits Low awareness of farm ecology and the application

(Source: survey, 2019)

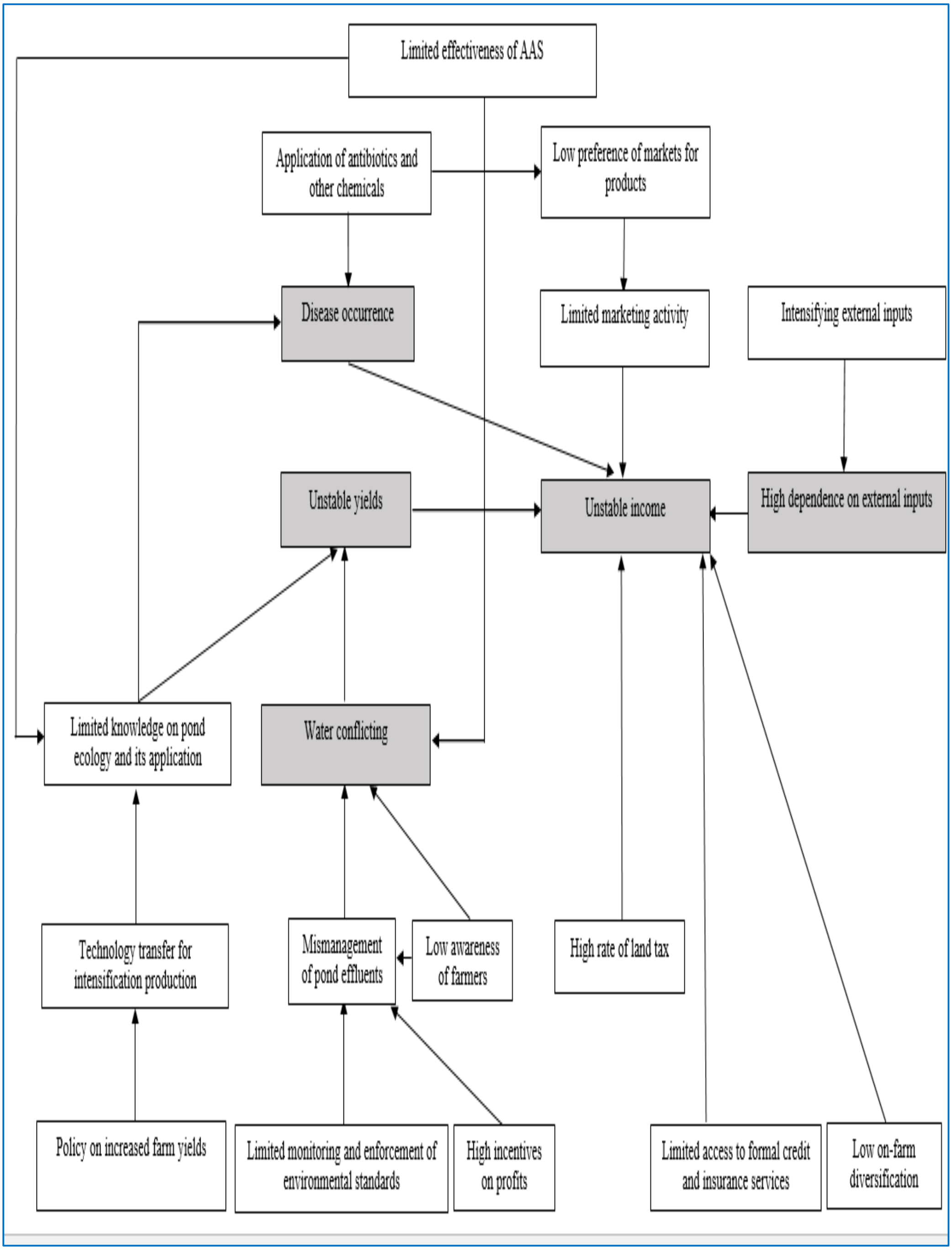


Figure 6.1: Constraints and underlying causes of ISH system
(Source: survey, 2019)

- *Rice-base system*

Table 6.2: Constraints and underlying causes of the RB system

Questions	Answers
Identify pressing constraints affecting your agricultural activities	**1. Mismanagement practices**
	Growing doses of pesticides
	Misuse of fertilizers
	Limited application of agroecological practices
	2. Economic constraints
	High dependency on external costs
	Limited marketing activities
	Low on-farm diversification
	Low financial returns
	3. Environmental constraints
	Soil health risks
	Fertilizer risks
	Pesticide risks
	Biodiversity risks
Identify the underlying causes of the constraints	**1. Policies and enforcement**
	Policies on agriculture and environment exist but improper enforcement
	High yield orientation
	Limited promotion of ecological agriculture
	2. Roles of agricultural advisory services
	Low performance of agricultural advisory services
	3. Awareness and objectives of farmers
	High incentives for profits
	Low awareness of farm ecology and its application

(Source: survey, 2019)

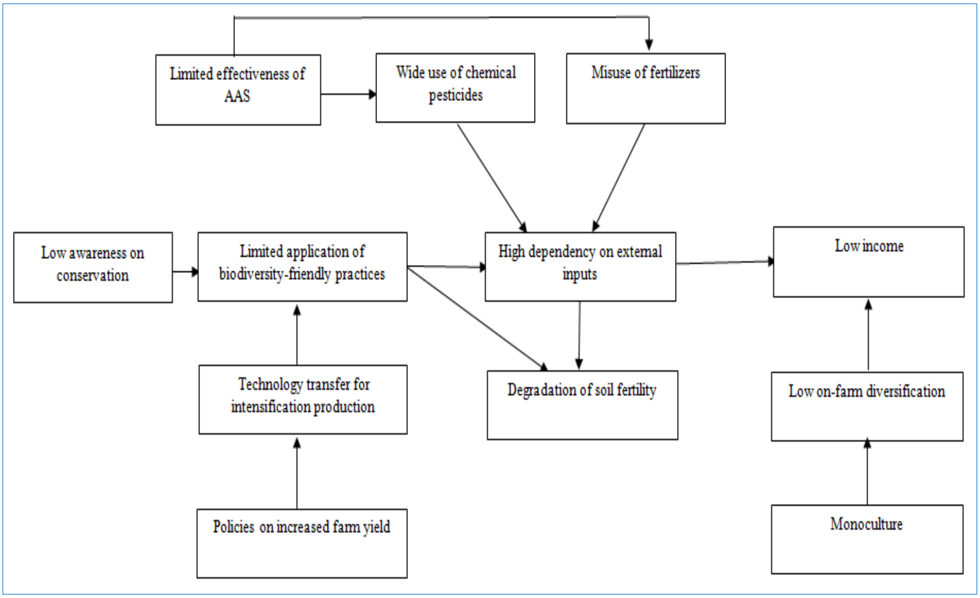


Figure 6.2: Constraints and underlying causes of the RB system
(Source: survey, 2019)

- *Integrated aquaculture-mangrove*

Table 6.3: Constraints and underlying causes of the IAM system

Questions	Answers
Identify pressing constraints effecting your agricultural activities	**1. Mismanagement practices** Use of wild captured species for seeds **2. Economic constraints** Low yield of aquaculture species Limited supported policies (certification) **3. Environmental constraints** Water conflicts with other farming systems Biodiversity degradation Low coverage of mangroves
Identify the underlying causes of the constraints	**1. Policies and enforcement** Policies on agriculture and environment exist but improper enforcement **2. Roles of agricultural advisory services** Low performance of agricultural advisory services **3. Farmers** Profit incentives

(Source: survey, 2019)

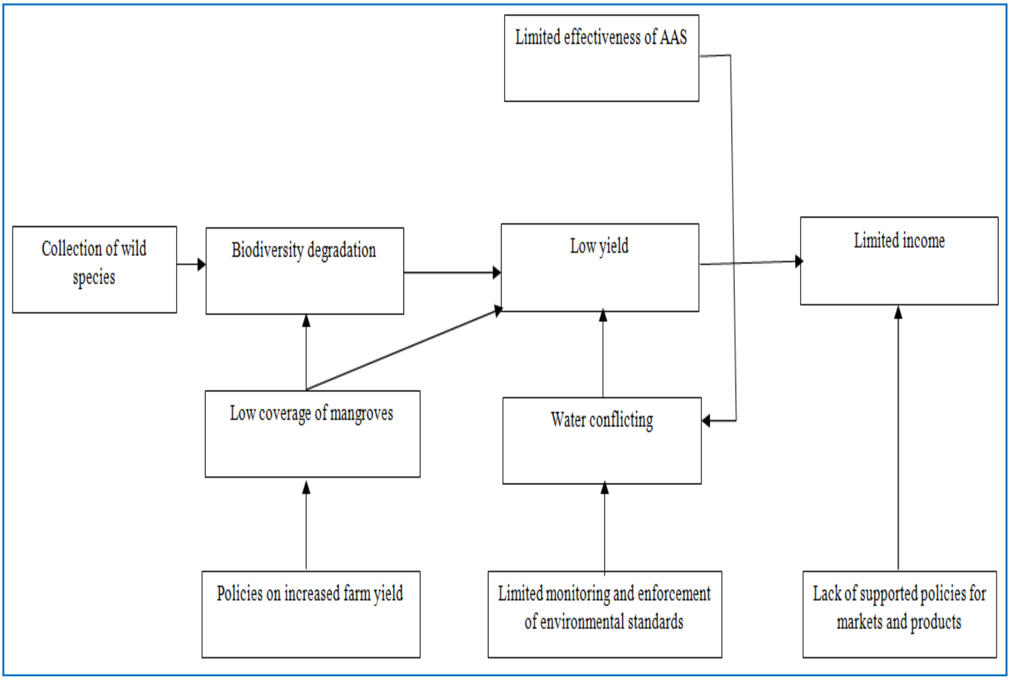


Figure 6.3: Constraints and underlying causes of the IAM system
(Source: survey, 2019)

6.2 Analysis of the underlying causes

6.2.1 Policies and law enforcement

- *National level:*

Vietnam Government issues diverse laws, policies and strategies to promote sustainable agricultural development simultaneously conserve environment with a vision to 2030:

- Law 55/2010/QH11 issue standards and processes for good manufacturing practices and good agricultural practices. The law also allows levels of pesticide residue, wastes, and other chemicals in foods as well as conditions for agricultural production and waste treatment.

- Decision 1690/QD-TTg approves the strategy of fishery development by 2020. The strategy of Vietnam is to expand intensive aquaculture farming with the adoption of good aquaculture practices and traceability in Red River Delta, Mekong River Delta and Coastal Central. Besides, organic aquaculture systems and improved extensive aquaculture systems are maintained and developed in wetland, mangrove forests for export and environmental protection.

- Circular 45/2010/TT-BNNPTNT regulates the practices of shrimp farming. The circular issues the criteria of infrastructure, equipment, pond management, and labor. The indicators of intake water and wastewater are enforced for all of individuals and organizations raising white-legged and black tiger shrimps in Vietnam.

- Circular 36/2010/TT-BNNPTNT issues the regulations of production and the use of fertilizers. The circular appoints the responsibilities of DARD at the provincial level to instruct lower levels to use fertilizer properly to ensure its efficiency and minimize negative impacts on the environment.

- Decision 1617/2011/QD-BNN-TCTS guides the adoption of VietGAP standard in white-legged shrimp, black tiger shrimp, and catfish aquaculture farming.

- Decision 3284/2014/QD-BNN-TCTS issues the regulations on the adoption of VietGAP in aquaculture by MARD. The decision encourages farmers with every scale of farmland to adopt good practices in order to produce high-value products and protect the environment. According to this decision, farmers must have commitments with the government to protect the environment or conduct assessment reports of environmental impacts. Farmers must ensure environmental quality indicators of farm effluents before releasing to the public environment and ensure no conflict for surrounding farms.

- Circular 48/2012/TT- BNNPTNT regulates the certification of crop, aquaculture and livestock products with good agricultural practices.

- Circular 42/2012/ND-CP and Circular 205/2012/TT-BTC appoint responsibilities of farmers are to use the land for rice cultivation properly and adopt rotational methods to improve soil fertility and protect the ecosystem. The circulars also prohibit farmers from polluting and eroding rice land. According to these circulars, the state budget supports local budget 0.5 mil.VND annually for each ha of rice to maintain and repair infrastructure, extension system and agricultural models (such as rice varieties, fertilizers, pesticides, machines, tools, etc.). Besides, the state budget supports directly for farmers 0.5-1.0 mil.VND/ha/year, 50% costs of pesticide and fertilizer if 30-50% production damaged and, 70% cost of pesticide and fertilizer if above 70% production damaged.

- Decision 899/2013/QD-TTg approves the project of restructuring agriculture toward value-added improvement and sustainability. The project determines the economic strategy for agriculture is to raise productivity, quality and income of farmers along with developing processing, preservation and marketing. The project also focuses on the reduction of negative impacts on the natural environment and greenhouse gas emission through the effective use of natural resources (land, water, sea, forest) and agrochemicals. The project strengthens the application of environmental standards with strict supervision and good agricultural practices (GAP) to develop a green supply chain. For aquaculture, the project concentrates on intensive production of primary products (black tiger shrimp, white-legged shrimp, tilapia, mollusk and pangasius).

- Decision 1445/2013/QD-TTg approves a strategic plan for aquaculture by 2020, with a vision to 2030. This decision organizes the development of sustainable aquaculture to enhance the value-added of aquaculture products and ensure environmental protection and conservation of aquatic resources. The decision emphasizes the focus on the development of intensive farming of key aquatic products including black tiger shrimp (80,000 ha), white-legged shrimp (60,000 ha), shutchi catfish (10,000 ha), and mollusk (40,000 ha). The decision also determines the yields and the growth rate of these products: 340,000 tons of black tiger shrimp with a growth rate of 0.02%/year, 360,000 tons of white-legged shrimps with a growth rate of 11.22%/year. The decision determines the prohibition of aquaculture activities that harm the environment and protected areas. The decision also encourages rotational or integrated aquaculture, promotes water-saving technique, restraint the discharge of wastewater and farm effluent to the surrounding environment. The decision promotes the application of VietGAP to protect the natural environment, food safety, and sustainable development.

The policies support great development potential for agriculture of Vietnam. Agriculture shifts from self-sufficient to commodity production. GDP growth of agriculture changes from low-unstable growth to recovery trend. Farm outputs has continuously increased, leading to the increasing export values. Vietnam exports about 8 million tons of food yearly which become top world exporters of rice, coffee, pepper, fish and shrimps. Reforms of agriculture have made farming households become the main stakeholder in rural area. However, the efforts to reform agriculture toward sustainable development have seem inadequate. Agricultural growth is still based on the expansion of arable land but limited technology application. Research and technical progress for farming is low. Service and process have been underdeveloped for brand, quality and food safety (Ngoc et al., 2021).

