Ecosystem-based adaptation:

Learning from participatory assessment in Viet Nam

Lien Tran[1] and Doland Nichols[2]

June, 2020

72 Xuan Dieu, Tay Ho, Hanoi, Vietnam
Phone +83 4 3 718 5836   Fax +84 4 3 718 5834
Email hanoi@rosalux.de   www.rosalux.vn

[1] Ecosystem-based Adaptation Freelancer Specialist, Viet Nam

[2] Associate Professor, Forest Science and Management Coordinator, Southern Cross University, Australia

Abstract

Smallholder farmers in Huong Lam commune, Ha Tinh province, Viet Nam were surveyed to identify what ecosystems they depend on, what climate change impacts they face, and what Ecosystem-based adaptation (EbA) measures that are appropriate for the area. Data was collected from commune staffs and farmers through questionnaires and focus-group discussions. Farmers acknowledged that they depend on ecosystems for their livelihoods. In contrast, climate change causes severe impacts on peoples' lives and environment, through floods that destroy houses and crops, cold spells that kill animals and seedlings, typhoons that damage big trees, and droughts that affect crop yields. Engineering options can have a positive impact in some certain casebut require costly investments. Meanwhile, there are green adaptation measures that offer assistance to farmers to mediate climate change impacts. Since the concept EbA is relatively new, it's necessary to develop and test practical methodologies and approaches for identifying EbA in the field.

Key words: Participatory, ecosystem-based adaptation, vulnerability assessment, ecosystem services, smallholder farmers.

Introduction

Climate change is one of the most significant challenges confronting human beings today. It has already affected agricultural and economic production. As predicted, climate change will extensively and intensively alter the development process with security related issues, including food, water, energy, economic, commerce and politics (Government of Viet Nam, 2008).

Viet Nam is among the countries most severely affected by climate change as it's located in Southeast Asia's tropical monsoon belt, and commonly affected by floods, droughts and typhoons, as well as occasional forest fires, and landslides. Average temperatures have been rising and the total precipitation has been increasing, especially during the rainy seasons (Government of Viet Nam, 2011). The Ha Tinh province in general the Huong Lam commune in particular have experienced diverse impacts from natural disasters like floods, storms, along with droughts that lead to the scarcity of drinking water and irrigation water. Every year, storms and tropical depressions cause floods, tube floods, flash floods and landslides. As a result, great loss of human life and property brings about difficulties for socio-economic development (Ha Tinh Provincial People Committee, 2016). Smallholder farmers are considered to be disproportionately vulnerable to climate change. The changes in temperature, rainfall and the frequency or intensity of extreme weather events directly affect the agricultural productivity as well as the household food security, income and well-being (Schmidt-Thomé et al., 2015).

The Central and Provincial governments in Viet Nam have introduced and implemented a number of adaptation measures, both hard and soft - to cope with climate change. Many recent climate change adaptation initiatives have focused on the use of engineering-based construction and the design of climate resilient infrastructure. However, there is growing recognition that maintaining healthy ecosystems can assist people to adapt to climate change. For example, in coastal protection area, hard measures are often employed as the traditional approach to coastal protection. These constitute structures which provide a solid barrier between land and sea, and resist the energy of the tides and waves, thus preventing land/sea interactions (French, 2001). Once hard measures are in place, they solidify the location of the coastline into a single position at the time of construction. Additional problems include that hard structures often impede the recreational use of beaches and are costly to construct and maintain (USACE, 2008 cited in Linham and Nicholls, 2010). Therefore, soft measures are sought to ameliorate the disadvantages of hard measures. This provides the potential to maximize the benefits of a scheme, minimize any environmental impacts and also create environmental opportunities (Chadwick et al., 2004). However, such soft engineered measures suggested by an EbA approach need ongoing and regular monitoring, maintenance and engineering which requires ongoing involvement from a variety of stakeholders (Edge et al., 2003).

New climate change adaptation approaches are evolving newer strategies than those offered by hard solutions. At the international level, ecosystem-based approaches for climate change adaptation are promoted and has received attention from scientists and governmental bodies alike (Wilkinson et al., 2013; Chong, 2014). EbA is a relatively new concept, defined as the "use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse impacts of climate change" (Convention on Biology Diversification 2009:41). EbA offers to systematically harness services of ecosystems to buffer communities against the adverse impacts of climate change (Jones et al., 2012, Munang et al., 2013).

The objective of this paper is to provide a framework for identifying which measures can be considered as EbA and for exploring which of these practices are practical for smallholder farmers in the study area. We explore the advantages and disadvantages in implementing EbA by smallholder farmers. We also identify ecosystem-based practices which can both help farmers adapt to climate change and also conserve ecosystems' capacity. For the smallholder farmers, the eco-systemic or wholistic approaches provide both on- and off-site gains. As the predicted rise in negative impacts from climate change on smallholder farmers, it's matched by increasing pressures from population that depends on ecosystems. Therefore, recording multiple focus group discussions within the commune allows this study to describe how ecosystem-based adaptation is understood and then integrated into local practices.

