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Agricultural Development Around Protected Areas in Vietnam: Agroecology Perspective

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Abstract

Agricultural development nearby protected areas is required to minimize negative impacts from uses of off-farm resources as well as improper activities on the ecosystem and ensure livelihood for local farming communities. This research aims at assessing agricultural management practices and outcomes toward agroecology of rice cultivation in the buffer zone of Xuan Thuy National Park. Data were gathered from ecosystem managers, communal authorities and 96 rice cultivators living in 14 villages adjacently to the park in 2017-2018. "Traffic light" approach developed by FAO was used as an analytical technique to evaluate and visualize the environmental sustainability of rice cultivation with three levels of desirable, acceptable and unsustainable. The assessment reveals that none of the environmental indicators achieved at sustainable including fertilizer management, soil fertility, pesticide management, biodiversity preservation, and water conservation. Therefore, agricultural development in this area is required to be scrutinized for improvements especially the overdependency on nitrogen fertilizers, improper application of pesticides, limited adoption of biodiversity-friendly practices as well as other environmentally-friendly practices. The research highlights the need of implementing agroecological approach and special regime for protected area buffer zone to strengthen environmental preservation.

Keywords

Xuan Thuy National Park, buffer zone, agroecology, agricultural development.

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Introduction

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 and 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 posed demonstrated risks to aquatic ecosystems, human health, and productive activities (Pedersen, 1996; Buckton, 1999; Gilmour and Van San, 1999; Haneji et al., 2014; Khai and 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 economic development of local residents. 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 and 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 relies 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 and Nhan, 2015; Kamoshita et al., 2018). Rice farming system dominate the buffer zone and provide main income sources for local people. 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 and Nguyen, 2003).

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

Materials and methods

Case study selection: Rice cultivation around Xuan Thuy National Park

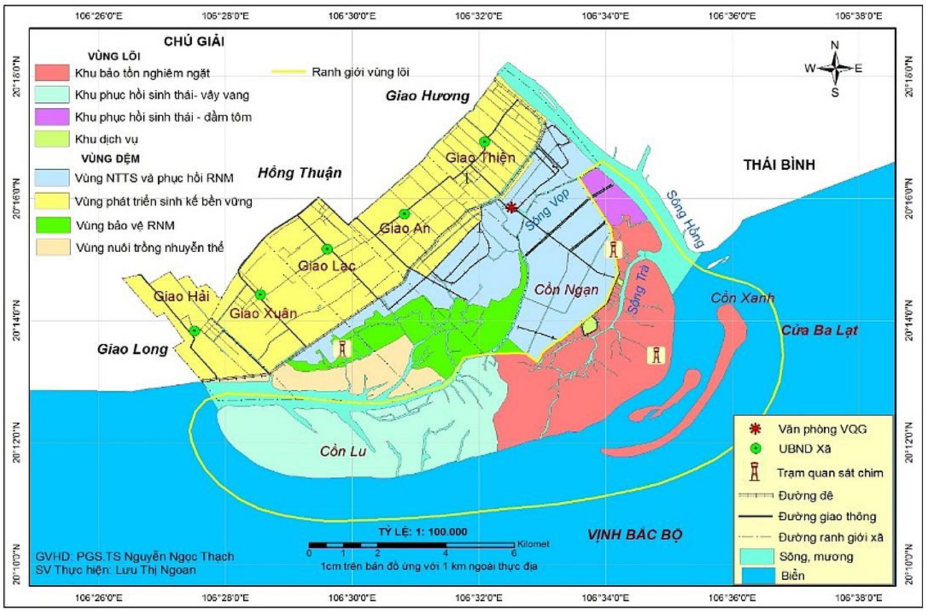
Xuan Thuy National Park (XTNP) situates in Giao Thuy district, Nam Dinh province, Vietnam. It covers a total area of 7,100 ha extending from latitude 20°10’ to 20°15’ North and longitude 106°20’ to 106°32’ East (VAF, 2017). The park is under the authority of Nam Dinh People’s Committee. The 8,000 ha buffer zone locates adjacently the park. The buffer communes are under the administrative management of Giao Thuy district People’s Committee. Agricultural production in the buffer zone is under the expertise instruction of the Division of Agricultural and Rural Development (DARD) and the Center of Agricultural Services of Giao Thuy district People’s Committee (Figure 1).

The case study taken is XTNP including its buffer zone due to several criteria as follow:

- The park has conservation and development functions:

  XTNP has particular environmental and economic significance because it has rich biodiversity and coastal protection role. Main functions of XTNP 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 and 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



Note: (1) Signifies rice fields
Source: Hai and Nhan, 2015

Figure 1: Map of Xuan Thuy National Park and the buffer zone.