- *Provincial and district level:*

Following national policies, Nam Dinh PPC has the viewpoint as to develop economic associating with the use of natural resources and protection of the ecological environment which ensures sustainable development and creating landscapes for the tourism sector. The policies of environmental protection refer that by 2020, 50% of the production of the province has to apply environmental standards, 60% of hazardous waste are collected and treated. The policies of agricultural development emphasize that Nam Dinh province has to restructure the current agricultural production towards clean, sustainable and high competitiveness through the application of technology with ecological protection. By 2020, the proportion of agriculture - forestry - fishery sector accounts for around 25% of the total GDP of the province (interviews with Nam Dinh Province DARD's representatives).

The policies define objectives of rice and aquaculture sectors in Nam Dinh province are set as follows:

- Rice: to expand special rice varieties and high-quality rice production; change inefficient rice land to vegetables or aquaculture and promote crop diversification.

We have collected legal documents including circulars, decrees and guidelines for rice production to assess how policies are transferred into practice. Table 6.4 shows that all of 9 legal documents for rice issued by Nam Dinh Province's PPC and DARD in one year (2020) only focus on the use of chemical fertilizers and pesticides to ensure grain yields. Agroecological methods have not been introduced or mentioned in the period 2014-2020 (interviews with Nam Dinh Province DARD's representatives).

Table 6.4: Legal documents from Nam Dinh Province DARD for rice production

Legal documents			Method toward	
			Chemical	Agroecology
Circular 585/SNN-TTBVTV	23/3/ 2020	Pest management for rice (season 1/1)	+	
Circular 81/TB-TTBVTV	15/4 2020	Pest management for rice (season 1/2)	+	
Circular 980/CD-SNN	28/4/ 2020	Pest management (season 1/3)	+	
Circular 1256/KH-SNN	2/6/2020	Training on pest management	+	
Decree 1685/SNN-TTBVTV	14/7/2020	Guideline for rice (season 2)	+	
Decree 1762/SNN -TTBVTV	21/7/2020	Pest management for rice (season 2)	+	
Decree 79/TB-TTr	24/7/2020	Chemical fertilizer management	+	
Decree 189/TB-TTBVTV	17/9/2020	Pest management for rice (season 2)	+	
Decree 3481/SNN-TTBVTV	15/12/2020	Chemical fertilizer advertisement	+	

Note: (+) signifies having chemical methods

(Source: DARD of Nam Dinh province, 2020)

We conclude that despite the existence of diverse policies from the national level for sustainable agricultural development integrating environmental protection, the works in the practice of provincial authorities focus mainly on allowing chemical utilization rather than introducing conservative methods for rice farmers.

- Aquaculture: Nam Dinh province has to expand aquaculture land from 17,000 ha in 2020 to 18,400 ha in 2030. The province promotes aquaculture to become an engine of economic growth. In fisheries, the province focuses on brackish aquaculture especially shrimps, crabs, clams, crayfish and tilapia (interviews with Nam Dinh Province DARD's representatives).

Following these policies, aquaculture has expanded rapidly over the last two decades. The provincial government provides incentives for aquaculture production in particular intensive shrimp system. More investment on infrastructure and irrigation for its districts. The government allows the conversion of rice land in coastal communes into shrimp ponds. More areas are shifted from extensive to intensive. Shrimp intensification relies more on industrial inputs (stocks, feeds, chemicals and drugs) (interviews with Nam Dinh Province DARD's representatives; Tran et al., 2013).

- *Communal level:*

- Rice: Management activities of buffer communal authorities have focused mainly on the orientation of intensification to ensure high yields:

Table 6.5 reveals impacts of legal documents from provincial-district-communal authorities and DARD to yield, growing dose of synthetic inputs, disease occurrence, and environmental conservation (soil fertility degradation, pollution, biodiversity degradation, etc.) in RB production in buffer communes:

The communal authorities promote RB intensification production through the expansion of hybrid varieties with higher adoption of commercial inputs, pesticides, fertilizers, irrigation, and mechanization as compared with inbred varieties (mentioned earlier in Chapter 5). It is consistent with the results of Kamoshita et al. (2018) that the utilization of agrochemicals in RB of Xuan Thuy National Park buffer communes is similarly high as those in non-buffer communes.

The use of diverse chemical fertilizers in buffer communes is promoted through permission from Nam Dinh province DARD for APROMACO company (Agricultural Products and Materials Joint Stock Company) to advertise and sell their fertilizers. APROMACO, top 200 largest companies of Vietnam, are allowed to sell 31 kinds of fertilizers in the communes (Decree 3481/SNN-TTBVTV issued by Nam Dinh Province's DARD). All of the mentioned kinds (NPK, P, NK) are chemical (interviews with Nam Dinh Province DARD's representatives).

Table 6.5: Impacts of legal documents from provincial DARD to buffer communes

Legal documents	Increased yield	Growing doses (inputs)	Disease occurrence	Environmental conservation
Promoting intensification	+			
Promoting hybrid rice varieties	+	-		
Allowing and advertising chemical fertilizers	+	-	-	-
Allowing the use of chemical pesticides	+	-	-	-
Remaining monoculture		-	-	-

Note: (+) signifies positive impacts, (-) signifies negative impacts
(Source: Interviews with Giao Thuy district DARD's representatives)

The monoculture of RB without application of crop rotation entails one-way consumption of soils and this causes harm to the soil. District DARD blamed that RB production accounts for the largest utilization of synthetic fertilizers and pesticides in this area. Farmers use fertilizers as the most reliable source ensuring high yield. They can buy these nutrients easily from local shops and CAC. But the utilization of fertilizers is not monitored by CAC, CAB or district DARD which leads to misuse and inefficiency. The excessive amounts of N fertilizers that are not converted completely into final grains are disposed of, thus becoming pollutants and leading to soil degradation. In this context, the local government rarely performs soil analysis or assessments on soil property and water or nutrient emissions. They face difficulty in matching crop needs with existing soil fertility due to a lack of equipment, capacity and budget. There is no tax or charge for excessive use of fertilizer to regulate farmers with lower production costs at the same time limit environmental risks (interviews with Nam Dinh Province DARD's representatives).

Even though the current situation of pesticide utilization is assessed at acceptable but the critical growing doses with more disease occurrence are hazardous for both production and human health. Private shops and retailers have less incentive for precision fertilization or IPM (interviews with Nam Dinh Province DARD's representatives). We have found that instead of having practical actions to strengthen the adoption of ecological-based practices, communication through the local loudspeaker system is the major solution that communal authorities use to induce or limit farmers for the use of agrochemicals. The programs of IPM were firstly introduced in Vietnam in 1992 based on the guidance of FAO and "One must do and Five reductions" (encouraged by Decision 3073/2009/QD-BNN-KHCN) help rice farmers select healthy varieties, protect natural enemies, and restrain agrochemicals, but we concern that the application of the two programs does not exist in this area.

Despite the environmental impacts, there are no policies for limiting the use of agrochemicals or programs for restoring degraded mangroves in the buffer zone.

- Aquaculture:

Decision 4175/2005/QDUB issued by Nam Dinh PPC: Strategies for the development of Xuan Thuy National Park's buffer zone from 2006-2020: (1) promoting intensification in rice production to enhance income for rural communities; (2) establishing 400 ha of semi-intensive shrimp in the buffer zone.

Decision 4803/2014/QD-UBND issued by Giao Thuy DPC: Decide to change 150.37 ha of the aquaculture-rice system to ISH system in the Xuan Thuy National Park's buffer zone with expect to increase higher shrimp yields.

Following the two Decisions, buffer commune authorities emphasize that yield is the key for the production because it supplies adequate food and additional profits. They see yield and profit as ideal means to encourage economic growth of the buffer zone. DARD of Giao Thuy district issued basic guidelines for ISH shrimps based on guidelines of MARD (Circular 45/2010/TT-BNNPTNT: criteria of infrastructure, equipment, pond management, indicators of intake water and wastewater), while IAM is not mentioned. From in-depth interviews with a representative of Giao Thuy district DARD, they have only two staff responsible for aquaculture of the whole district. Due to the shortage of quantity and qualified employees for aquaculture, limited budget and laboratory equipment, district DARD has not monitored and assessed environmental impacts of aquaculture production. This provides more evidence for the conclusion of Tran (2013) that the management of Nam Dinh province is ineffective in monitoring intensive shrimp toward sustainability in its communes.

Due to high yield incentives but small farm size, ISH farmers maximize land use for grow-out ponds and minimize canals for wastewater treatment. However, they lack ecological knowledge to manage farming in the fragile buffer zone which has long been displaced by dense population and intensified production. ISH is cultivated with higher stocking density than IAM, wide use of commercial feeds and diverse drugs but farmers face limited knowledge and training on pond ecology.

Regarding drainage problems, the lack of proper enforcement capacity of regulatory on wastewater and pond effluent disposal from ISH culture contributes to the self-polluted among ISH farms and for the common water bodies. Even though being under the compulsory regulations of ensuring environmental indicators for white-legged and black tiger shrimp farming which have been approved by MARD in Circular 45/2010/TT-BNNPTNT, but the facilities as well as laboratories of Giao Thuy district's DARD and DoNRE and buffer communes are inadequate to perform. The local managers rarely test the current situation of drainage and waste from farms. According to Xuan Thuy National Park's staff, the water quality indicators around this park have been tested irregularly by several international organizations or national scientists with their funds (2-3 times/year depend on the number of projects implemented).

A dearth of data has been reported and updated on shrimp effluents in this area even local people claim for the pollution based on their observation and experience. The authorities from provincial to local levels mainly encourage awareness of farmers on protecting the mangroves and birds rather than implement and monitor environmental indicators as the compulsion. Plus, ineffective communication, limited involvement of primary stakeholders and shortage of collective actions contribute to the water conflicting between RB, ISH and IAM farms and among ISH ponds. The implementation of policies with weak regulatory regimes and enforcement capacity has not yet ensured high profitability and sustainability in agriculture. According to FAO (2002), improper management is one of the most dominant factors that has threats on the ecosystem and jeopardize the balance of the ecology. The enforcement of environmental standards should be effective to enable shrimp aquaculture to be well-positioned in terms of development.

In IAM farms, farmers are not allowed to cut mangroves but mangrove density just scattered (with 24.28% tree coverage - based on self-reported). The proportion of mangroves is below the coverage of 30-50% providing the highest shrimp yield (Bosma et al., 2016) and much lower than the optimal mangrove coverage for the highest level of output and profit in Vietnam (Thuy & Luat, 2018). Planting more mangroves in IAM farms contributes to the implementation of the National Strategy for Environmental Protection until 2020 which set a goal to increase the mangrove areas in Vietnam by 80% as compared with those in 1990 and Decree 119/2016/ND-CP issued the policy on coastal forest management and development. However, Xuan Thuy National Park and communal authorities have not programs to increase mangroves in IAM. It is urgent for specific policies on agriculture nearby the protected areas to ensure the application of environmentally protective technology around the country.

The implementation of ecological-based agriculture projects and practices which are promulgated in legal policies but we found limited practices in all three groups. Despite the efforts of the government to encourage high-quality and safe products in every region of Vietnam, these eco-agricultural programs do not reach farmers on this site. There are no practices of VietGAP, BMP (best management practice), GAqP (good aquaculture practice) in cropping and aquaculture systems in Xuan Thuy National Park buffer zone because the adoption is not compulsory. In addition, these practices require complex principles and huge investment in infrastructure, farm management, harvesting and waste treatment, and standard application process, therefore they become not appropriate for small-holding farmers in this site who mainly face a limited financial capacity. The government funds the costs of administrative, assessment and training for VietGAP farmers, but it still lacks supports to infrastructure construction such as the public electricity system and water exchange system. Even though the credit programs (based on Circular 55/2015/ND-TTg) are working in Giao Thuy district, formal banks have not met the needs of aquaculture farmers. Thus, the policies at the national level have low impacts on the management of buffer communes except when they are specified into programs for local levels.

There are none of the agricultural insurance programs in this site even though more frequent disease outbreaks in cropping and aquaculture cultivation presently. None of the eco-friendly product certificates or eco-certification provided for farmers especially for IAM farmers. The investment in research in the agriculture sector in the buffer zone of Xuan Thuy National Park is moderate. Most investments have been used for the Xuan Thuy National Park (core zone) and some of the budgets have been spent for roads of the buffer zone. The shortage of economic incentives contributes to the limited investment in resource-conserving equipment or shift to environmentally friendly practices.

Farmers in the buffer zone can sell their land tenure spontaneously for others from outer districts or provinces which also discourages the long-term investment in responsible practices or sewage treatment systems. The emergent constraints call for a reorientation of policies, proper enforcement and effective government legislation/regulations and incentives in the agricultural sector around protected areas to ensure the integration of ecological indicators in farming management practices and performance.

We conclude that provincial-district-communal authorities focus mainly on farm intensification with high incentives for profits rather than providing farmers conservative methods. While Xuan Thuy National Park has very little political power for the improper practices of IAM, ISH and RB.

6.2.2 Agricultural advisory services

This part belongs to the article: *"Structure and performance of advisory services in agricultural development around protected area: the case of Xuan Thuy National Park, Vietnam".* Asian Journal of Agriculture and Rural Development, 10(1), 95. Group of authors: Nhung, N. T. T., Tran, H. C., & Lebailly, P.

6.2.2.1 Governance structure

The governance structure refers to the institutional set-up of agricultural advisory service (AAS) (Birner et al., 2009). The governance structure of AAS system includes an entire set of organizations that support and facilitate farmers to solve problems and to obtain information, skills and technologies to improve agricultural production and farmers' livelihoods (Anderson & Feder, 2007; Birkhaeuser et al., 1991; Anderson, 2008). The initial objective of AAS is to enhance farm productivity. Furthermore, AAS helps to reduce the gap between potential and actual yields in farms by accelerating technology transfer and promote farmers for better management skills. Currently, AAS is reformed to confront changes in global food and farming system such as the expansion of supper-markets, growing importance of standards and labels, increasing non-farm rural employment, agricultural industrialization and the degradation of natural resources, etc. (Anderson, 2008).