1. Study area

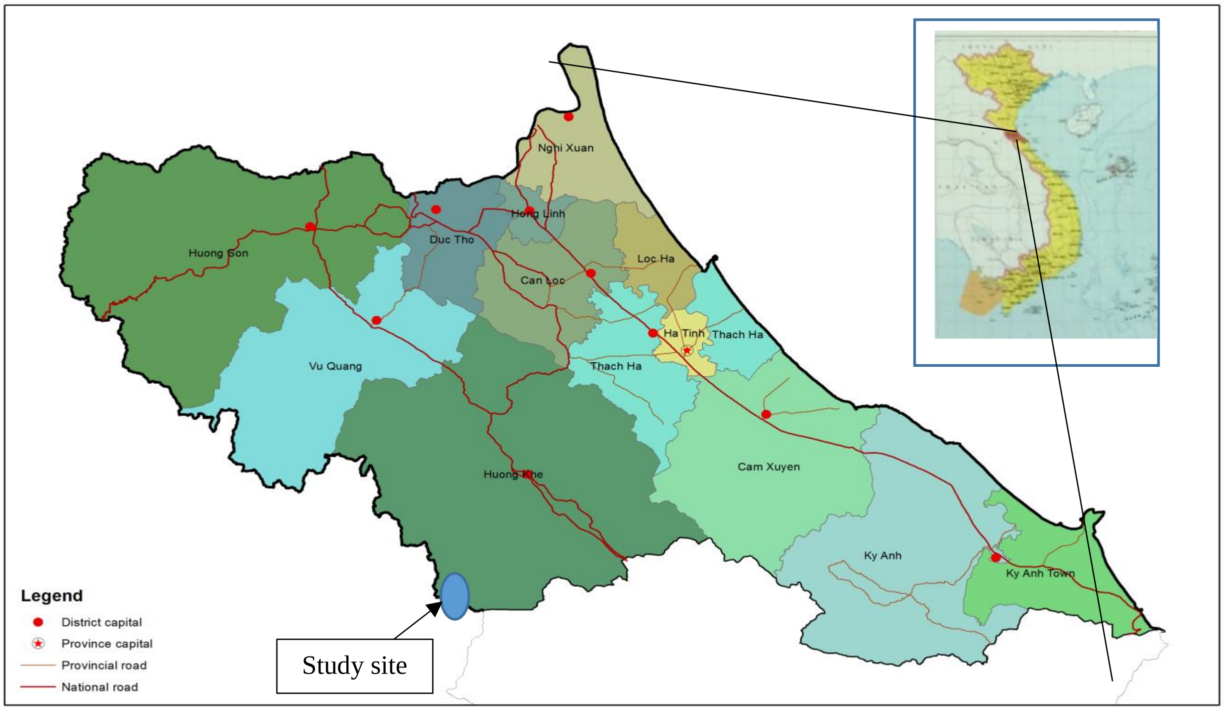


Fig 1. The study site, (Ha Tinh DONRE, 2019).

The study was carried out in Huong Lam, a mountainous commune located in the western part of Huong Khe district, Ha Tinh province, Viet Nam. The commune has 17,156.59 hectares of natural area, composed of 90% forested land. The study area is home to 6,673 people in 1,636 households. The main livelihood activities were agriculture (crop production - peanut, paddy rice, maize, sweet potato, green bean, cassava, fruit trees; livestock - pig, cow, buffalo, chicken; forestry - acacia, *Aquilaria crassna* – Agarwood), small industries - construction (carpenters, constructors, salaried, pensioned, and hired laborers, etc.), and trade - service (tailors, haircut, groceries, butchers).

Huong Lam commune was selected for study based on the following criteria: i) How the area is exposed to the influence of climate change?; ii) How the area is vulnerable to climate change?; iii) What sensitivities in the area could influence climate change?; iv) How the system is capable to manage these impacts?

2. Methods

The study used both primary and secondary data sources. The primary data were collected from two field visits. The first was conducted in October 2019 for five days and the second was carried out in January 2020 for ten days. Data collection techniques including participatory rural appraisals, focus-group discussions, and questionnaires, as well field observations were employed. Information was collected from males and females separately in ten different groups

(5-7 informants per groups) and two replications took place to test assumptions for the most frequently offered answers. In all, 130 villagers were randomly surveyed who came from the whole spectrum of community members, including vulnerable groups from a gender, age, educational status, different income classes. Sample respondents were intensively surveyed about how they see climate change and its impacts on their sites.