- Contributing to socio-economic development for the region.

- XTNP is place for balancing socio-economic 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 reducing natural disaster losses, providing commercial values of fisheries and non-timber forest products, improve outcomes from farmed/harvested species.

- Local communities continue to rely on XTNP's ecosystem for rice-related livelihoods.

Rice farming system has been cultivating largely with almost all households around XTNP 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 XTNP in comparison with outer communes. The guidelines for rice cultivation have been disseminated similarly for all communes of Giao Thuy district.

Data collection and analysis

Data collection

Fieldwork is carried out from 2017 to 2018 with a total of 96 respondents. 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 (2,737 households); *e* = level of precision (e = 0.1). For this parameters, *n* = 96 respondents. Then, Fish Bowl Draw sampling (simple random sampling) was used to choose interviewers in 14 village of Giao Thien buffer commune. All aspects of rice cultivation were interviewed including farming knowledge and practices, production management, farm performances, economic and environmental issues incorporated with the production

Moreover, this research also approached Xuan Thuy National Park managers, headers of the Giao Thien commune to investigate their roles in disseminating advisory services for rice growers.

Data analysis

This research uses core indicators of agroecological outcomes with links to the development and conservation aims. Table 1 presents indicators used if farms are utilizing agroecological principles in their design and management:

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).
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)

Source: Mottet et al., 2020; Trabelsi et al., 2019; FAO, 2018; D'Annolfo et al., 2017; Trabelso et al., 2016; Buck et al., 2006.

Table 1: Core indicators of agroecology with links to sustainable livelihood and sustainable agriculture.

- *Net farm income:* Income from agroecological production enables the economic viability of farms. Incomes of farms ensure households gain profits. 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).
- *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: farmers use at least four measures.
  - Acceptable: farmers use 2-3 measures.
  - Unsustainable: farmers use fewer than 2 measures.
- *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: farms do not use pesticides or use slightly: farmers follow three measures of health protection and at least four measures of environmental protection.
* Acceptable: farm applies at least two measures of health protection and at least two measures of environmental protection.
* Unsustainable: farm applies fewer than two measures of each above list.

◦ *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: less than 10% of the farmland is affected by any of the four threats.
* Acceptable: 10-50% of the land is affected by any of the four threats.
* Unsustainable: above 50% of the land is affected by any of the four threats.

◦ *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: farms do not use fertilizers or use fertilizers and apply at least four above measures.
* Acceptable: farms do not use fertilizers or use fertilizers and apply at least two above measures.
* Unsustainable: 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: farmers use irrigated water below 11% of farmland
* Acceptable: 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: others.

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.

Results and discussion

Agricultural development toward agroecology around Xuan Thuy National Park

Knowledge and application of agroecological 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 for their knowledge and the application of eco-friendly practices in previous cropping seasons. Our results reveal the low percentage of farmers knowing different methods of agroecology as well as limited application (Table 2).

Our further results reveal diverse reasons for the limited application of agroecological-based practices as follow:

- 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 neighbors do. New things become unfamiliar for farmers. Farmers also perceive complexity when changing current activities.

Third, lack of institutional supports for sustainable

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		
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 predator 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

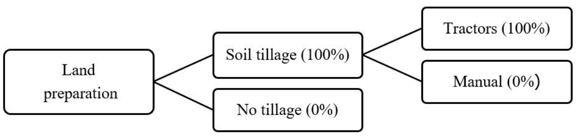
Table 2: Knowledge of farmers and the application of agroecological practices in RB.

practices: Shortage of environmentally 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?

Current practices

Land preparation

Farmers apply two mono-crops annually. The first crop starts from the middle to the end of January to the end of May. Land is dried for several weeks before starting the second crop in the middle of June to the end of October. This production is a low-intensive technological application. Farmer use machines in two production stages (plow land and harvest grain) and animals are no longer used in the production (Figure 2). 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 incorporated in the plowing. Soil is plowed to become puddle and levelled. Farmers do not apply the non-tillage method.

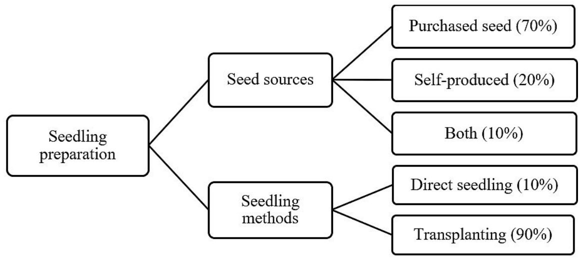


Surrvey, 2018

Figure 2: Land preparation.