The services are transferred firstly by the public sector. Currently, the decentralization of the system includes more involvement of the private sector and the third sector (non-government organizations, farmers' organizations) contributes to pluralistic forms of AAS (Sulaiman & Hall, 2002). Classifying stakeholders in the AAS system can help to demonstrate their involvement and which sectors they belong to (pubic, private or third sector such as NGO or farmers' organizations). Each structure has its management style including top-down or participatory, rule-focused or result-focused. The management should fit the objectives of AAS and be adjusted to the government structures and methods**.**

The public AAS system was officially established in Vietnam in 1993 firstly to provide advanced technology and training and to disseminate agricultural-related policies (Bo, 2012). This is the most supporting organization to facilitate the largest proportion of farmers in agriculture and rural development in this country. Currently, the public AAS system operates nationwide with five administrative levels (central, provincial, district, commune, and village) at an average ratio of one officer per 280 households to help farmers to improve yield through responding to outbreaks of pests or diseases and supporting the implementation of new varieties. Besides some achievements, public AAS sectors still have various limitations, including: (1) the shortage in the quantity and quality of extensional personnel; (2) a lack of general and integrated specialized workers for the whole production process; (3) AAS has not yet focused on processing and marketing; (4) methods of AAS has not yet satisfied diverse demands of different farming systems; and (5) low participation of farmers (Bo, 2012). The public sector by itself cannot meet the needs of various production typologies and diverse classes of farmers. Since 2015, Vietnam began transforming its AAS to improve efficiency as well as the competitiveness of agriculture and the livelihood of farmers (Ngan & Suresh, 2018). Pluralistic actors from private sectors participate in carrying out advisory tasks including farm households, common interest groups, and agribusiness enterprises. They provide formal and informal knowledge and contribute to the enhancement of social learning among communities.

Figure 6.4 illustrates the governance structure of AAS in promoting agricultural production in Nam Dinh province including buffer communes of Xuan Thuy National Park. There is a wide variety of stakeholders in the system belonging to public sectors (state and local authorities, Xuan Thuy National Park) and private sectors (agro-input providers, irrigation companies). Within the public sector, governance structures differ from the degree of decentralization. Currently, both public and private providers focus on advisory service for raising yields and productivity in agricultural production.

The district Department of Agriculture and Rural Development (DARD) and Center of Agricultural Services (CAS) are specialized agencies working under the authority of Giao Thuy District People's Committee. They coordinate with communes to promote agricultural production of the whole district including buffer communes of Xuan Thuy National Park. The main responsibilities of the district DARD are defined in Circular 14/2015/TTLT-BNNPTNT-BNV of the MARD and Ministry of Home Affair (Birner et al., 2009). It is in charge of: (1) preparing, submitting and implementing to the DPC programs and projects for agriculture, forestry, salt industry, aquaculture, irrigation and rural development of the district; (2) assisting the DPC in giving local people permission for natural forests; (3) checking, monitoring and supervising communal authorities in agriculture, aquaculture, forestry management; (4) controlling natural disasters, pest and disease of the whole district; (3) protecting irrigation infrastructure; (5) managing services to promote agriculture, forestry, and aquaculture.

The Nam Dinh PPC defines responsibilities of CAS in Decision 2721/QD-UBND in 2018 as (1) implementing programs of crop cultivation, plant protection, veterinary service provision, and agricultural extension; (2) transferring advanced technologies for agricultural production; (3) organizing training for rural communities; (4) providing technical knowledge of crop cultivation, plant protection, and livestock raising (Birner et al., 2009).

At the commune level, Communal People's Committee (CPC) has responsibilities in coordinating with Xuan Thuy National Park management board to organize programs on environmental protection, environmental education, security, ecotourism, and community development, etc. to develop the socio-economic condition of the region (Decision 1893/2006/QD-UBND on the coordination of management of conservation of Xuan Thuy National Park issued by Nam Dinh PPC). Communal People's Committee (CPC) designates communal agricultural board (CAB) and communal agricultural cooperative (CAC).

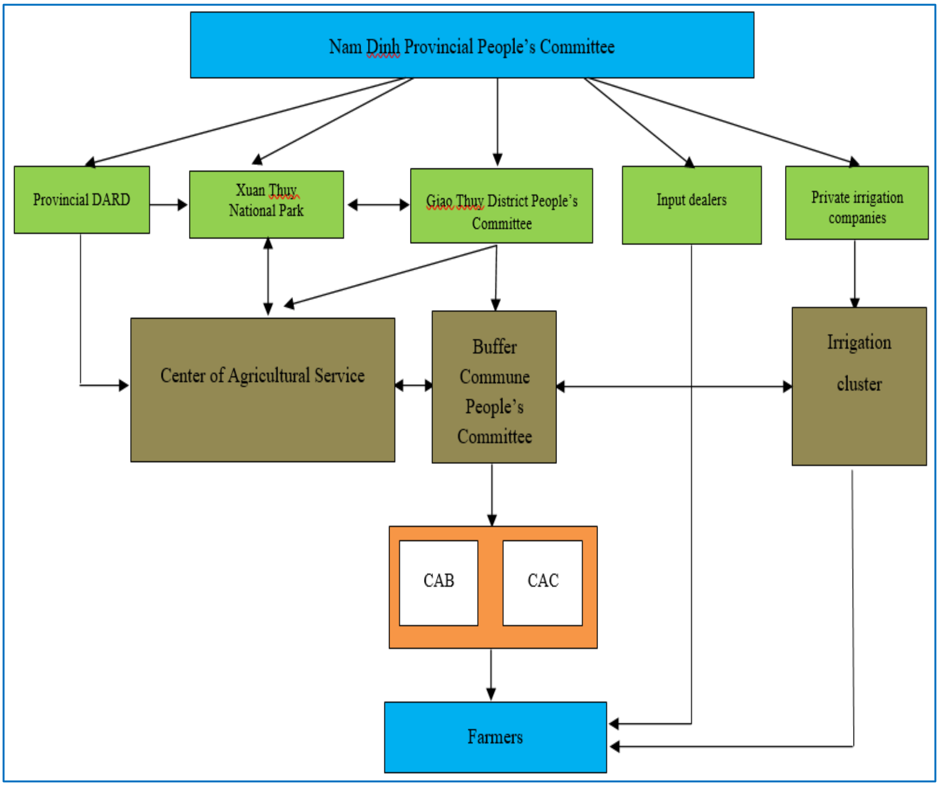


Figure 6.4: AAS system in Nam Dinh province including Xuan Thuy National Park's buffer zone
(Source: Author's elaboration based on interviews)

The establishment of CAB and CAC has not based on the election of farmers. The CAB of each buffer commune has four members including one vice-chairman of CPC, one veterinary staff, one plant protection staff, and one extension personnel. The CAB is established in order to recruit and coordinate officials and technicians to instruct and manage the cultivation, livestock raising activities, food safety programs and rural development. Each commune has one CAC which is regulated by Cooperative Law 2012. CAC is considered as a business-oriented organization. CAC is mainly responsible for selling agricultural materials (fertilizers, pesticides, and rice varieties), and transferring agricultural information (land preparation, irrigation, plant protection, applying advanced technologies, etc.) for farmers. Currently, CAC in 05 buffer communes of Xuan Thuy National Park does not cover tasks of market development for its members.

Private sectors' involvement in AAS in the study area is advancing rapidly. A range of private companies facilitates in promoting agricultural and aquaculture production including various input traders (input enterprises, distributors, agro-dealers), and irrigation companies. The growing importance of private sectors leads to diverse embedded topics related to advanced agriculture and aquaculture is transferred to farmers. They offer comprehensive services and qualitative services for client farmers including technical advice on the application of inputs at the stages of production growth or working with farmers to confront problems at farms. The staff of irrigation companies in buffer communes was a private sector that is responsible for managing water for production.

- Interaction between agricultural advisory service providers and farmers

Agricultural development is a complicated task with the involvement of public and private stakeholders as well as cooperation among them. These stakeholders formulated directly on how operational agricultural activities should be conducted in the study area. The interaction of AAS providers and farmers are assessed differently from public and private service actors according to different types of production systems. It was found that private input suppliers transferred several kinds of services including disseminating conventional and conservation agriculture knowledge, organizing training and selling farm inputs for all three production patterns. Private companies have been providing extension workers whose specialization in agriculture, aquaculture, veterinary or economics. While selling companies' products, they work with farmers to find the problems and solutions based on the participation of farmers. Irrigation companies are responsible for water management and provide a timetable of irrigation gates for merely rice growers through CAB and CAC.

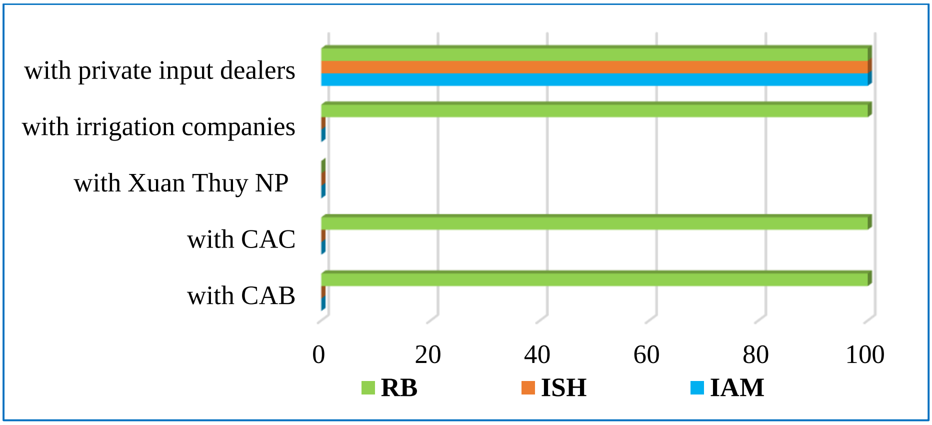


Figure 6.5: Interaction between service providers and farmers in cultivation (% of respondents) (Source: Household survey, 2019)

On the other side, CAC worked as business enterprise which played an important role in selling inputs in accordance with guiding RB farmers how to use inputs. CAB together with private input suppliers organized meetings or training to promote companies' input products and disseminate rice production-related information. However, CAC, CAB has not played roles in promoting aquaculture production. Xuan Thuy National Park does not have interaction with three groups of farmers for farming practices.

In conclusion, poor interaction between providers and receivers in AAS work partly prevent sustainable development. In general, there is a dearth of collective actions to maintain the public environmental quality and water conflict resolution within the region.

6.2.2.2 Performance of agricultural advisory services

- The relevance of agricultural advisory services

Needs of farmers

Different farming systems require relevant information to gain higher productivity and profitability for the improvement of their livelihoods (Singh et al., 2016). The buffer zone of Xuan Thuy National Park has diverse farming systems. The farms of the zone are cultivated in a changing environment. Farmers were asked for the major interests in getting services from AAS providers. Table 6.6 illustrates various advisory services needed regarding technical management, marketing promotion, and credit access required by different groups.

Table 6.6: Needs of farmers

AAS needs	Percent (%)
1. IAM (n=84)	
Controlling of pesticide contaminants from rice farms	90.47
Controlling effluent from ISH ponds	33.33
Monitoring marine post-larvae quality	14.28
Marketing, certification	72.62
Disease outbreak management skills	10.71
Drastic weather adaptation skills	100.00
2. ISH (n=54)	
Controlling of pesticide contaminants from rice farms	77.78
Controlling effluent from ISH ponds	100.00
Monitoring marine post-larvae quality	100.00
Disease outbreak management skills	38.89
Credit access supports	68.52
Drastic weather adaptation skills	100.00
3. RB (n=96)	
Disease outbreak adaptation	63.54
Solutions for decreasing in use of chemical fertilizers	73.96
Solutions for decreasing in use of pesticide	100.00
Controlling of exotic snails	100.00
Drastic weather adaptation skills	**21.88**

(Source: Household survey, 2019)

The majority of IAM and ISH culturists expected solutions for their intake water which have been impaired in months applying pesticides in rice fields and effluent discharge from intensive shrimp ponds. The frequency of water exchanges in aquaculture farms might incur more effects from external pollution. Our results further show that all of RB farmers in this area routinely use numerous pesticides followed the announcement of CAB's louder instead of field visits. Rice farmers do not practice any IPM technique to protect natural barriers and minimize pesticide usage. Pesticides are used as the end-of-the pipe of solutions to eliminate pests, golden snails because of immediate effectiveness and less time-consuming. This leads to an increase in the dependency of rice production on agrochemicals. Thus, RB cultivators needed extension people to address the spread of exotic snails and disease outbreaks which they cannot tackle individually.

Natural disaster adaptation skills related are also mostly requested by both groups of culturists and some of RB growers since their farms are located near the coastline which has been affected by erratic climate variability including storms, fluctuation of salinity, and climate changes. Shrimp larvae quality monitoring is another emerging problem required to solve by ISH and some IAM farmers. In comparison with the needs of farmers, advisory services received are poorly defined and quite simple as presented in the following part.

Receipt of farmers

Farmers were asked for advisories obtained from agricultural extension people. One indication reveals that government-based AAS actors of CAB and CAC have been reaching a significant proportion of RB farming populations on a sustained basis with information and guidance on the use of farm inputs.

On the other hand, private input suppliers played an important role with respect to provide knowledge and facilitate consultation on pond and feed management for culturists. Irrigation time of opening and closing sluice system was available for all of the rice farmers but for a moderate percent of culturists. The needs of farmers are many, but practical assistance is still poorly defined. In conclusion, our results demonstrate perceived gaps in advisory needs and received across production systems.

Table 6.7: Receipt of farmers

Receipt	Percent (%)	Providers
1.IAM (n=84)		
Shrimp larvae management	100.00	Private input dealers
Pelletized feed use	100.00	Private input dealers
Irrigation calendar	7.10	Irrigation staff, CAB
Training	60.71	Private input dealers
2.ISH (n=54)		
Shrimp larvae management	100.00	Private input dealers
Pelletized feed use	100.00	Private input dealers
Pond management	100.00	Private input dealers
Veterinary medicine application	100.00	Private input dealers
Disease adaptation skills	100.00	Private input dealers
Training	100.00	Private input dealers
Irrigation calendar	14.80	Irrigation staff, CAB
3.RB (n=96)		
Pesticide application	100.00	CAB, CAC
Fertilizer application	100.00	CAB, CAC
Crop calendar	100.00	CAB, CAC
Training	77.08	CAB, input dealers
Irrigation calendar	100.00	CAB, CAC, irrigation staff

(Source: Household survey, 2019)

- Effectiveness of agricultural advisory services

An assessment of the effectiveness of the AAS provision is to provide evidence from advisories in the region. This part explores locals' views on the effective levels of AAS in terms of technical and non-technical services. Responses were ranked as very high, high, medium, low, and very low as presented in Table 6.8. WAI is one of the social scaling assessing the extension service quality (Chowdhury et al., 2006; Chowdhury et al., 2015). The sustainable levels of WAI are based on the research of Chowdhury et al. (2006) indicate that the AAS effectiveness of CAC, CAB, and Xuan Thuy National Park management board are rated less sustainable, while those of input dealers is ranked moderate. None of the providers gained sustainable effectiveness.