Residents were asked about the intensity of the changes in their immediate ecosystems, from very high, high, moderate, low, and very low and no change. Then, questions were asked to provide information on how ecosystems are supporting direct benefits, regulating the ecological, social and economic buffers against climate shocks. The survey also covered Hazards, Exposures, Sensitivity, and Impacts relating to climate change in the last ten years (2010-2019) to rank their vulnerability to climate risks. The vulnerability was ranked based on type, magnitude, and rate of climate change and variability to which a system is exposed to measure its sensitivity, and its potential adaptive capacity (Intergovernmental Panel on Climate Change [IPCC], 2015). People's opinions were also recorded about the efforts and responses from local communities to minimize the adverse impacts of climate change. The questions focusing on the ecosystems sought to explore awareness of various nearby ecosystems and their importance and benefits to human and environment.

3. Results and Discussion

3.1. Major ecosystems and their roles to livelihood and environment

The main ecosystems and their benefits are presented in the Table 1. Ecosystems have different functions which are classified to provisioning, supporting and regulating. Provisioning function comprise food for human and animal daily needs. Supporting function include habitat for native species and soil improvement. And regulating function offer storm prevention and erosion control.

Table 1. Ecosystems and their importance to livelihood and environment.

Ranking 1 is the most important, ranking 5 is the least important

Ecosystems	Roles in livelihood	Rank	Roles to environment	Rank
Home garden	Organic vegetable for human daily use	3	Regulate the temperature in the hot days in the garden	1
	Income from fruits (orange and pomelo)	4	Regulate the storm intensity	2
	Organic food for human daily use (chicken)	5	Enjoyment and family satisfaction	4
	Income from animals (chicken, pigs, cows)	2	Control the quality of food	3

Ecosystems	Roles in livelihood	Rank	Roles to environment	Rank
	Shelter for human and animals	1	Erosion control	5
	Easy to access (farmers can save time and money)	6		
Agriculture land	Fodder for animals (peanut and rice residues, maize stem)	3	Improve soil conditions with the proper farming practices	
	Income from peanut, green bean	2	Control runoff and erosion	
Paddy rice	Food for human daily use	1		
	Fodder for animals	2		
	Grazing land for animals in five months, after the second harvest	3		
Acacia plantation	Income in every 6-year rotation	1	Improve soil conditions with the nitrogen fixing legume species	1
	Fuel wood	2	Regulate the temperature in the hot days for a certain area (temporary shelter for animals)	2
Natural forests	Income from non-timber forest products	2	Lessen the erosion process	2
	Fuel wood	1	Provide the habitat for flora and fauna	1
	Fodder for animals	4	Regulate the temperature in the hot days for a certain area (temporary shelter for animals)	3
	Grazing land for animals	3		

Table 1 describes the main ecosystems and ecosystems that benefit local livelihoods and environment. In 2019, home gardens account for 20% of the total area of the commune, providing a large return in terms of ecosystem services, and indicating that the cultural integrity was the highest indicator. The importance of ecosystem services from the home garden differ from those provided by other types of agro-ecosystems (Calvet-Mir, Gómez-Baggethun and Reyes-García, 2012). Mohri and colleagues argue that, home gardens have broader benefits measured across various household scales than abandoning cultivation for alternative incomes (Mohri et al., 2013). Livelihood benefits beyond providing income include resilience to food scarcity, and security from broad-scale economic and environmental shocks (Landreth and Saito, 2014). Specifically, informants agreed that their home gardens not only provide incomes from fruits and livestock, but also offer rewards for the gardeners. Immediate access to fresh food, quality control of the food grown, positive environmental impacts, erosion control, enjoyment and family satisfaction, etc. are recognized at significant levels by the informants (Agbogidi and Adolor, 2013).

Agricultural lands are under threat to maintain sufficient production for an expanding population in food - deficient mountainous regions. In addition, agricultural activities are important to the restoration and management of natural resources. Maintaining agricultural and forestry activities can reduce the environmental risks and prevent the direct economic damage caused by landslides, erosion, forest fires, etc. (Food and Agriculture Organization of the United Nations [FAO], 2006). However, agricultural production must be increased in the future to meet the food demands of rising human populations and increasing livestock production (Longhurst, 2009). Short-term crops, including peanut, green bean, maize and cassava not only contribute the income source of farmers, but also the cultivation of maize and the residuals of rice and peanut crops are important fodder sources to animals. Broadly, crop products play a central role in the livelihood of growers (Cuong and Anh, 2016). In particular, poorer households depend almost entirely on agricultural products for both food and cash to buy necessary items (Carr, 2008).

In 2019, rice paddy fields account for 12% of the area maintaining a crucial role in the region's food security. In fact, the commune's rice production is consumed by the commune's total population, which establishes the region's economic and social stability (Asian Development Bank, 2012). The rice crop also plays a part in the region's ecological and environmental conservation (Chen and Liu, 2002). The data from the study area indicates that a slight decrease in the cultivated paddies (15% of the area in 2010 to 12% in 2019) caused an increase in the peak discharge of downstream river flow. Likewise, lowland paddy fields act as a buffer and subsequently increase the water storage capacity of the basin (Matsuno et al., 2006).