Seedling preparation and transplanting

Rice seedlings were transplanted (90% respondents) or direct seeded (sa lua) (10% respondents) with plentiful varieties including pure-line and high-yielding. The majority of farmers (70%) bought seeds from communal agricultural cooperatives and local traders in villages, while a small number of respondents used self-produced varieties (Figure 3). 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 hill to hill was ranged from 20 x 20 cm to 25 x 25 cm. In this stage, no machines were used.

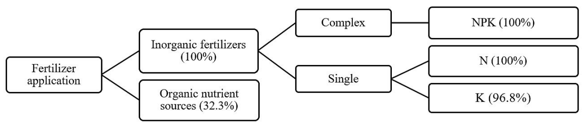


Surrvey, 2018

Figure 3: Seedling preparation.

Fertilizer application

Figure 4 shows the utilization of fertilizers during the growth of rice. Farmers in the buffer zone of XTNP 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), whilst only 32.3% of farmers still used organic sources (compost and manure).



Surrvey, 2018

Figure 4: Fertilizer application.

There were diverse kinds of NPK fertilizers with different ratios of pure N-P-K 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. Tables 3 presents the amount of N, P and K used in rice after authors' conversion from farmers' uses.

Based on demographical characteristics, the Division of Agriculture and Rural Development of Giao Thuy district recommended farmers to apply less fertilizers in the 2nd season than 1st season for both kinds of varieties because the 2nd season has better favorable weather with more rain and shorter

Fertilizers	Inbred varieties		High-yielding varieties	
(kg/sao/season)	1st season	2nd season	1st season	2nd season
N	15.74[a]	15.65[a]	14.17[a]	14.0[a]
P	9.27[a]	9.36[a]	9.13[a]	7.11[a]
K	4.85[a]	4.86[a]	4.22[a]	3.31[a]

Note: The same alphabet characters after mean denote the similarity between two seasons ($p > 0.05$) from the Mann-Whitney U test. Significance at 1%. 1 sao is equivalent to 360 m^2.
(Source: survey, 2018)

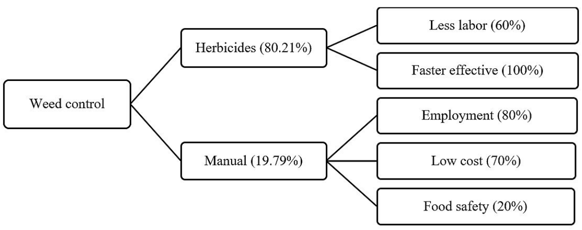
Table 3: Fertilizer rates according to different varieties in different seasons.

growth duration (12-20 days) (DARD, 2017). 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

Results also highlight the overloading of N. 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 the Division of Agriculture and Rural Development (maximum 12 kg/sao/season or 333.36 kg/ha/season) (DARD, 2017) and other tropical regions such as China (360 kg/ha) (Xiaowei et al., 2016) and in Philippines (from 60 to 120 kg N/ha) (Shaobing et al., 2004).

Weed, pest and disease control

Weeds are one of the most serious constraints to rice cultivation in this area because weed competes with rice for light, water, nutrients, and space. Figure 5 shows two methods of weeding in XTNP'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 requests less labor and has faster effectiveness.

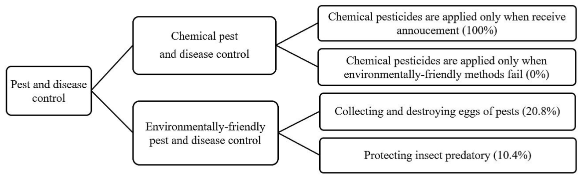


Surrvey, 2018

Figure 5: Weed control.

A small percentage of farmers recognized the negative impacts of herbicides for grain quality, they applied hand weeding. They removed weed manually after about 20-25 days since transplanting time or about 30-35 days after direct seedlings. They repeated weeding the second time or more. Hand weeding also provided employment and lower cost especially poor farmers.

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 6). Besides chemical inputs, a moderate proportion of farmers adopted ecosystem management-based methods such as destroying eggs of caterpillars and snails (20.8%) or protecting insect predators such as toads and birds (10.4%).

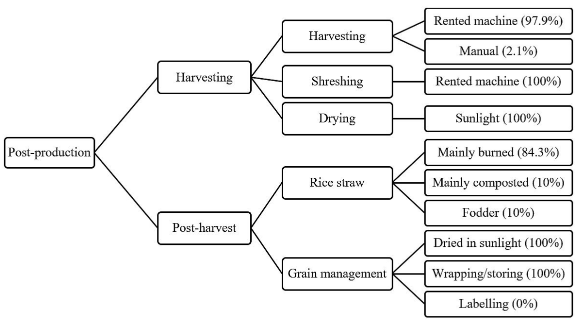


Surrvey, 2018

Figure 6: Pest and disease control.