Table 6.8: Value index of effective level from the farmers' perspective

	Very high (1.0)	High (0.8)	Medium (0.6)	Low (0.4)	Very low (0.2)	WAI	Sustainable level
1. IAM farmers (number of respondents)							
CAC	0	0	14	70	0	0.43	Less sustainable
CAB	0	0	4	80	0	0.41	Less sustainable
Park	0	0	11	73	0	0.42	Less sustainable
Irrigation board	0	0	17	67	0	0.44	Less sustainable
Input dealers	0	61	12	11	0	0.72	Moderate sustainable
2. ISH farmers (number of respondents)							
CAC	0	0	6	48	0	0.42	Less sustainable
CAB	0	0	4	50	0	0.41	Less sustainable
Park	0	0	3	51	0	0.41	Less sustainable
Irrigation board	0	0	7	47	0	0.43	Less sustainable
Input dealers	0	39	15	0	0	0.74	Moderate sustainable
3. RB farmers (number of respondents)							
CAC	0	51	45	0	0	0.71	Moderate sustainable
CAB	0	5	61	30	0	0.55	Less sustainable
Park	0	0	31	65	0	0.46	Less sustainable
Irrigation board	0	37	59	0	0	0.68	Moderate sustainable
Input dealers	0	13	83	0	0	0.63	Moderate sustainable

(Source: Household survey, 2019)

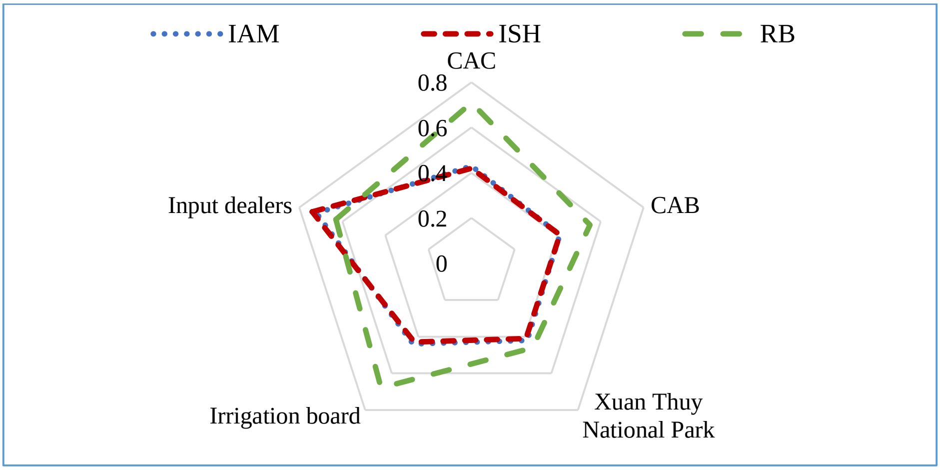


Figure 6.6: Effectiveness of service providers from farmer perspectives

Equality in accessing support services can ensure social stability and encourage farmers to improve production while conserving resources (Zhen & Routray, 2003). However, Figure 6.6 displays a different level of farmers' views on benefits from service providers and stakeholders. CAC, CAB, Xuan Thuy National Park, and irrigation companies gained higher effectiveness in the case of RB than IAM and ISH, nevertheless, input dealers are essential for two aquaculture farming groups. Xuan Thuy National Park has low responded in delivering agriculture advisory for three groups of farmers.

Figure 6.7 – Figure 6.9 shows the delivery of AAS for different groups of farmers in this area. The advisory delivery of public and private stakeholders was different for different groups. The main findings show that the public AAS concentrated more on RB production. The shortage of staff holding aquatic expertise prevents both CAB and CAC from providing farming management knowledge and skills for IAM and ISH. Our further results reveal that in RB production, almost all topics on conventional agriculture are disseminated instead of conservation agriculture. The focus on conventional agriculture is based on strategies of Nam Dinh PPC as well as Giao Thuy DPC toward raising productivity. This partly leads to the misuse of fertilizers as analyzed.

CAB has a small role in decreasing the use of chemical fertilizers and pesticides due to the lack of extension staff. Their works mainly were transferring news and recommendations through one-way propagation on local loudspeakers. Meanwhile, CAC has made a little more effective in providing knowledge on conservation agriculture through direct communication with farmers while selling agricultural inputs. CAB sometimes helps private input suppliers to gather farmers in meetings or training organized by these companies for promoting their agro-input products.

Private input suppliers transferred various kinds of advisory services to two groups of IAM and ISH. Extension workers from these companies often visit and help farmers manage farms and disease. The role of private input supply companies has been increasing in aquaculture farming with the dissemination of materials, new technology, and training based on a demand-driven approach. Distribution of feeds, additive nutrients and diverse artificial inputs for aquaculture production is carried by staff experts of national and international companies. However, the majority of the two groups cannot access irrigation services. IAM and ISH farmers managed brackish water for their ponds with low collaboration with irrigation staff. This leads to frequent complaints on notable negatively affected by freshwater and pesticide residue from RB areas.

Results demonstrate that in the period from 2017-2019, Xuan Thuy National Park management board has been implemented several activities to promote environmental protection in core and buffer zones, including environmental education, forest replanting, and ecotourism development (14 households), supporting mushroom growing (20 households) and beekeeping (10 households). The staff of Xuan Thuy National Park has not involved much in RB, IAM and ISH production.

Our results indicate limited interaction between the public and private sectors. One indication that there is a lack of conservation agriculture programs based on on-site characteristics and technological development in the buffer area. Even some information on conservation agriculture is transferred to farmers but farming activities are still conducted toward the manner of profitability which may incorporate environmental problems.

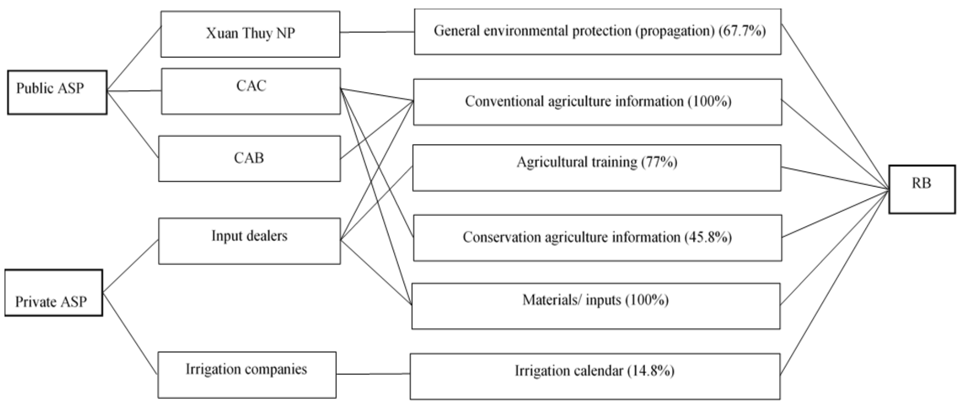


Figure 6.7: AAS flows for RB farmers (ASP: Agricultural service provider)
(Source: Survey, 2019)

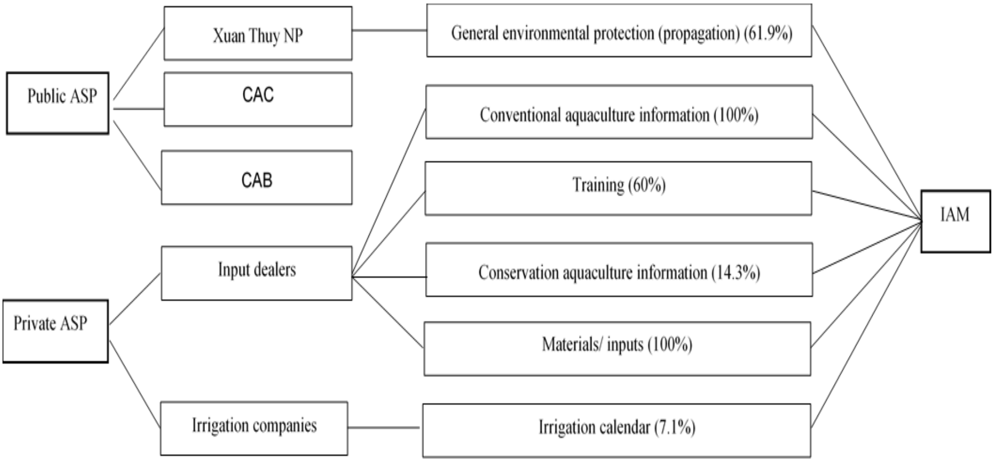


Figure 6.8: AAS flows for IAM farmers (ASP: Agricultural service provider)
(Source: Survey, 2019)

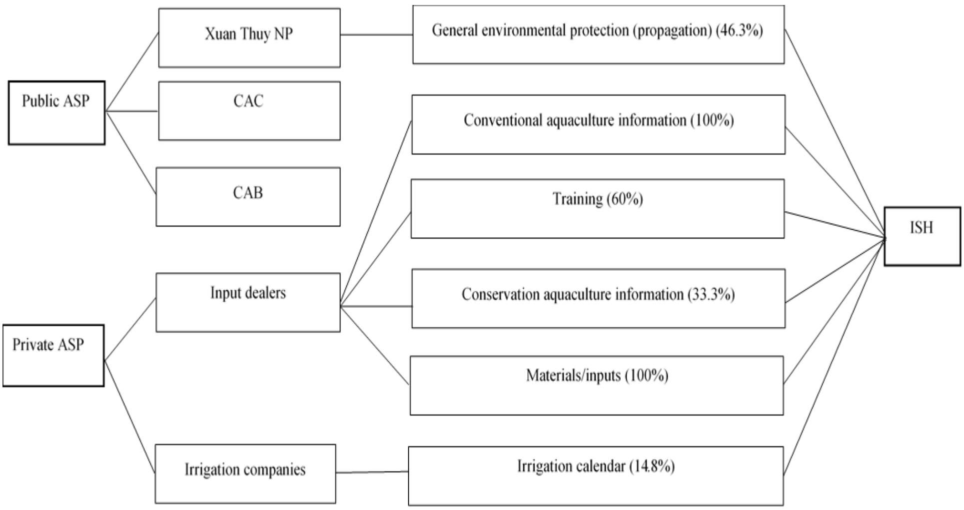


Figure 6.9: AAS flows for ISH farmers (ASP: Agricultural service provider)
(Source: Survey, 2019)

The AAS methods refer to means that are used by providers in their interactions with farmers such as Farmers' Field School, Participatory Extension Approach, or Participatory Technology Development. Table 6.9 presents the methods and tools of AAS. Input dealers have more types of delivery methods than Xuan Thuy National Park, CAB, CAC, and irrigation companies. Input dealers considered ISH farm owners are core customers with a diversity of AAS methods and tools including selling, meeting, training, field visit, one-to-one advice, technicians. While CAB has an only one-way method for AAS provision through the public louder.

Table 6.9: Methods of AAS

Service providers	**Methods and tools**		
	IAM	ISH	RB
Input dealers	Meetings, training courses, and selling	Meetings, training courses, field visits, one-to-one advice, input supplier technicians, selling	Training courses, selling, and direct consultation
Irrigation companies	Informing working times of sluice gates through public louder	Informing irrigation times of sluice gates through public louder	Informing irrigation times of sluice gates through public louder
Xuan Thuy National Park	Meetings, training	Meetings, training	Meetings, training
CAB	None	None	Public louder
CAC	None	None	Input supplying, direct consultation

(Source: Survey, 2019)

Currently, the ecosystem of this area bears many environmental impacts partly due to improper practices of farmers. As concerned earlier, RB farmers apply an excessive dose of inorganic fertilizers but a dearth of organic nutrient sources. Contaminants of pesticides from RB fields were pollutants for IAM and ISH farms as claimed by farm communities. Sludge and sewage without careful treatment from ISH ponds lead to degradation of intake water for both ISH and IAM. The findings of this study reveal that farming practices and management are guided by DARD of Giao Thuy district and applied similarly between the buffer and outer communes of the district. The DARD of Giao Thuy district regulates standards and permits of farm disposal based on index introduced by the MARD in Circular 22/2014/TT-BNNPTNT but they are not implemented as a compulsion among farmers. AAS has been promoting with the main aim at grain yield improvement, but the farm yields were unstable in farming systems. This may mismatch between dual goals of Xuan Thuy National Park's buffer area which seeks to achieve the livelihood of farmers and preserve the ecosystem.

The AAS system in the buffer zones of Xuan Thuy National Park involves public and private stakeholders. They are crucial in promoting agricultural production by providing materials and disseminating knowledge and practices for classes of farmers. Public AAS providers have been reaching a number of marginal farmers, but their methods and flows remain a supply-driven approach with single technical services. This resulting in a lower level of AAS effectiveness of government-based sectors as compared with private sectors in responding to the needs of different farmer groups in the area. As concerned earlier by Minh et al. (2010) and Van De Fliert et al. (2007), the AAS system of Vietnam has been designed and implemented by the MARD and provincial government based mainly on top-down hierarchy. It is seen as a critical weakness preventing the effectiveness of AAS leading to a high dependency on external resources of local people. In this study site, the interaction between farm practitioners and AAS providers is still low which is not different from the existing situation of the whole country as Hoang et al. (2006) pointed out. The AAS works for RB focuses more on supplying seeds, pesticides, fertilizers and informing cropping calendar. Meanwhile, there is a lack of transferred works for IAM and ISH because the communal authority has a lack of aquaculture technicians and field workers. AAS providers have little roles in assisting farmers to confront regional issues including negative impacts from pesticide contaminants and pond effluents, a disease outbreak in production, drastic weather, post-larvae quality management, etc.

On the other side, input dealers contribute growing roles in delivering materials and updated technical knowledge, instructing new technologies, and providing direct consultation based on community-led and demand-driven approach for farmer clients in particular in the case of IAM and ISH. Some other successfully cases from the private sector are documented in the report of Katothya et al. (2020):

- In Mazao Safi (Kenya), AAS from private sector support small and medium-scale farmers through a decision support system to enhance productivity, quality and market access. Farmers are offered advisory (with fees) for perennial crop production through farm visits twice per month. Farm information are continuously collected and used to consult. Service providers have mini soil lab for rapid tests of pH, nitrogen, phosphorus, and potassium for soil improvement advice. Farmers are reminded to test their soil after every three years. Advisory providers recommend inputs and they also intend to gradually transition into organic farming. Green technology is provided with charges including equipment, protective clothing, solar lanterns and clean cookstoves. The advisory works contribute to increased coffee yield for farmers, increased tested soil cases for communities, and profitable revenues generation for service providers themselves.
- Instaveg, a medium-scale enterprise, has worked with various actors to promote fresh vegetables of in Kenya for export. Partnerships of Instaveg company are various:

+ Public actors: Pests Control Product Board is responsible for training in safe use of pesticides, regulatory services.
+ Food processors (private): expertise on food safety and technology.
+ Europe-Africa-Caribbean-Pacific Liaison Committee: Financial support for certification services

Instaveg provides a diversity of advisory works:

+ Land use assessment: Production team (agronomist staff) visit farms to assess land-use status and infrastructure accessibility.
+ Group meeting: Production team and other colleagues share information on engagement rules.
+ Planting training: Production team shares planting programme, train farmers in practices (land preparation, spacing, timings), and supply seeds.
+ Training: Production team and experts from other private and public actors provide main topics: safe use of pesticides, crop nutrition, labelling for traceability, harvesting hygiene and managing delivery of produce.
+ Farm monitoring visit: Production team works with Quality team visit farms (random) to monitor crop performance, check for pests and diseases, and advise growers about actions required, especially on spraying, weeding and watering.
+ Hotline contact: Production team and Technical department response calls from individual growers and/or group leaders to attend to observed concerns.
+ Special meetings: Mixed teams from all all department organize meetings between growers and Instaveg advisors to discuss and resolve emerging issues.
+ Distributing information, education and communication materials for farmers.