The introduction of hybrid acacia plantations in this study area creates many categories of benefits. The plantations generate employment, both in the plantations and in value-adding activities such as hired labour-thinning-cutting-debarking and seedling production for those of different household workers (Sein and Mitlöhner, 2011). These plantations also have the potential to provide marketable commodities. Hybrid acacia produces wood of good quality for paper making as the pulp is easy to bleach to a very bright colour (Sein and Mitlöhner, 2011). Similar to all legumes, they provide environmental benefits, by their ability to fix atmospheric nitrogen. This benefit has been long noted in the literature, facilitated by a symbiosis between nitrogen-fixing bacteria and the plant's roots (Sein and Mitlöhner, 2011). Furthermore, acacia offers other purposes, such as the conservation or restoration of soils; carbon sequestration and climate regulation (Bauhus, van der Meer and Kanninen, 2010). Hybrid acacia improves infertile soil that could provide an economic benefit to subsequent rotations of acacia or other crops. It's anticipated that fast growing acacia plantations could reduce the pressure on native forests as a source of industrial raw material (Sein and Mitlöhner, 2011).

In the study site, natural forests produce timber for non-commercial uses at the household level - for fences, animal shelters, agricultural labour, equipment and low cost building materials (Turner and Daily, 2007; Natural Resources Canada, 2016). Non-timber forest products also provide incomes, fuelwood and traditional medicines. Cash income from the sale of non-timber forest products can be highly variable from sources such as: honey, bamboo shoot, and Rattan to ornamental plants (Turner and Daily, 2007; Natural Resources Canada, 2016).

The benefits of forest cover on local temperature extremes are well documented. Forests regulate local temperature extremes by providing shade and surface cooling of soils. They can act as a local greenhouse agent to hold heat, block searing winds and trap warmth (Turner and Daily, 2007). The provision of organic contents through leaf and branch fall in forests assists to limit erosion and prevent soil run off by buffering the direct impacts of heavy rainfall (Turner and Daily, 2007).

Another hypothesis is that natural forests improve the quality of the water. The purity of drinking water and the efficiency of hydroelectric power plants or fish habitats is likely to be better in forested catchments than in barren areas. It can be argued that adverse effects on water quality relate to bad management practices rather than elements within the forests themselves (Turner and Daily, 2007; Natural Resources Canada, 2016). Participants often agreed that natural forests will become the key issue for ecosystem biodiversity, in themselves as well as a habitat for other species in the future if they can be well protected (Turner and Daily, 2007).

3.2. Ecosystems and changes

3.2.1. The changes of ecosystems over the time

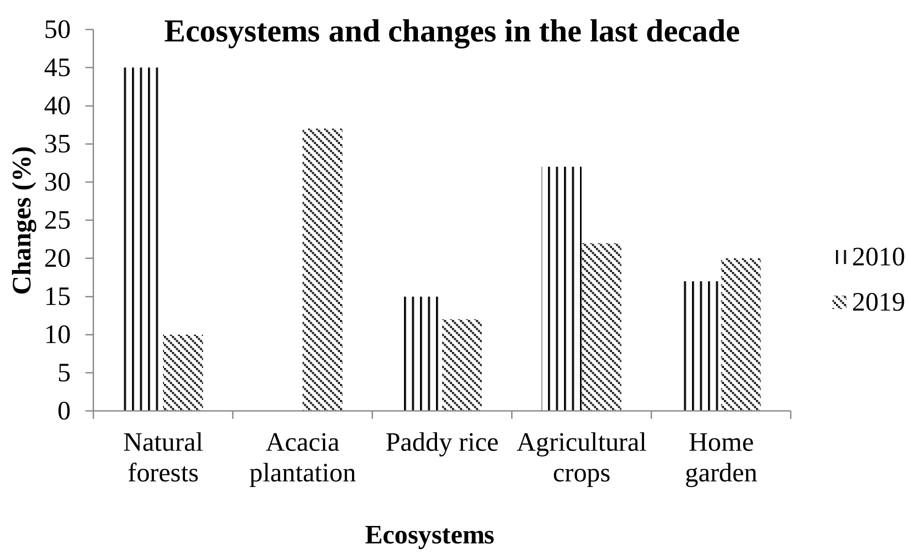


Fig 2. The situation of ecosystem changes in the last decade, 2010-2019. Source: Focus-group discussion and secondary data at commune, 2019.

The existing ecosystems in 2010 and 2019 are shown in Fig 2 (according to discussions with farmers and confirmation by secondary data). There were five main ecosystems in the area in

2010, of which, natural forests accounted for the largest proportion of area. Acacia plantation, in an opposite trend, nobody saw any plantation forest in 2010. Ten years later, in 2019, there was a change in ecosystems, in terms of the area, the acacia plantation was added in the list of ecosystems and accounted the highest proportion.