Post-production

Post-production includes harvesting, bundling, hauling, threshing, drying, cleaning, storage, milling and grading of rice. 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 them harvested grains 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. Rice straw was mainly burned (84.3% of respondents) in fields or composted with other household wastes (6.2% of farmers) or carried home to use as fodder for animals (9.5% of farmers) (Figure 7).



Surrvey, 2018

Figure 7: Post-production.

Outcomes

From economic perspective, 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. Rice yield was 6,22 kg/ha/crop, which was much higher than the Vietnam national average (5,54 kg/ha) (FAO, 2017). High yield and net farm income are considered a top incentive of local farmers and communal authorities (Table 4).

Indicators	Value	Percent (%)
1. Total cost (mil.VND/ha/year)	104.31	
1.1. Purchased input costs	103.20	
Family labor	58.34	55.93
Hired machinery	16.50	15.82
Seedlings	3.15	3.02
Chemical fertilizers	15.68	15.03
Pesticides	6.21	5.95
Hired labor	3.32	3.18
1.2. Fixed costs		
Land charge	1.11	1.07
2. Yield (ton/ha/crop)	6.22	
3. Product price (mil.VND/kg)	0.006	
4. Gross output (mil.VND/ha/year)	124.79	
5. Net farm income (mil.VND/ha/year)	20.48	

Note: VND: Vietnam Dong. Exchange rate: 1 USD = 23,300 VND on October 13rd 2021
Source: Survey, 2018

Table 4: Net farm income of rice production.

From environmental perspective, rice cultivation creates many problematic issues in this area. Our results reveal none of the environmental indicators gain desirable or sustainable (Table 5).

We highlight that the utilization of synthetic fertilizers in rice fields was mainly unsustainable (67.7% of respondents) because they apply none of the measures to restraint the environmental risks. Only 32.3% of respondents applied two measurements to reduce associated environmental consequences (use organic nutrient sources and distribute fertilizers several times over the growing period). Due to inordinate practices, the sustainability of soil fertility was mainly undesirable (88.54% of respondents).

The adoption of chemical pesticides was assessed at acceptable but interviews with farmers and locals reveal the growing doses of pesticides incorporated with the dramatic reduction of biodiversity in paddy fields, frequent disease occurrence, and serious outbreak of exotic snails (Pomacea canaliculata). However, very few eco-friendly practices of pest and disease control are introduced and applied. Most farmers consider pesticides as a preventive resort rather than disease treatment.

The practices of agrobiodiversity conservation are also evaluated as unsustainable levels (100%

Indicators	Percent (%)	Levels of sustainability
1. Fertilizer usage		
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 and do not apply measures to reduce fertilizer-related risks	67.70	Unsustainable
2. Soil fertility		
Below 10% farm area get affected	0.00	
10%-50% farm area gets affected	11.45	Acceptable
Above 50% of farm area get affected	88.54	Unsustainable
3. Pesticide management		
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	
4. Biodiversity-friendly practices		
Above 3 measures	0.00	
From 2-3 measures	0.00	
Below 2 measures	100.00	Unsustainable
5. Water preservation		
Use irrigated water below 11% of area	0.00	
Use irrigated water above 10% of area/water availability reduction experienced	100.00	Acceptable
None of above cases	0.00	

Source: Survey, 2018

Table 5: Environmental issues of rice production.

of respondents) because farmers applied only one measurement of biodiversity conservation (growing several kinds of varieties including inbred and hybrid).

Rice cultivation in this area relies mainly on 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 rice was acceptable. 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 rice system might leach more chemicals into nearby ecosystems.

Discusion

Agricultural operation adjacent protected areas needs to meet plentiful goals of increasing farm outputs and reducing costs through raising the quality of habitats and ecosystem services (Sara and Jefferey, 2008). This helps to satisfy the demands of foods and ecosystem services of communities in environmentally sensitive sites such as flood control or climate change adaptation. According to Sara and Jefferey (2008), agroecology manages landscapes for both production and conservation purposes including: (1) ensuring sustainable livelihood for farmers, (2) benefiting agriculture through ecosystem services such as pest control, soil fertility, water quality, and pollination, etc., (3) conserving outside landscape such as flood protection and carbon sequestration, etc.