Private actors carry out AAS with multiple instructional methods but they might have fewer mandates to provide services as a "public good" and usually lack interest in serving smallholding farmers as well as solving environmental issues in this site. They may focus more on the needs of businesses than sustainability. According to Umali & Schwartz (1994), the public sector should provide advisory services if the advice has the nature of public goods, while the private sector is a preferred choice if the advice represents private goods. In addition, as mentioned by Boyd (2004) and Oladosu (2006), an advisory service system is designed to help farmers to identify problems, educate them and link them with the environment. Thus, it is urgent for more programs in conservation agriculture (including cropping, aquaculture farming, and forestry) and water conflicting resolutions should be implemented and monitored strictly by government-based sectors along with cooperation with grass-root extension force from private companies to obtain advanced technical knowledge. Strengthening the cooperation and coordination between public and private sectors can complement and supplement of AAS system in the area and encourage multi-directional flows of information, knowledge and management skills.

However, the roles of the third sector in the AAS system is not help much in conservation in this area. Farmers' organizations at commune level include CAC and CAB with main task of transmission technical knowledge. Lack of community user groups limits discussions and negotiation the water conflict problems among communities.

Since agricultural production in the buffer zone depends on changing conditions and needs of farmers for knowledge and information are various, but the AAS received is still poorly delivered for all farming systems. Hence, relevant packages of technical advisory and problem-solving skillsets have not yet satisfied the needs and improved the economic and environmental outcomes of diverse production systems. Target farm management skills, training, and solutions for different groups of farmers should be addressed to motivate farm owners to comprehensively adapt for sustainable production for example lower antibiotics, improving recycling and reducing water exchanges in ISH; restraint nitrogen fertilizers, and synthetic fertilizer imbalance and pesticide in RB. Sustained efforts are required to assure the use of AAS in decision-making and enhance its effectiveness.

The findings indicate no capital investments in promoting environmentally friendly farming practices for RB, ISH, IAM in the buffer area in the recent three years (2017-2019). Moreover, results highlight the deficient incentives on conservation agriculture of farmers. These imply that conservation agriculture programs and public education are urgent to be strengthened in this area. Even though being a buffer zone of the national park with the highest level of preservation of Vietnam, Xuan Thuy National Park management board has important functions as approved in official documents, but in practices, the park has little authorization in monitoring the cultivation of surrounding inhabitants. The board has a prior goal of ecosystem preservation, therefore, their frequent involvement in agricultural planning of buffer communes might assure the conservative goals are integrated within natural resource use and farm performance.

6.2.3 Personal characteristics of farmers

The analysis of relationships between farmers' characteristics and their adoption of conservation methods could assist a better understanding of farmers' behaviors.

Table 6.10 depicts main characteristics of RB farmers – decision makers in the study site (education levels, farming experience, and participating in training). The majority of farmers (62.5% of respondents) have completed primary and secondary school, while a few of them gains high school (25% respondents) or college and higher (12.5% of respondents). A large number of farmers (57.3% of respondents) have grown rice for more than 10 years, whilst small number of them (21.9% of respondents) have less than five-year experience. There were only 39.6% of RB farmers reported to participate in training, while 60.4% of them did not so.

Table 6.10: Characteristics of RB farmers

Farmers' characteristics	Percent (%)
1. Education levels	
- Primary and secondary school	62.5
- High school	25.0
- College and higher	12.5
2. Farming experience	
< 5 years	21.9
From 6 -10 years	20.8
> 10 years	57.3
3. Participated in training	
- Yes	39.6
- No	60.4

(Source: Survey, 2019)

The Pearson Chi-square tests show that training participation, experience, and education of RB farmers have relationships with their adoption of agroecological-based methods (Table 6.11). This is consistent with the analytical results of other authors. According to Sidibé (2005), training is the determinant of small-holding farmers' adoption in soil conservation techniques in Fumanat plain (Iran). Ghimire et al. (2015) conclude that education is the factor of farmers' adoption in rice cultivation in Nepal. Azam & Banumathi (2015) also find a positive association between schooling years of farmers with their practices in organic farming. Illukpitiya & Gopalakrishnan (2004) confirm that farming experience and education level affect on farmers' decisions in conservation agriculture in Sri Lanka.

Table 6.11: Relationships between RB farmer's characteristics with the application of agroecological-based practices

Methods	Training	Experience	Education
- Incorporate residues from previous crops into the soil during land preparation	0.50***	0.43**	0.52***
- Incorporate organic manure and compost with chemical fertilizers	0.40***	0.22*	0.53***
- Collecting eggs of harmful pests by screens/barriers	0.55***	0.35***	0.47**
- Trapping insects by devices (light, nets)	0.47***	0.49***	0.45***
- Removing affected rice plants to prevent spread of diseases	0.43***	0.25***	0.60***
- Conservation of natural enemies	0.38***	0.56***	0.29**
- Do not use preventive insecticides	0.54***	0.40***	0.48***
- Do not use early preventive spraying (before first 40 days after transplanting)	0.47***	0.41***	0.46***
- Used chemical pesticides as the last methods when all of the non-chemical methods are fail to control	0.43**	0.25**	0.60**

Note: (***): Pvalue at 0.001 significant, (**): Pvalue at 0.01 significant, (*): Pvalue at 0.05 significant.

(Source: Complies from owned data)

Table 6.12 reveals that predominant ISH farmers have schooling years at primary and secondary levels (42.6% of respondents). Intensive shrimp have introduced in Xuan Thuy National Park at the end of 2014, a large number of shrimp culturists (68.5% of respondents) have experienced less than 3 years and a small proportion of farmers have more than 3-year experience. Most farmers (70.4% of respondents) participated in the training, the remaining (29.6% of respondents) did not. For those who adopted one or several methods of agroecology, Pearson Chi-square tests show that training participation, experience, and education of ISH farmers have relationships with their adoption of several agroecological-based methods (Table 6.13).

Our analytical results are consistent with the conclusion of Chittem & Kunda (2018). These researchers also emphasize that education and farming experience of white-legged shrimp farmers are critical factors of BMP (Better Management Practice) application. In the research of Jeeva et al. (2009), the authors also conclude that training programs have contributed significantly to the adoption of improved practices among shrimp culturists.

Table 6.12: Characteristics of ISH farmers

Farmers' characteristics	Percent (%)
1. Education levels	
- Primary & secondary school	42.6
- High school	31.5
- College and higher	25.9
2. Farming experience	
≤ 3 years (6 production crops)	68.5
> 3 years (6 production crops)	31.5
3. Participated in training	
- Yes	70.4
- No	29.6

(Source: Survey, 2019)

Table 6.13: Relationships between ISH farmer's characteristics with the application of agroecological-based practices

Methods	Education	Experience	Training
- Avoid discharges to sensitive environments.	0.56***	0.31*	0.42**
- Minimize water exchange without effecting shrimp production	0.63***	0.28*	0.22
- The use of veterinary drugs and other chemicals should be recorded well.	0.49***	0.08	0.11
- The use of veterinary drugs and other chemicals should follow the manufacturers' recommendations (doses, store, disposal, etc.)	0.23	0.10	0.26*
- Antibiotics should not be used for preventive plans	0.50***	0.55***	0.53***
- Waste and sludge after the treatment should not be used/discharge to the water bodies	0.24	0.36***	0.39***

until these compounds have had enough biodegradation time			
- Cooperating and communicating with neighboring farms for common problems of disease spread.	0.36*	0.49***	0.25
- Dead or sick shrimps must be handled to avoid disease spread to other farms.	0.48***	0.07	0.19
-Giving adequate times for degradation of disease before discharging into water bodies.	0.48***	0.41***	0.55***
- Using sedimentation ponds/traps to reduce suspended material and increase effluent quality.	0.49***	0.41***	0.37***
- Wastewater should be treated in an environmentally responsible manner before discharging to the water bodies.	0.58***	0.16	0.27*
- Mangroves should be planted on discharge channels as natural filters.	0.51***	0.46***	0.27

Note: (***): Pvalue at 0.001 significant, (**): Pvalue at 0.01 significant, (*): Pvalue at 0.05 significant.

(Source: Complies from owned data)

6.3 Conclusion of the chapter

We identify three clusters of constraints that block the developments of farming systems adjacent Xuan Thuy National Park including improper management practices of farmers, economic issues, and environmental-related issues:

In ISH production, the restraint comprising (1) improper management practices: dependency on antibiotics and diverse aquatic drugs; mismanagement of pond effluents); (2) problematic issues of economic aspect: frequent occurrence of diseases, unstable yield and income, high dependency on external production costs, limited marketing activities, low on-farm diversification, limited access to credit, high rate of land tax; (3) problematic issues of environmental aspect: water conflicting between users.

In RB production, constraints of the cultivation concern: (1) improper management practices: growing doses of pesticides, misuse of fertilizers, Limited application of eco-friendly practices; (2) problematic issues of economic aspect: high dependency on external production cost, limited marketing activities, low on-farm diversification, low financial return; (3) environmental issues: soil health risks, fertilizer risks, pesticide risk, and biodiversity risk.

In IAM production, constraints comprising: (1) improper management practices: use of wild captured species for seeds (2) problematic issues of economic aspect: low yield of aquaculture species, limited supported policies (certification); (3) problematic issues of environmental aspect: water conflicts with other farming systems, biodiversity degradation, low coverage of mangroves.

From our findings, the study of interlinked causes helps to deepen understanding of blocking mechanisms of the challenges. The first cause starts with problems related to poor policy development associated with the limited implication of the regulatory framework for the ecological-based production in the protected area buffer zone. While Vietnam has numerous laws, policies and regulations for eco-friendly cultivation, they have not been effectively transferred into practices along province-district-commune levels. DARD of province and district has focused on RB intensification production with the wide use of synthetic fertilizers and pesticides rather than introducing ecological-based methods. As a result, higher yield is recognized incorporating growing doses of agrochemicals, more disease occurrence associated with diverse environmental risks. In aquaculture, management of Nam Dinh province as well as buffer communes is ineffective in monitoring shrimp production toward environmental protection.

The second cause that influences the developments are limited transferred works of agricultural advisory services in this area. AAS received is still poorly performed for all farming systems. The effectiveness levels of different service providers have assessed as moderate and less sustainable. None of the service providers gained sustainable effectiveness. The needs of farmers for advisory works are various, while the service transferred fails to solve environmental problems the farmers are facing such as being affected by pesticide contaminants and pond effluents, a disease outbreak, drastic weather, and water conflicting, etc. The AAS works for rice cultivation focuses more on supplying seeds, pesticides, fertilizers and informing the cropping calendar rather than assisting farmers with conservative methods. Meanwhile, there is a lack of transferred works for aquaculture cultivation because the communal authority has a lack of technicians and field workers. Xuan Thuy National Park management board have not interacted with RB, IAM and ISH production. Due to the lack of involvement of the park authority, the conservation activities are not well integrated with the management of agricultural production in the buffer zone.

The third blocking mechanism is related to the objectives and characteristics of farmer-decision makers. The majority of farmers care most about profits more than feeling responsible for long-term maintenance. This is express the improper activities in the land-use systems and thus partly leads to the undesirable environmental risks in surveyed farms. Whilst the conservative authorities expect both conservation and development, but it is not always possible for them to do so.

The findings also concern that farmers' knowledge of ecological agriculture is limited, and these have a direct impact on the low adoption of conservation methods among communities.

7

Conclusion and recommendation

7.1 Conclusion

Protected areas in Vietnam have important roles in preventing exploitation or harmful management practices of human activities and conserving the unique biodiversity values of the whole country. Currently, Vietnam has a total of 272 protected areas locating from north to south and at both national and international importance. There are two administrative levels involved in protected area management. At the national, the Vietnam Administration of Forestry (under MARD) manages six inter-provincial national parks. At the provincial, the PPCs manage the protected sites locating entirely within one province. For Vietnam, national parks are ranked at the first level of protection, followed by Nature Reserves for protecting nature, rare species, forest ecosystems and genetic resources. MARD and MoNRE, two specialized agencies at the national level, are tasked with executing the management of forest, land use, and other natural resources in the whole country including those in protected areas. MARD has main roles in managing agro-forestry-fishery sectors, while MoNRE is responsible for the management of land, water, environment, and biodiversity. PPCs have roles in implementing strategies on environmental protection at the provincial level including that of protected areas.

DARD and DoNRE, two functional departments of provinces, receive technical guidance from MARD and MoNRE, but they are under the administration of PPCs and report to PPCs. DARD and DoNRE are also two administrative agencies having responsibility for disseminating national laws and regulations to communes, consulting resource users, and enforcing laws on natural and environmental protection at the local level including that in protected areas. Through the professional works of DARD and DoNRE, PPCs manage protected areas.

DPCs support programs of socio-economic development, biodiversity conservation and raise awareness of people at the local level. DPCs do not participate much in the environmental management of protected areas.

CPCs are the lowest hierarchical level of administration. CPCs play key roles in managing agricultural production and other livelihood development activities of buffer protected area communities. CPC may allocate use rights to local people and designate them to manage natural resources together with protected area management boards.

Management boards of protected areas are administrative organizations. The assigned tasks of protected area management boards are in charge of applying laws on natural environmental protection and biodiversity conservation within protected areas (core zones). Protected area management boards also have roles in organizing the participation of buffer communities in forest protection, conservation, wise utilization of natural resources, and environmental service provision (Decision 186/2006/QD-TTg). Vietnamese Government assigns the management boards of protected areas to organize and cooperate with local authorities and communities to develop programs and projects for buffer zones (Decision 156/2018/ND-CP). However, our further results show the low effectiveness in the works of park managers in economic development activities for buffer zones.

All of five surveyed protected areas have their buffer zones where have been designed for agricultural production and residential land. Cropping systems of rice, maize, potato, and cassava are dominated in the buffer zones. Shrimp aquaculture also exists in these areas (except in Tam Dao National Park). Several issues of agricultural production around the sites are the dependency on agrochemicals, lack of enforcement regulation, low awareness of locals, low economic performance and lack of incentives for conservation. The management boards do not have the authority to enforce measures of environmental quality in the buffer zones. The practical programs for socio-economic development or transfer economic models for buffer communities of management boards are limited due to insufficient funding for the buffer zone, limited capacity of management boards, pressures from the economic development of the surrounding communities, and a dearth of specific policies and operation mechanisms for development - conservation activities in the protected area buffer zones.