3.2.2. Drivers of ecosystem changes

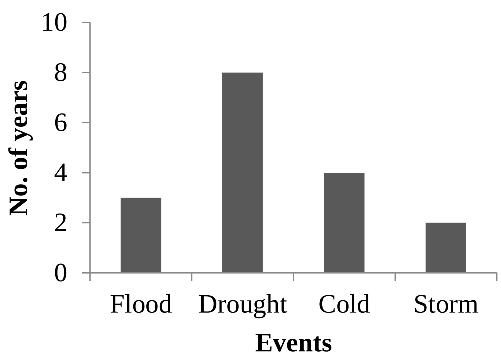
Table 2. The drivers of ecosystem changes in the period from 2010 to 2019. Source: Focus - group discussion, 2019.

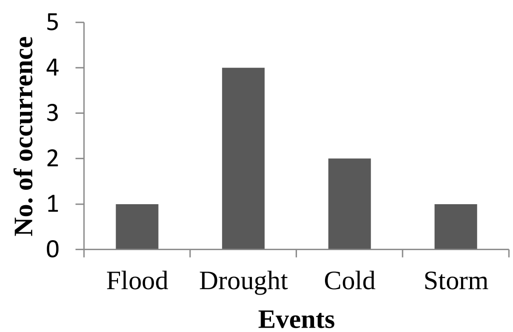
Ecosystem 2010	Ecosystem 2019	Drivers
Agricultural crops	Agricultural crops (reduced)	Floods cause landslides Stone sedimentation Land use changes (crop lands are converted to paddy rice and residential land + infrastructure)
Paddy rice	Paddy rice (reduced)	Landslides Lack of water for cultivation Riverbank erosion Stone sedimentation
Home garden	Home garden (increased)	Population increased -> more houses and other facilities (shelters for cattle, sanitation area)
Natural forests	Natural forest (reduced) and acacia plantation (increased)	Afforestation plans from district, commune Land use changes (poor forests are converted to acacia) Forest/land allocation to households and infrastructure Over exploitation

It explains the main drivers of ecosystem changes in the two periods of time. Key informants agreed that landslides and local development trends (population growth and land-use planning) were the major reasons for the changes. Fig 2 and Table 2 show the changes in ecosystems and the drivers of those changes based on local people's recollections during the focus group discussions. The agricultural crops experience the considerable decline of 10% over the ten-year period from 2010 to 2019. The major contributor to this decline is land conversion from crops to residential land and infrastructure (road construction). There is a slight reduction in paddy rice as the consequence of the land conversion from paddy rice to crops or abandoned due to landslides, water scarcity, sedimentation, and riverbank erosion. At the same time, the home garden ecosystem is slightly increased over the period because of population increase along with the demand for housing. Natural forests and plantations were expected to change dramatically over the last ten years as a consequence of various local processes that interact at several scales and different domains. Besides the natural hazards, key drivers for change include technological change, population growth, and regional trade. Furthermore, over exploitation decimated forests and even produced barren lands which are now only suitable for new plantations. Studies of Lai and his colleagues in the US, Bhattarai in global scale, and in particular, Castella and his colleagues in northern Viet Nam provided the similar findings (Lai et al., 2004; Bhattarai, 2004; Castella et al., 2005).

3.3. Vulnerability assessment

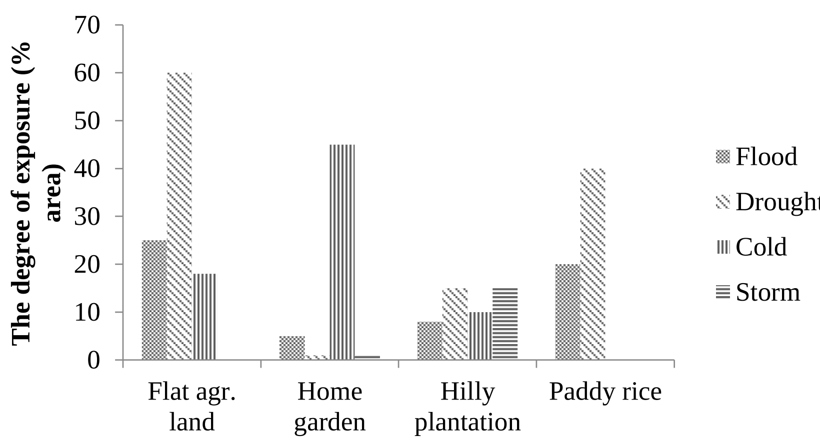
3.3.1. The extreme weather events and exposure in last ten years.





a - No. of years with events

b - No. of occurence within the year with event



C - The exposured areas by events

Fig 3. The extreme weather events and exposure for the last ten years. The number of years when events - flood, drought, cold and storm - occur (a); the relative number of events within years affected (b); and the exposure of events (c). Source: Focus group discussions, 2019.