Even though being a buffer zone of international and national importance site, this zone lacks agriculture conservation-related programs. At the commune level, buffer communal authorities (communal agricultural board and communal agricultural cooperative) focus mainly on food security and income improvement through grain yield enhancement. They sell materials (fertilizers, pesticides, and rice varieties), and disseminate knowledge on stages of production (land preparation, irrigation, plant protection, fertilizing, etc.) for farmers. While XTNP management board is in charge of ensuring environment conservation within the park (core zone-7,100 ha). The park only approaches local communities to educate and propagate them to preserve the living environments, such as garbage managing, bird conservation, and growing trees. Currently, farmers have no interaction with XTNP's staff for rice cultivation. This research recommends that the park should have more political authority to restraint the farming activities that harm the environment and promote decisions in eco-friendly cultivation. The park should have the political power to maintain environmentally-friendly production. 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.

Thus, special regimes for agricultural development nearby the protected area need to be issued to restraint the risk of agrochemical pollution. Nam Dinh PPC must establish specific laws and regulations for XTNP's buffer zone which ensure that agricultural production nearby the park should be a mean to continue protecting soil, water sources and biodiversity. To ensure biodiversity conservation and landscape improvement, Nam Dinh PPC must integrate ecological outcomes of agricultural production. 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. 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.

Without some forms of intervention, short-term financial incentives lead to the intensive use of agrochemicals, while conservative measures were not adopted around the sensitive site. Current 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 conservation site:

One indication that farmers overused chemical fertilizers than local suggested standards. 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.

As warned by Lin and Jayant (2003), the overuse for these inputs can lead to leaching fertilizers and expanding nitrate contents into soil, groundwaters, crops and human health. Therefore, this research recommends that a reduction in nitrogen dosage and precise fertilizing can help reduce the input costs and improve soil health. Precision fertilizing knowledge is urgent to be transferred for farmers through communal extension personnel and XTNP's staff to tackle the abuse of N. Applying leaf color chart (Singh et al., 2007; Singh et al., 2014) can help farmers to determine the volume of N for different rice varieties in different seasons. This is a simple farming equipment for judging the dosage of N based on plant demand and soil variability, it, therefore, helps cultivators to manage farms with greater precision and cost-saving. Growing legumes and adding them with farm residues to the soil is an effective way to improve lowland rice yield and reduce the overloading of N which was pointed out earlier by Ladha and Reddy (2003). In addition, integrated mechanical, biological and botanical methods of pest and disease control should be enhanced in this area to improve the efficiency simultaneously reduce threats to wildlife including collecting and destroying eggs of pests; removing affected rice plants to prevent the spread of diseases; allowing grasses and vegetation adjacent to rice fields to conserve natural enemies; conserving as much as possible insect predators (birds, frogs, and toads, etc.) to stimulate rice insect pests; and maximizing the use of local resources through extracting oil and powdering seeds from locally available plants (papaya, custard apple, lemongrass, etc.). Rewarding farmers for their eco-friendly efforts would be considered to encourage more people to protect the environment.

Lack of awareness on the long-term benefits of agroecological production of provincial and lower authorities remains high-yielding orientation. 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.

Conclusion

The small-scale rice cropping system has been cultivated largely by households in the XTNP's buffer zone. Farmers grow rice in two mono-crops per year and synthetic fertilizers play essential roles for rice growth. Farmers preferred to combine diverse kinds of compound NPK with single N and K. There was a small proportion of households that used organic nutrient sources but they overused N. Pest and disease were controlled widely by chemical pesticides, whilst farmers applied limited requirements of health and environmental-related risk mitigation.

The research highlights the limited knowledge and application of agroecological-based practices in rice cultivation. The range of environmental indicators was evaluated. The application of biodiversity-friendly methods was critically unsustainable. Pesticides and water use were evaluated at acceptable but they are required to adjust. Soil fertility and fertilizer-related risks are concerned as unsustainable. In general, most of the environmental indicators are not sustainable.

Agriculture adjacent to protected areas needs to ensure dual goals of development and conservation or in other words, satisfy economic viability for people and environmental soundness for the ecosystem. Agroecology approach is highly recommended in this research to (1) improve economic resilience at farm level through effective cost strategies incorporate with eco-friendly farming practice, and (2) strengthen collective actions between XTNP and local authorities. The researchers suggest that XTNP should become a major agency to lead nearby communities to move forward conservation agriculture. The park needs to work with buffer communes to assist farmers with integrated nutrient management for crop yield enhancement while maintaining soil health. The coordination between XTNP and buffer communes in agricultural programs or assigning technicians of the park to work with buffer communes can ensure conservative goals and environmental performances are integrated into agricultural developments.

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