The integration development plan for the buffer zones with the activities of protected area management boards is not fully operated. The integration of biodiversity and environment conservation into the socio-economic development of local people is still limited in most of the surveyed sites. Eco-tourism development can share its revenues for funding. This effort is ranked at “very low” and “low” at Tam Dao National Park, Bai Tu Long National Park, and Tien Hai Nature Reserve, while Xuan Thuy National Park and Cat Ba National Park achieve at the “medium” level. Our further in-depth interviews show the major causes of the low level of effectiveness including (1) due to insufficient funding, a majority of funds were used for basic running costs or hard infrastructure rather than conservation; (2) limited capacity of staff; (3) pressures from economic development; (4) a dearth of specific relevant policies and operational mechanisms for large-scale participation of communities in conservation activities.

Taking Xuan Thuy National Park as a case analysis to deepen the understanding of the dynamics of agricultural production and analyze constraints of sustainable agriculture around the protected area:

Three farming systems with a substantial focus on cropping and aquaculture subsector have been analyzed. We have concluded by emphasizing that guidance and management of cultivation practices from the local government for farmers in the buffer zone is similar as those in non-buffer communes.

Farming systems gained different levels of whole-farm performance in regards to socio-economic facets. But diverse issues related to the risks of the natural environment and ecosystem biodiversity have arisen.

The monoculture practice of ISH and RB incorporates with the level of intensity lead the wide use of synthetic inputs. Although ISH is considered as the most attractive system among the three systems and it is also expected as an economic engine for the local economy because of the highest income but we have found that the efficiency is below the potential. Moreover, when compared with the financial performance in other provinces, the income of ISH nearby Xuan Thuy National Park acquired at a medium level.

ISH and RB farmers sold farmed products through the conventional channel (direct sales), while IAM products were sold through both conventional and short-channel (online sales).

The IAM aqua-products were preferred by the local and distant markets and they were checked for food safety by the National Institute for Food Control (the application was done by an individual farmer) but there were not eco-labeling regimes for further promotion.

Currently, the state government still subsidizes 0.5 million VND/ha/year of conventional rice in this area. None of the farmers received subsidies for conservation practices except IAM farmers do not have to pay land tax for their ponds.

From ecological and environmental sustainability perspectives, the cultivation rose diverse undesirable problems:

In cropping cultivation, RB farmers overused chemical fertilizers. They applied higher rates of N fertilizer than local suggested standards and higher than many tropical regions such as China or the Philippines. Even though the imbalance fertilization has long been existed, farmers and local authorities face difficulty in matching crop needs with existing soil fertility due to the lack of equipment, capacity and budget. We highlight that the utilization of synthetic fertilizers in RB was mainly unsustainable.

Due to inordinate practices in rice farming, the sustainability of soil fertility was mainly undesirable. The adoption of chemical pesticides was assessed at acceptable but the fact that growing doses have been used in recent years, whilst very few eco-friendly practices of pest and disease control are introduced and applied.

The adoption of other practices for agrobiodiversity conservation and natural ecosystem protection in RB farming is also evaluated at an unsustainable level. Burning rice straw after harvesting has effects on the daily life of local residents, but farmers do not know how to deal with the residues. In brief, none of the environmental indicators gain desirable or sustainable in the RB sector.

In ISH, the use of aquatic chemicals, drugs and pelleted feeds, as well as disposal of wastewater and pond sludge into common rivers are concerning. Farmers did not reuse water or their own recirculation water system. Most of them applied frequent exchange regimes to supply inlet water for ponds, while water from outside rivers is impaired by contaminants of agrochemical from nearby RB fields, polluted waste from other ISH ponds and residential garbage. The reluctance of wastewater treatment before releasing it to the water bodies is stressing the environmental quality around the park. ISH production faces a number of issues related to environmental risks including disease occurrence, self-pollution and external pollution.

In IAM, the co-culture of diverse aquatic species gained several environmental and economic benefits, but the biodiversity loss rate was recognized due to this system depends on wild-capture marines and the low density of mangroves inside farms. IAM farmers claimed for the gradual reduction of yields due to water pollution from other farming systems. Unregulated production of RB and ISH creates frictions between farmers who derive their main livelihood from rice and those who rely on aquaculture.

A number of critical constraints that pose particular problems for sustainable development and the application of ecological-based agriculture have been identified:

Poor policy development, low enforcement capacity and ineffective management toward conservation agriculture at the provincial - district - communal authorities is the first major cause of the constraints. DPC and CPC see agriculture as an ideal means to encourage economic growth of the buffer zone and they issue decisions to develop the sector. However, they lack ecological knowledge and tools to manage farming in the fragile buffer zone which has long been displaced by dense population and intensified production. Xuan Thuy National Park management board has important functions as defined in the official document but this organization has only authority within the park (core zone). For the buffer zone, they have very little authorization in monitoring improper practices of peripheral communities although they have more scientists working on the issues related to environmental protection. The integration of agricultural development in the buffer zone with the activities of the management board is not fully operated as expected by the laws. Farmers have little interaction with the park management board for agricultural production. Furthermore, the enforcement of environmental standards is limited despite the existence of regulations at the national and district level. The weak enforcement of environmental standards in agricultural production attributes by the lack of facilities, resource-conserving equipment, laboratories, and technician of district and commune levels. Provincial DARD promotes intensification and monoculture production with the wide use of agrochemicals more than introducing agroecological methods. In summary, environmental standards were given too much emphasis in documents, while they have not transferred into practice and materialized in this site.

There is also a shortage of special policies, regulations, regimes, and development measures for agricultural production around Vietnamese protected areas including Xuan Thuy National Park. Thus, there are deficient practices of ecological-based practices such as VietGAP, BMP, GAqP standards in cropping and aquaculture systems in the buffer zone. In addition, these practices require complex principles and huge investment in infrastructure, farm management, harvesting and waste treatment, and standard application process, therefore they become difficult for small-holding farmers without the supports of the government. In this context, there is also a shortage of economic incentives for farmers who conserve nature. On the other hand, there is no restriction upon the use of agrochemicals such as pesticides and fertilizers around this sensitive area. The emergent constraints call for a reorientation of policies and the proper enforcement in the agricultural sector around protected areas to ensure the integration of ecological indicators in farming management practices and performance. Weak institutions associated with poor enforcement capacity and lack of economic incentives from the government sector can restraint conservative systems surrounding the park.

The second major interlinked cause of the constraints for such a situation can be attributed to the fact that limited performance of AAS in this area. The advisory service system in Vietnam is designed to help farmers to identify problems, educate and connect farmers with the natural environment, but the AAS received is still poorly performed for all farming systems. Packages of technical advisory and problem-solving skillsets have not yet satisfied the plentiful needs of local farmers or improved the economic and environmental outcomes of diverse production systems. The AAS works for rice cultivation focuses more on supplying seeds, pesticides, fertilizers and informing the cropping calendar. Meanwhile, there is a lack of transferred works for aquaculture cultivation because the communal authority has a lack of technicians and field workers. AAS providers have little role in assisting farmers to confront problems of this region including being affected by pesticide contaminants and pond effluents, a disease outbreak in production, drastic weather, and water conflicting, etc. Among the AAS providers, the role of Xuan Thuy National Park management board for agricultural development in the buffer zone is not specific. Xuan Thuy National Park management board has important functions as approved in official documents, but in practices, the park has little authorization in monitoring IAM, ISH, RB cultivation of surrounding inhabitants. Most surveyed farmers do not have interactions with the park authority for agricultural production. Due to the lack of involvement of the park authority, the conservation activities are not well integrated with the management of agricultural production in the buffer zone.

One of the critical interlinked constraints that arose related to the gap between the objectives of farmers and the park authority. Primary, local farmers have the top priority for profits and they want to satisfy their own needs rather than feeling responsible for long-term maintenance. More farmers enjoy direct benefits than preservation. This is express the improper farming methods in the land-use systems and thus partly lead to the undesirable environmental performance in surveyed farms. Whilst the conservative authorities expect both conservation and development, but it is not always possible for them to do so.

Lastly, the finding of the research shows that farmers' knowledge on ecological agriculture is limited, and these have a direct impact on the low adoption of environmentally friendly methods in this area. So, capturing the knowledge of farm ecology in production is also important to ensure the form of agriculture nearby protected areas.

7.2 Recommendation

The focus of this study is to prove that investigation into agricultural production practices and the constraints for long-term development and conservation can produce useful information for planning and management issues concerning protected areas. This research underlines the necessity to consider strategic responses to this condition. The institutional responses as well as actions to further stabilize the agricultural front of these areas while improving farm yields are recommended. Plus, recognizing the importance of knowledge, technology and regulation for mitigating pollution and enabling farming systems to better adapt to the changing environmental condition. This part will highlight some implications for the improvements to farming practices and management and improved monitoring and regulatory system across production.

7.2.1 For policymakers

This research underlines the necessity to incorporate several key elements for the successful implementation and management of sustainable agricultural development toward agroecology around the protected area as follow:

- Special regimes for agricultural development nearby the protected area: To restraint the risk of agrochemical pollution, Nam Dinh PPC must issue specific laws and regulations for Xuan Thuy National Park's buffer zone which ensure that agricultural production nearby the park should be as a mean to continue protecting soil, water sources and biodiversity. The Laws on Environment and Agriculture must be translated into conservation and development activities in the buffer zone. To ensure conservation, biodiversity enhancement and landscape improvement, the PPC must integrate ecological outcomes of agricultural production and strengthen more agroecological programs in the buffer zone. These programs require to safeguard wild habitats through the restriction of synthetic fertilizers, chemical pesticides and other drugs. The government might allow farmers to continue farming activities but without fertilizers, pesticides, and other hazardous chemicals and subsidy for the loss of income.
- Xuan Thuy National Park management board: The board has a prior goal of ecosystem preservation, therefore, their compulsory involvement in agricultural planning of buffer communes assure the conservative goals are integrated within natural resource use and farm performance. The conditions and structure of the agricultural landscape around protected areas should preferably be as similar as possible to that of the conservation zone, as the agricultural areas

are the extension of the core zones. An agroecological approach should be followed as much as possible in the management of the park authority to develop the ecological agriculture of the buffer zone. The park should ask the PPC for more political authority to restraint the farming activities of its buffer zone that harm the environment and promote the decision management in eco-friendly cultivation. The park should have the political power to maintain environmentally-friendly production but restraint improper ones. The park should have key roles to monitor environmental assessment of agriculture, work with farmers to suggest alternative and more natural-friendly activities and techniques.

- Resolving the conflict of interests: It is also compulsory that environmental outcomes must be integrated and evaluated with economic growth in agricultural development programs and projects for buffer communities.
- Economic instruments: There is a need for economic incentives from the government for local farmers. Economic instruments require regulations on paying farmers directly or creating markets for those whose practices for minimizing environmental impacts and provision of ecosystem services for the region, reward farmers and communities for their conservative activities in cultivation or participate in the protection of the landscape.
- Participation: Landscape management plans for protected area buffer zones require more involvement of participatory appraisals of problems and solutions, collaborative management and participatory schemes to integrate managers and community members and ensure long-term supports to conservation.
- Strengthening local people's awareness: Lack of awareness on the benefits of agroecological production among stakeholders, especially district and provincial managers remains a major constraint to its adoption. Thus, there is also a dramatic need for education creating and/or improving awareness and willingness of managers, environmentalists, agriculturists, and farmers to participate in ecological agriculture programs.
- Conservation education and training for farmers: Lack of knowledge on agroecology remains a constraint to its promotion and application. Conservation education programs and training can widen and deepen the farmers' perspective. When farmers understand the environmental degradation they are causing, the concern for maximizing profit makes them dismiss their awareness. The promotion of conservation education is an effective means of achieving goals of environmental protection and providing long-term benefits for the local. Conservation education and training should tackle real problems at specific places and find solutions for participants to improve practical effectiveness. Various tools need to include in conservation education and training such as film

shows, posters, slide presentations, and holding discussions for information exchange and conflict resolution.

- The roles of agricultural advisory service system: Nam Dinh PPC should promote the role of AAS with capable personnel and laboratory equipment from provincial to communal levels to help farmers address the problems in the region. Advisory work might reinforce smallholder farmers' knowledge on the need of farm ecology for sustainable production. Advisors should promote farmers to grow more biodiversity-friendly crops and assist them to reach certified products.
- Resolving the conflict of water: Applying community-based approaches, which support farmers and local stakeholders to work collectively in addressing common problems. Local authorities, protected area management authority, and locals in the buffer zone cooperate in planning and management in a manner that supports the conservation objectives for the protected area and the buffer zone. Plus, based on the evidence of Tilley et al. (2002), we recommend that the Nam Dinh PPC needs to design wetland vegetation surrounding the ISH farms to deal with the pollution of intensive shrimp effluents. The evidence of these authors prove that constructing wetland vegetation areas around intensive shrimp farms as circulation filters and lessen the impacts of effluent on local water bodies, conserving water and providing valuable ecological habitat.

7.2.2 For farmers

Agricultural production plays an important role for buffer communities but it becomes one of the predominant threats to environmental integrity surrounding the protected area. The unsustainable management of agricultural production practices leads to environmental pollution and ecosystem degradation. Practices need to be modified if they cause potential impacts on the environment. Agricultural production in this area is required to be scrutinized for improvements to ensure that agriculture would remain viable in the future. A major focus of activities needs to be targeted on individuals and groups of farmers that still make the greatest use of natural resources adjacent to the protected area. Roles of farmer producers should be more promoted in coping with current problems. Therefore, this research proposes several management practices that need further modification as below:

- For ISH cultivation:

To comply with self-pollution and external pollution, farmers need to obey the environmental regulations on farm effluents, apply low-discharge system, modify current systems to re-circulate system.

Integrating closed recirculation systems should be implemented in this area to deal with the growing concern of pesticide contaminants from rice fields and avoidance of disease infection through water exchange.

Storing sufficient water for grow-out ponds during the culture period at the preparation stage is one of the solutions for the existing situation of water conflict. Reducing water exchanges through good water management to minimize the effects of external pollution on shrimp ponds. All wastewater and pond effluents need to be treated through the planting mangroves around the farms for effluent absorption.

To replace antibiotics with natural medicines to improve the health of shrimps.

- For IAM cultivation:

The farmer needs to regenerate more mangrove coverage in farms to provide a better environment for aquatic marines and contribute to maintaining the ecosystem services for the coastal area.