3.3.2. The sensitivity to extreme weather events

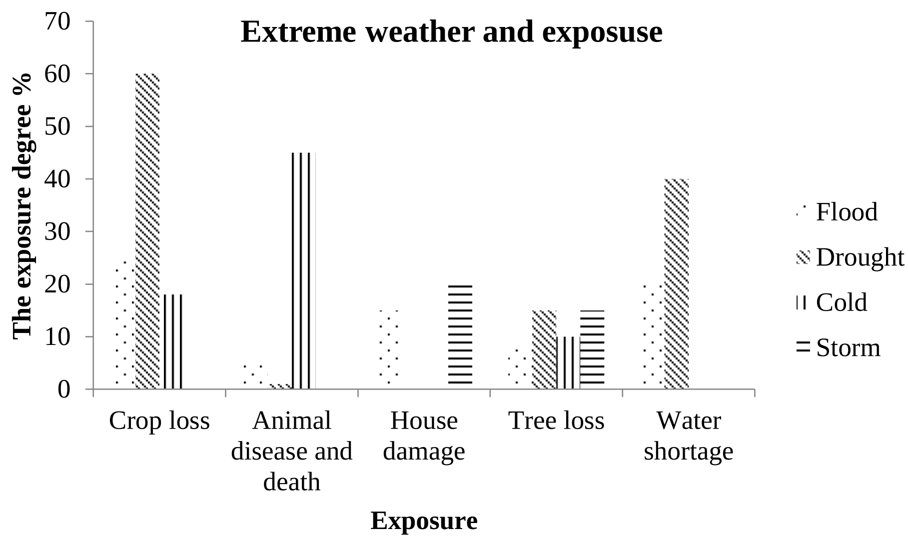


Fig 4. The extreme weather events and sensitivity. Droughts and colds are major sources of damage. While droughts cause the severe loss of crop and water shortage, colds cause disease and death in animals. Source: Focus group discussion, 2019.

3.3.3. The extreme weather events and impacts

Table 3. The extreme weather events and negative impacts to local people. Source: Focus group discussions, 2019.

Weather events	Negative impacts
Flood	• Loss and reduction of 2nd rice crop yield • Loss and reduction of fruit trees • Animal loss and disease, stored products destroy • Houses are flooded and appliance is damaged • Lack of clean water for human • Consequence to the next crop rotation due to the fungi

Weather events	Negative impacts
Drought	• Lack of water for human and crops/trees • Several paddy rice plots are abandoned • Reduction of crop quantity and quality • Lack of food and pasture for animals • Increase of forest fire risk
Cold	• Peanut and rice seedlings (after germination) died in a large area • Animal disease (swollen feet) and death • Human health problems (flu, cough)
Storm	• House roofs are blown up • Animal death • Uproot crops and trees broken • Fruits are shed

The results of focus group discussions indicate people in the study sites have experienced several extreme weather events, including droughts, floods, untimely cold weather and storms. Fig. 3.a illustrates the number of years with events in the period between 2010-2019. Fig. 3. b describes the number of occurrences within the year with each event. Droughts are reported most frequently, appearing in nine out of ten years and four times per year. Fig. 3.c presents the ecosystems that are exposed to the extreme weather events. Flat agriculture land and paddy rice are two components that were most severely affected by droughts. Meanwhile, untimely cold weather brought severe problems to the health of home gardens. The main direct consequences of these extreme weather events in the agriculture sector are summarized in Fig. 4 and Table 3.

The most immediate impact of droughts is a reduction and often losses in crop production (paddy rice, peanut, maize, etc.) due to inadequate and poorly distributed rainfall. Informants agreed that with their small harvests caused by droughts were not enough to feed their family members and provide for other needs in the home. Another severe impact of droughts is water shortages for human, animals and crops/trees (Charlotte, 1997). Pasture production is also likely to decline, which may also lead to a decrease in fodder supplies for animals. Insufficient amount of fodder around the village leads to weight loss and increased disease infestation among animal stocks. The land area available to people in the study site for agriculture is small, so they do not have enough flexibility and/or opportunities to reduce risk through diversification (Beckman, 2011).

One of the highest disaster-related agricultural losses occurred in the area as a consequence of floods, man from accompanying typhoons. Floods destroy both standing crops - paddy rice and fruit trees, and even stored food products. Rice and other agriculture products are normally stored in the upper part of the house so are not damaged by low-level flooding. However, higher floods can destroy the entire house, its appliances, and important food stores. Apart from the washing away of food stores, they may have to be discarded if they are too wet to be milled. Consequences to the next crop rotation due to the proliferation of fungi are reported as an additional problem of flooded agricultural land.

Intense floods that persist over a long duration can deliver serious health problems for local people, in particular, disabled and elderly family members, or those who live in poor conditions with limited food sources, polluted water sources, and bad sanitation. Epidemic diseases, including dengue fever and diarrhea, among many others also appear after floods (Few et al., 2004). The informants here also confirmed the same problems that inflict their livestock.

The typhoons associated with floods can also uproot crops and trees whilst breaking the stems, branches off and defoliating any remaining trees (Few et al., 2004). Typhoons can blow the roofs off of houses and animal shelters (barns) and subsequent exposure to the extreme weather can cause valuable animals, including pigs and cows, death. The group discussion shared these negative impacts as they have experienced them over the ten-year period.

Unseasonal cold weather brings another set of problems, including very poor germination rate and growth of peanut and rice crops. In particular, these seedlings can be destroyed by severe cold spells. Hundreds of cows and buffalo, the main asset of farmers in the study area, being killed by disease or outright from exposure during cold spells (Charlotte, 1997). Moreover, cold spells often lead to some human health problems, such as influenza and coughs.

3.4. EbA options

3.4.1. Identification of the potential EbA options

Members from focus groups were facilitated to establish a list of feasible EbA options that fit to the changing weather conditions. Then, groups were asked to score the selected options. Criteria was set for decision-making on EbA interventions. Five criteria were chosen to discuss and score including: i) Cost effectiveness - the financial resource required to implement the intervention, the lower the cost investment, the higher the score; ii) Up-scaling possibilities - the planting techniques are simple, ecosystems are available, commitment/demand of local people to try and then support new approaches, in line with local policy, strong community leadership and social networks, the more possibilities indicated the higher the score; iii) Suitability to local conditions - the use native species that fit with soil conditions, local people with enough experience to run the intervention, linkages available between existing capacity development or investments to support a potential adaptation initiative, the higher suitability, the higher the score; and iv) Supporting people to address the extreme weather conditions that provides direct benefits, the more benefits, the higher the score; v) Use ecosystem services such as provision, regulation, cultural and support the more services that support local concerns, the higher the score.

Table 4.

No.	Type of EbA intervention	Criteria and scoring					Total score	Ranking
		Cost efficiency	Scaling up possibility	Suitable to the local conditions	Supporting people	Ecosystem services		
1	Home garden intercropping	3	4	4	4	3	18	2
2	Forest protection and enrichment	4	4	5	5	5	23	1
3	Natural pond/lake upgrades to increase the water storage capacity	2	2	2	4	3	13	4
4	Introduce drought tolerant species (green tea plantation) on the previous paddy fields	3	3	3	3	2	14	3
5	Fruit tree plantation and bee raising in forestry lands	3	2	3	3	2	13	4

3.4.2. Description of two EbA priorities

Forest protection and enrichment

Forest enrichment supplies a number of ecosystem benefits, including water and soil conservation, windbreaks, carbon sequestration, biodiversity and increased crop productivity. Trees with deep roots can help with erosion control and maximize the use of water and nutrients that are not available to crops (FAO, n.d2). Good forest management can be strengthened by complementing it with enrichment planting and assisted natural regeneration.

Participants from focus group discussions agree that, inappropriate farming practices of farmers including forest clearing, forest degradation, and the destroying land productivity are ubiquitous throughout the areas. Therefore, ecosystem and productivity restoration has generally counted on human abandonment of the land to allow for subsequent natural forest succession. In addition, forest enrichment planting could offer low-income communities with a source of revenue, as well as ecological and social benefits. As a result, enrichment planting in older fallow ground with high-value native timber species can be considered a land-use alternative. It could also increase the terrestrial sinks (Paquette et al., 2009).

In the focus groups, scenario is ranked positively by men and women, with a high potential to scale up from an initial experiment. The locals feel they can afford to implement this plan by participating in forest patrolling team, doing forest maintenance work, and planting native spices. This intervention is expected to provide a wide range of ecosystem services mechanisms to support farmers - in coping with natural disasters and climate change impacts (Table 4). Nonetheless, it may be costly for the establishment as it involves a coordinated effort with planting components.

Home garden intercropping

Intercrops can have effects on weeds away from alleopathy. In one study by Liebman (1995) demonstrated several mechanisms that offer fewer weeds, greater yield, fertility improvement and favorable environmental conditions. Through the elimination of herbicides or hand weeding, the canopy above closes sooner and thicker, and by the prevention of erosion control from heavy rain or running water through methods such as mulching, the growth of weeds is inhibited. Also, the microclimate could be modified by reducing light intensity, air temperature, desiccating wind and other climatic components from intercropping (Kamel et al., 2004). The relative humidity within the canopy can be maintained by the intercropping of various plants. This is very important to avoid desiccation and create good growth conditions during moisture deficit times. Economic return, yield stability, social benefits, pest control, and nutrient use efficiency are all cited in support of intercropping. Both above and below ground potential complementarities of component plants provides the most important advantage of intercropping systems. In fact, both tall and short plant components can utilize sunlight by their aerial differences (Gebru, 2015).

The study ranked home gardens with intercropping as second option after the forest enrichment intervention with benefits that include the possibilities for scaling-up, it's suitable to local conditions, and may allow some income generation. However, it needs to come to the forefront as farmers consider the benefits to ecosystem services created by the intervention (Table 4).