Use hatchery-produced seeds (crab post-larvae) instead of wild-capture ones to conserve the biodiversity of the region.

Develop value chains for certified IAM products to improve income opportunities for rural households.

- For RB cultivation:

This chemical input-based farming system is based strongly on the simplified crop, standardized crop management, and systematic use of chemical inputs. To deal with sustainability issues, environmental regulations can lead farmers to introduce more substantial changes. Farmers who have conservative practices need to be rewarded or supported for market access for higher incomes.

To improve input efficiency and decrease pollutions through the application of ecosystem-based methods and precision agriculture can help to promote sustainable intensification.

To use more environmentally friendly inputs such as bio-pesticides and organic fertilizers to replace as much amount of chemical agrochemicals as possible. Furthermore, diversifying farms with site-dependent ecological-based practices will help to increase agricultural biodiversity in the future.

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QUESTIONNAIRE OF CHAPTER 4

I. QUESTIONNAIRS FOR PROTECTED AREA MANAGERS

Information on the respondent

Position of the protected area:

Email address: Telephone number:

Date of response:

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1. Profile information of protected areas

1.1. Name of protected area:

1.2 Location:

1.3 Phone number:

1.3. Area of protected areas

- [ ] The core zone:
- [ ] The buffer zone:

1.4. Governance: Which organizations govern your park/nature reserve?

- [ ] Vietnam Administration of Forestry (VNFOEST)
- [ ] Provincial People's Committee

1.5. Which organization/ministry/agencies are involved in the protection process?

- [ ] Ministry of Agriculture and Rural Development (MARD)
- [ ] Provincial People's Committee
- [ ] Ministry of National Resource and Environmental (MONRE)
- [ ] Ministry of Culture, Sport and Tourism
- [ ] Others.

2. Designation of protected areas

2.1. What are the objectives of the protected area?

2.2 What are the assigned tasks of the protected areas?

Assigned tasks	**Tick here**
1. Managing, protecting and developing natural resources of protected area	
2. Conducting scientific research activities	
3.Conducting environmental education activities for communities	
4. Organizing eco-tourism and entertainment activities	
5. Cooperating with international organizations	
6. Organizing environmental services	
7. Developing livelihoods for buffer zones	

8. Providing and transferring agricultural advisory services and agricultural models for buffer zones	

2.3 What are current activities of protected areas based on assigned tasks?

Current activities	**Tick here**
1. Managing, protecting and developing natural resources of protected area	
2. Conducting scientific research activities	
3. Conducting environmental education activities for communities	
4. Organizing eco-tourism and entertainment activities	
5. Cooperating with international organizations	
6. Organizing environmental services	
7. Developing livelihoods for buffer zones	
8. Providing and transferring agricultural advisory services and agricultural models for buffer zones	

2.4 How is the organization chart of the protected area?

2.5 How is the workforce and educational background of the staff?

Educational background	**Number of staff**
1. Biology, ecology, environmental protection	
2. Economic, business management	
3. Laws	
4. Forestry, fishery, agriculture	
5. Tourism	
6. Geography, geology	
7. Others (history, cultural, etc.)	

3. Laws for protected areas

3.1. What do laws/regulations manage your protected areas? And which do administrative agencies monitor the application of these laws?

Legal normative documents	**Agency**
1. Biodiversity law 20/2008/QH12 issued in 2008 (with the amended Biodiversity law 32/2018/VBHN-VPQH), Decree 65/2010/ND-CP: Guidelines for implementing articles of Biodiversity law, Decision 1250/2013/QD-TTg: Strategy for managing the biodiversity to 2020, with a vision toward 2030	

2. Environmental protection law 55/2014/QH13 and Decree 19/2015/ND-CP: Guidelines for implementing articles of Environmental protection law 55/2014/QH13	
3.Forestry law 16/2017/QH14 and Decree 156/2018/ND-CP: Guidelines of implementation articles of Forestry law, Decree 99/2010/ND-CP: Policies on payment of forest environmental services and amended Decree 147/2016/ND-CP	
4. Fishery law 18/2017-QH14 and Decree 26/2019/ND-CP: Guidelines of implementation articles of Fishery law	
5. Decision 24/2012/QD-TTg: Policies of investment and development of Special-use forests in the period 2011-2020	
6. Decision 218/2014/QD-TTg: Management strategy on Special-use forests to 2020, with a vision forward 2030	
7. Decree 117/2010/ND-CP: Organization and management of Special-use forests and Circular 78/2011/TT-BNNPTNT: Guidelines of implementation articles of Decree 117	

3.2. Law implementation: Does your protected area apply these laws/regulations?

Law (number, issue)	**Tick here**
1. Biodiversity law 20/2008/QH12 issued in 2008 (with the amended Biodiversity law 32/2018/VBHN-VPQH), Decree 65/2010/ND-CP: Guidelines for implementing articles of Biodiversity law, Decision 1250/2013/QD-TTg: Strategy for managing the biodiversity to 2020, with a vision toward 2030	
2. Environmental protection law 55/2014/QH13 and Decree 19/2015/ND-CP: Guidelines for implementing articles of Environmental protection law 55/2014/QH13	
3.Forestry law 16/2017/QH14 and Decree 156/2018/ND-CP: Guidelines of implementation articles of Forestry law, Decree 99/2010/ND-CP: Policies on payment of forest environmental services and amended Decree 147/2016/ND-CP	
4.Fishery law 18/2017-QH14 and Decree 26/2019/ND-CP: Guidelines of implementation articles of Fishery law	
5. Decision 24/2012/QD-TTg: Policies of investment and development of Special-use forests in the period 2011-2020	
6. Decision 218/2014/QD-TTg: Management strategy on Special-use forests to 2020, with a vision forward 2030	
7.Decree 117/2010/ND-CP: Organization and management of Special-use forests and Circular 78/2011/TT-BNNPTNT: Guidelines of implementation articles of Decree 117	

3.3 How do you assess the effectiveness levels of current activities of protected area management boards based on the application of legal normative documents?

Levels of effectiveness: very low (1); low (2); medium (3); high (4); very high (5)

Activities	**Effective levels**
1. Payment of forest environmental services	
2. Environmental protection/biodiversity conservation	
3. Scientific research	
4. Eco-tourism development	
5. Environmental education for buffer communities	
6. Socio-economic development for buffer communities	

4. Agricultural activities

What are issues of agricultural development around protected areas and its seriousness?

Levels of seriousness: very low seriousness (1), low seriousness (2), moderate (3), high seriousness (4); very high seriousness (5)

Issues	**Levels of seriousness**
1. Dependency on agrochemicals	
2. Pollution from surrounding aquaculture farms	
3. Pollution from surrounding crop farms	
4. Low economic performances of crops	
5. Low economic performances of aquaculture	
6. Farming encroaches on natural ecosystems	
7. Un-regulation in farm production	
8. Lack of regulations and enforcement	
9. Low awareness of farmers	
10. Lack of incentives for conservation farming	
11. Others	

6. Other information

Please provide secondary data of natural and geographical characteristics of the protected area?

……………………………………………………………………………………….
……………………………………………………………………………………….
……………………………………………………………………………………….
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II. QUESTIONNAIRES FOR BUFFER COMMUNES

Information on the respondent

Position in the protected area:

Email address:

Telephone number:

Date of response:

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1. General information of buffer zone

1. 1 Please provide the information of land use of the buffer zone?

1.2 Please provide the information of the population of the buffer zone?

2. Objectives

What are objectives of the communes for agricultural development?

3. Agricultural production

3.1 What are main agricultural production systems in the buffer zone?

3.2. How are main characteristics of the production systems?

- Area
- Yield
- Production system
- Diversity of species
- Stocking density
- Seed sources
- Number of crop/year
- Chemical used
- Feed used
- Aeration
- Survival rate of shrimp (%)
- Water exchange
- etc.

3.3. What are issues of agricultural development around protected areas and its seriousness?

Levels of seriousness: very low seriousness (1), low seriousness (2), moderate (3), high seriousness (4); very high seriousness (5)

Issues	**Levels of seriousness**
1. Dependency on agrochemicals	
2. Pollution from surrounding aquaculture farms	
3. Pollution from surrounding crop farms	
4. Low economic performances of crops	
5. Low economic performances of aquaculture	
6. Farming encroaches on natural ecosystems	
7. Un-regulation in farm production	
8. Lack of regulations and enforcement	
9. Low awareness of farmers	
10. Lack of incentives for conservation farming	
11. Others	

QUESTIONNAIRES OF CHAPTER 5

I. QUESTIONNAIRES FOR RB FARMERS

Name of respondents:
Address:
Name of interviewer:
Date:

1.Household information

No.	Name	Gender	Schooling years	Age	Occupation	Training
1						
2						
…						

2. Objectives of farmers

Why do you start the production?

3 Land use for the cultivation

3.1 Please describe characteristics of your fields in the table below?

Land characteristics	**Plot 1**	**Plot 2**	**…**
3.1 Area (ha)			
3.3 Land used prior			
3.4 Distance from your farm to the agricultural sluice gate			
3.5 Distance from your farm to the coast			
3.6 Distance from your farm to the core zone			
3.7 Distance from your farm to Xuan Thuy National Park office			
3.8 Any problems of this location (pollution/waste/ect.)			
3.9 Land tenure (yes = 1, no = 0)			
3.10 Land fee (VND/ha/year)			
3.11 Ecosystem fee (VND/ha/year)			
3.12 Other fee (VND/ha/year)			

3.2 Do you apply soil tillage?

☐ Yes ☐ No

3.3 What are your seed sources?

☐ Purchased ☐ Self-produced ☐ Both

3.4 What are your seedling methods?

☐ Direct seedling ☐ Transplanting

3.5 What are nutrient source?

☐ Inorganic ☐ Organic

3.6 What are your methods of weed control?

☐ Herbicides ☐ Manual

3.7 What are your methods of pest and disease control?

☐ Chemical ☐ Environmentally friendly

3.8 What are your methods of harvesting?

☐ Rented machine ☐ Manual

4 Water source and wild species for production

Please clarify characteristics of water source for your production in the table below:

Water source and wild species	**Plot 1**	**Plot 2**	**…**
4.1 Water source of ponds (rivers/sea mouth, etc.)			
4.2 Frequency of water exchange (times/crop)			
4.3 How many percent of wild species for your production			

5. Labor source for the production

5.1. How many family members participate in the production?

- In which, number of men labor:…………, and number of women labor?

- In which, total working hours of men labor:……...., and total working hours of women labor?

5.2 Activities of men labor in the production?

5.3 Activities of woman labor in the production?

5.4. How many hired laborers participate in the production?..............................Cost of hired labor?

6. Production costs

Inputs	**Cost (VND)**
Rice varieties	
Formulated feed/rice bran	
Electricity	
Oil	
Fertilizers	
Pesticides	
Rented machinery	
Land rents (pay for private land owner)	
Land rents (pay for government)	
Interest (pay for loan)	

7. Farmed products

	Rice grains
7.1 Total quantity (kg)	
- Home consumption (%)	
- Farm produce sold in markets (%)	
7.2 Average selling price	
7.3 Who is the buyers	
7.4 Where do you sell?	

8. Marketing activities

8.1. What are your channels of sale?

☐ Conventional channel ☐ Short-channel

8.2. What are types of markets?

☐ Sale through local markets ☐ Sale through outside markets

☐ Sale through restaurants ☐ Sale through ethical purchasing groups

8.3. Are farmed products being preserved?

☐ Yes ☐ No

8.4. Are farmed products being processed?

☐ Yes ☐ No

8.5. Are farmed products being packaged?

☐ Yes ☐ No

8.6. Are farmed products being labeling?

☐ Yes ☐ No

8.7. Do farmed products have eco-labeling?

☐ Yes ☐ No

8.8. Do you apply agri-tourism?

☐ Yes ☐ No

9. Income generation activities and income stability

Please indicate percent of income generation activities for home consumption and market?

Income activities	Home consumption (%)	Market (%)
Crop cultivation		
Livestock		
Aquaculture production		
Fishing		
Off-farm		

10. Issues of the production

10.1 How do you use rice straw?

☐ Mainly burned ☐ Mainly composted

☐ Mainly fodder ☐ Others

10.2 What do you see the effects of rice straw burning?

☐ Polluted air ☐ Effect on the soil property

☐ Effect on the daily life activities ☐ Do not know

10.3 Do your farms is impaired by contaminants of agrochemical from other fields?

☐ Yes ☐ No

If yes, please clarify which fields?

11. Environmentally friendly practices

Please clarify methods that you know and applied in the table below:

Methods	You know	You applied
11.1. Soil fertility management		
- Incorporate residues from previous crops into the soil during land preparation		
- Incorporate organic manure and compost with chemical fertilizers		
11.2.Site specific integrated nutrient management		
- Use leaf color chart as a mean to assist farmers to use proper dose of N fertilizer in different plots		
11.3. Integrated pest management		
11.3.1 Agronomic tactics		
- Crop rotation/mixed crop/intercropping/ trap crops		
11.3.2 Mechanical tactics		
- Collecting eggs of harmful pests by screens/barriers		
- Trapping insects by suction devices (light, nets, etc.)		
- Removing affected rice plants to prevent spread of diseases		
11.3.3 Biological tactics		
- Conservation of natural enemies		
- Do not use preventive insecticides		
- Do not use early preventive spraying (before the first 40 days after transplanting)		
- Growing legumes or broad leaf weeds on rice field bunds for natural enemies		
- Growing grass and other vegetation near rice fields for natural enemies		
- Conserve insect predator frog, toad, birds by preventing their capture from rice fields		
11.3.4 Chemical tactics		
- Used chemical pesticides as the last methods when all of non-chemical methods are fail to control		

12. Fertilizer utilization

12.1 How have you use fertilizer according to different growing seasons and rice varieties?

Fertilizers (kg/sao/crop)	**Hybrid rice**		**Inbred rice**	
	1st season	2nd season	1st season	2nd season
NPK (16-16-8)				
NPK (5-10-3)				
NPK (5-12-3)				
P				
K				

12.2 Do you apply any one of methods for sustainable utilization of fertilizers as follow:

1. No use of fertilizers
2. Not exceed dosages
3. Use organic nutrient sources
4. Use leguminous plants to reduce chemical fertilizers
5. Distribute fertilizers in several times over the growing period
6. Consider soils and climate conditions
7. Use soil sampling at lease every five years to calculate nutrient budget
8. Apply precision farming
9. Use buffer strips along watercourses

12.3 How many percent of your farm have been under reduced soil fertility?

1. Below 10% of farmland get affected
2. From 10-50%
3. Above 50%

13 Pesticide utilization

13.1 Do you apply any methods of health-related risks for pesticide utilization?

1. Following label recommendations
2. Cleansing equipment after use
3. Safe disposal of waste

13.2 Do you apply any methods of environmental–related risks for pesticide utilization?

1. Following label recommendations
2. Applying good agricultural practices (crop rotation, mixed cropping, inter-cropping, etc.)
3. Adopting biological pest control or bio-pesticides
4. Applying pest resistant/ tolerant rice varieties/disease resistant/certified seeds
5. Removing rice plant attacked by pest and disease
6. Cleansing equipment after use
7. Using less than two times for each pesticide in a season to restraint pesticide resistance.

14. Irrigation

How many percent of your farmland use irrigated water?

15. Biodiversity-friendly practices

Do you apply any one of methods of biodiversity-friendly practices?

1. Leaving at least 10% total area for natural or various vegetation
2. Non-pesticides and antimicrobials application
3. Adopting crop rotation

4. Using different rice varieties

5. Diversifying at least two of following farm production including crop, tree, animal products or livestock and fish.

II. QUESTIONNAIRES FOR ISH FARMERS

Name of respondents:
Address:
Name of interviewer:
Date:

1.Household information

No.	Name	Gender	Schooling years	Age	Occupation	Training
1						
2						
…						

2. Objectives of farmers

Why do you start the production?

3 Land use for aquaculture production

3.1 Please describe characteristics of your ponds in the table below?

Land characteristics	**Pond 1**	**Pond 2**	**…**
Area (ha)			
Percent of mangroves (%)			
Land used prior			
Distance from your farm to the agricultural sluice gate (m)			
Distance from your farm to the coast (m)			
Distance from your farm to the core zone (m)			
Distance from your farm to Xuan Thuy National Park office			
Any problems of this location (pollution/waste/ect.)			
Land tenure (yes = 1, no = 0)			
Land fee (VND/ha/year)			
Ecosystem fee (VND/ha/year)			
Other fee (VND/ha/year)			

3.2 Do your farms have good access to brackish water sources?

☐ Yes ☐ No

3.3 Do your farms have good access to electricity system?

☐ Yes ☐ No

3.4 Do your farms locate nearby waste areas?

☐ Yes ☐ No

3.5 Do your farms locate nearby waste areas?

☐ Yes ☐ No

3.6 Do your farms have supply reservoir area?

☐ Yes ☐ No

3.7 Do your farms have effluent treatment area?

☐ Yes ☐ No

4 Water source and wild species for production

Please clarify characteristics of water source for your production in the table below:

Water source and wild species	**Pond 1**	**Pond 2**	**…**
4.1 Water source of ponds (rivers/sea mouth, etc.)			
4.2 Frequency of water exchange (times/crop)			
4.3 How many percent of wild species for your production			

5. Labor source for the production

55.1. How many family members participate in the production?

- In which, number of men labor:…………, and number of women labor?

- In which, total working hours of men labor:……...., and total working hours of women labor?

5.2 Activities of men labor in the production?

5.3 Activities of woman labor in the production?

5.4. How many hired laborers participate in the production?.............................Cost of hired labor?

6. Inputs and costs

Inputs	**Value**
6.1 Post-larvae shrimps	
Where is the hatchery (sellers)?	
Quantity of post-larvae	
Unit price of the post-larvae	
6.2 Formulated feed	
Quantity	
Unit price	
6.3 Sand	
Quantity	
Unit price	

6.4 Lime	
Who is the sellers	
Quantity	
Unit price	
6.5 Antibiotic	
Quantity	
Unit price	
6.6 Probiotic	
Quantity	
Unit price	
6.7 Chlorine	
Quantity	
Unit price	
6.8 Drugs	
Quantity	
Unit price	
6.9 Supplement	
Quantity	
Unit price	
6.10 Oil	
Quantity	
Unit price	
6.11 Electricity	
Number of KW	
Unit price	
6.12 Tubes	
Numbers of tubes	
Cost	
Expected years in use	
6.13 Plastic mat	
Cost	
Expected years in use	
6.14 Electric generator	
Numbers	
Cost	
Expected years in use	
6.15 Aerator	
Cost	
Expected years in use	
6.16 Water pump	
Cost	
Expected years in use	
6.17 Testers (pH, salinity, etc…)	
Cost	

Expected years in use	
6.18 Land rent	
6.19 Interest	
6.20 Others	

7. Farmed products

	Farmed shrimp
7.1 Total quantity (kg)	
- Home consumption (%)	
- Farm produce sold in markets (%)	
7.2 Average selling price	
7.3 Who is the buyers	
7.4 Where do you sell?	

7.5 How do yields change in recent 05 years?

8. Marketing activities

8.1. What are your channels of sale?

☐ Conventional channel ☐ Short-channel

8.2. What are types of markets?

☐ Sale through local markets ☐ Sale through outside markets

☐ Sale through restaurants ☐ Sale through ethical purchasing groups

8.3. Are farmed products being preserved?

☐ Yes ☐ No

8.4. Are farmed products being processed?

☐ Yes ☐ No

8.5. Are farmed products being packaged?

☐ Yes ☐ No

8.6. Are farmed products being labeling?

☐ Yes ☐ No

8.7. Do farmed products have eco-labeling?

☐ Yes ☐ No

8.8. Do you apply agri-tourism?

☐ Yes ☐ No

9. Income generation activities and income stability

Please indicate percent of income generation activities for home consumption and market?

Income activities	**Home consumption (%)**	**Market (%)**
Crop cultivation		
Livestock		

Aquaculture production		
Fishing		
Off-farm		

10. Issues of the production

10.1 Do you apply wastewater treatment methods before releasing it into the natural environment?

☐ Yes ☐ No

10.2 Where do you drain pond sludge?

[ ] Treatment ponds of your farms [ ] Common rivers, sea mouth

10.3 Before releasing wastewater, do you test quality standards of wastewater?

☐ Yes ☐ No

10.4 Do your farms is impaired by contaminants of agrochemical from other fields?

☐ Yes ☐ No

If yes, please clarify which fields?..

10.5 Do you experience disease occurrence in the recent years:

2018 ☐ Yes ☐ No
2017 ☐ Yes ☐ No
2016 ☐ Yes ☐ No
2015 ☐ Yes ☐ No

If yes, please clarify which are reasons of disease occurrence:

1. Self-pollution
2. Low quality of post-larvae
3. Effected from outside pollution
4. Weather
5. Do not know

10.6 Do you see any of the below negative impacts of your production?

1. Use of chemical and drug
2. Use of formulated feed
3. Use of water, discharge of water
4. Discharge of sludge
5. Pollution risks
6. Disease occurrence
7. Others

11. Environmentally friendly practices

Please clarify methods that you know and applied in the table below:

Practices	**You know**	**You applied**
1. Farm design and building		
- Having separate canals for water input and output		

- Avoid discharges to sensitive environments		
- Maintaining riverside vegetation/buffer zone between ponds and adjacent water bodies for restoration of natural habitats		
- Maintaining vegetation buffer zones among the mangroves/rivers		
2. Water quality monitoring		
- Pond water monitoring should be done at the water pond gates		
- Pond water monitoring should be done at the water outcoming pond gates		
- Evaluating effluents (water used and discharged) with reference to the quality of receiving water bodies		
3. Water exchange		
- Minimize water exchange without effecting shrimp production		
4. Veterinary drugs and chemical products		
- The use of veterinary drugs and other chemicals should be recorded well		
- The use of veterinary drugs and other chemicals should follow the manufacturers' recommendations (doses, store, disposal, etc.)		
- Antibiotics should not be used for preventive plans		
- Expired veterinary products should be removed under a not environmental contaminating way		
- Waste and sludge after the treatment should not be used/discharge to the water bodies until these compounds have had enough biodegradation time		
5. Disease management		
- Cooperating and communicating with neighboring farms for common problems of disease spread		
- Testing diseases for new shrimp PLs before stocking		
- Dead or sick shrimps must be handle to avoid disease spread to other farms		
- Use recycle water instead of water exchange during disease occurrence		
- Giving adequate times for degradation of disease before discharging into water bodies		
6. Pond effluent management		
- Implement water circulation system to reduce water consumption and effluents		
- Sedimentation and reservoir ponds store sufficient volume of anticipated water for daily used		
- Using sedimentation ponds/traps to reduce suspended material and increase effluent quality		

- Waste water should be treated under environmentally responsible manner before discharging to the water bodies		
- Mangroves should be planted on discharge channels as natural filters		

III. QUESTIONNAIRES FOR IAM FARMERS

Name of respondents:
Address:
Name of interviewer:
Date:

1.Household information

Please provide some personal information about your family members:

No.	Name	Gender	Schooling years	Age	Occupation	Training
1						
2						
…						

2. Objectives of farmers

Why do you start the production?

3 Land use for aquaculture production

Please describe characteristics of your ponds in the table below?

Land characteristics	**Pond 1**	**Pond 2**	**…**
3.1 Area (ha)			
3.2 Percent of mangroves (%)			
3.3 Land used prior			
3.4 Distance from your farm to the agricultural sluice gate (m)			
3.5 Distance from your farm to the coast (m)			
3.6 Distance from your farm to the core zone (m)			
3.7 Distance from your farm to Xuan Thuy National Park office			
3.8 Any problems of this location			
3.9 Land tenure (yes = 1, no = 0)			
3.10 Land fee (VND/ha/year)			
3.11 Ecosystem fee (VND/ha/year)			
3.12 Other fee (VND/ha/year)			

4 Water source and wild species for production

Please clarify characteristics of water source for your production in the table below:

Water source and wild species	Pond 1	Pond 2	…
4.1 Water source of ponds (rivers/sea mouth, etc.)			
4.2 Frequency of water exchange (times/crop)			
4.3 How many percent of wild species for your production			

5. Labor source for the production

5.1. How many family members participate in the production?

- In which, number of men labor:…………, and number of women labor?

- In which, total working hours of men labor:……...., and total working hours of women labor?

5.2 Activities of men labor in the production?

5.3 Activities of woman labor in the production?

5.4. How many hired laborers participate in the production?..............................Cost of hired labor?

6. Inputs and costs

Inputs	Value
6.1 Black tiger shrimps	
Where is the hatchery (sellers)?	
Quantity of post-larvae	
Unit price of the post-larvae	
6.2 Crabs	
Who is the hatchery (sellers)?	
Quantity of post-larvae	
Unit price of the post-larvae	
6.3 Formulated feed	
Quantity	
Unit price	
6.4 Rice bran	
Quantity	
Unit price	
6.5 Miscellaneous (fish/bivalve, etc…)	
Who is the sellers	
Quantity	
Unit price	
6.6 Antibiotic	
Quantity	
Unit price	

6.7 Lime	
Quantity	
Unit price	
6.8 Oil	
Quantity	
Unit price	
6.9 Electricity	
Number of KW	
Cost	
6.10 Sluice	
Number of sluice	
Cost	
Expected years in use	
6.11 Watch-tower	
Number of sluice	
Cost	
Expected years in use	
6.12 Testers (pH, salty, etc…)	
6.13 Rented excavator	
Cost of rented excavator	
Years in use	
6.14 Loan	
Cost of the loan for the production	
6.15 Others	

7. Farmed products and co-products

	Farmed shrimp	Farmed crabs	Wild-caught shrimp	Wild-caught fish	Wild-caught miscellaneous bivalve	Seaweed
7.1 Total quantity (kg)						
- Home consumption (%)						
- Farm produce sold in markets (%)						
7.2 Average selling price						
7.3 Who is the buyers						
7.4 Where do you sell?						

7.5 How do yields change in recent 05 years?

1. Increase
2. Remain the same
3. Decrease

8. Marketing activities

8.1. What are your channels of sale?

☐ Conventional channel ☐ Short-channel

8.2. What are types of markets?

☐ Sale through local markets ☐ Sale through outside markets

☐ Sale through restaurants ☐ Sale through ethical purchasing groups

8.3. Are farmed products being preserved?

☐ Yes ☐ No

8.4. Are farmed products being processed?

☐ Yes ☐ No

8.5. Are farmed products being packaged?

☐ Yes ☐ No

8.6. Are farmed products being labeling?

☐ Yes ☐ No

8.7. Do farmed products have eco-labeling?

☐ Yes ☐ No

8.8. Do you apply agri-tourism?

☐ Yes ☐ No

9. Income generation activities and income stability

Please indicate percent of income generation activities for home consumption and market?

Income activities	Home consumption (%)	Market (%)
Crop cultivation		
Livestock		
Aquaculture production		
Fishing		
Off-farm		

10. Issues of the production

10.1 Do you apply wastewater treatment methods before releasing it into the natural environment?

☐ Yes ☐ No

10.2 Where do you drain pond sludge?

☐ Treatment ponds of your farms ☐ Common rivers, sea mou

10.3 Before releasing wastewater, do you test quality standards of wastewater?

☐ Yes ☐ No

10.4 Do your farms is impaired by contaminants of agrochemical from other fields?

☐ Yes ☐ No

If yes, please clarify which fields?.....................

10.5 Do you experience disease occurrence in the recent years:

2018	☐ Yes	☐ No
2017	☐ Yes	☐ No
2016	☐ Yes	☐ No
2015	☐ Yes	☐ No

If yes, please clarify which are reasons of disease occurrence:

1. Self-pollution
2. Low quality of post-larvae
3. Effected from outside pollution
4. Weather
5. Do not know

10.6 Do you see any of the below negative impacts of your production?

1. Use of chemical and drug
2. Use of formulated feed
3. Use of water, discharge of water
4. Discharge of sludge
5. Pollution risks
6. Disease occurrence
7. Others.

QUESTIONNAIRES OF CHAPTER 6

1. Please identify pressing constraints affecting your agricultural production?

2. Please identify the underlying causes of the constraints that affect your agricultural production?

3.Visualize the governance structure of agricultural advisory service of Nam Dinh province?

4.Please identify the interaction between agricultural advisory service providers and farmers?

Providers	Interaction
Communal Agricultural Cooperative	
Communal Agricultural Board	
Xuan Thuy National Park	
Irrigation Board	
Input dealers	

5. What do you need from agricultural advisory service providers for your production?

6. What do you have received agricultural advisory service for your production?

Providers	Specify
General environmental protection (propagation)	
Conventional production information	
Training	
Conservation production information	
Materials/inputs	
Irrigation calendar	

7. What are methods and tools and from which service providers?

Methods/tools	Providers				
	Communal Agricultural Cooperative	Communal Agricultural Board	Xuan Thuy National Park	Irrigation Board	Input dealers
Meetings					
Training					
Field visits					
One-to-one advice					
Direct consultation					
Information provision					
Public louder					
Other					

8. How do you assess the effectiveness of agricultural advisory service provision from different providers?

Level of effectiveness: very high (5); high (4); medium (3); low (2); very low (1)

Providers	**Effectiveness levels**
Communal Agricultural Cooperative	
Communal Agricultural Board	
Xuan Thuy National Park	
Irrigation Board	
Input dealers	

9. Please give your comments to improve the issues of the production?