Natural pond/lake upgrades to increase the water storage capacity

During the group discussions, the third intervention is upgrading existing natural ponds or lakes to increase the capacity in water storage, so this water source would be used for paddy fields where possible. Some potential measures include cleaning those ponds/lakes that are sedimented by domestic wastewater and livestock's waste; making green embarkments for ponds and lakes to protect them during heavy rainy days. However, the distribution of those ponds and lakes limits the connection to some paddy fields, thus, this upgradation just brings sine certain services to farmers - mainly indirect benefits (environmental values), not direct benefits (economical values).

Introduce drought tolerant species (green tea plantation) on the previous paddy fields

Due to droughts, many rain-fed paddy fields can't be cultivated for years, farmers at discussions consider to use perennial species that require less water than rice for these fallow lands. Green tea planting is the most promising intervention as farmers are able to harvest many times per year in long period. Additionally, the local market for green tea is quite stable, although the price isn't high. Nevertheless, this monoculture practice may bring about other negative impacts to environment, such as soil erosion or run-off. Also, green tea growers are dependent on middlemen for selling products.

Fruit tree plantation and bee raising in forestry lands

According to group discussions, this intervention provides a number or benefits to farmers, from direct ones - fruits for sale after three to four years, honey for sale after one year, to indirect ones - microclimate regulation, pollination... However, it isn't cost-effectiveness, farmers need to spend a significant financial capital to implement. Thus, this intervention is the least priority.

Conclusion

The ecosystem-based adaptation interventions provide a number of comparative advantages, such as, cost-effective, robust and flexibility, that can cope with the magnitude, speed and uncertainty of climate change. EbA has already proven its worth in many situations supporting people adapt to climate variability and change. The utilization of ecosystem-based adaptation interventions in rural areas with a difficult terrain and limited space for crop production provide an important opportunity to support smallholder households who must adapt to climate change. Likewise, the EbA interventions offer important livelihood and environmental co-benefits. This study focused on identifying which agricultural interventions could be considered as EbA and further, which of these interventions could be practical for smallholder farming systems. The interventions that support EbA principles include forest protection and enrichment, home garden intercropping, mangrove rehabilitation, water conservation practices, etc., are already popular in the literature and in this study, have been shown to help smallholder farmers adapt to climate unpredictability. Nonetheless, the ever-present financial and technical constraints limit a more widespread adoption of these practices among smallholder farmers.

The loss and damage to small farmers in the Huong Lam commune associated with climate unpredictability increasing in the area, this points to a vital need it to introduce and scale up the EbA approach to strengthen the resilience of other communities - both rural and urban to achieve more sustainable economic development. To promote the EbA approach, it's very important that policy makers at all levels (local, national and international) recognize the importance and comparative advantages of EbA approaches in promote agricultural development in times of climate unpredictability and adopt appropriate environmental strategies. These important findings from this study offer suggestions for further research and promotion of using EbA practices at the local levels. There are also some key contributions to offer future research on the EbA approach. Without a baseline for EbA at the local level, it's not possible to analyze the cost and benefit of the EbA interventions in larger locations. Further, there is a lack of data to differentiate between advantages from infrastructure improvements versus EbA options. We expect that the baseline will be expanded as study results from the local levels can corroborate the importance of EbA as a mechanism for supporting local changes that have the potential to offer solutions on a larger scale. This study based on a sample of 130 farmers in a mountainous and rural area of Viet Nam. However, we believe that these findings will show some relevance and interest in applying EbA measures as a part of the overall adaptation strategy to counteract climate instability.

References

Agbogidi, O.M., Adolor, E.B., 2013. Home gardens in the maintenance of biological diversity. Applied Science Reports. 1, 19-25.

Asian Development Bank, 2012. The Rice Situation in Viet Nam. Technical Assistance Consultant's Report. Available for download at https://www.adb.org/sites/default/files/project-document/73083/43430-012-reg-tacr-04.pdf.

Bauhus, J., van der Meer, P.J., Kanninen, M., 2010. Ecosystem Goods and Services from Plantation Forests. Earthscan, London. Washington DC.

Beckman, M., 2011. Converging and conflicting interests in adaptation to environmental change in central Viet Nam. Climate and Development. 3, 32-41.

Bhattarai, M., 2004. Irrigation Kuznets Curve, governance and dynamics of irrigation development: A global cross-country panel analysis from 1972 to 1991. Research Report 78, 2004, International Water Management Institute, Colombo, Sri Lanka, pp. 523-529. Available for download at http://ageconsearch.umn.edu/bitstream/43246/2/Report78.pdf.

Calvet-Mir, L., Gómez-Baggethun, E., Reyes-García, V., 2012. Beyond food production: Ecosystem services provided by home gardens. A case study in Vall Fosca, Catalan Pyrenees, Northeastern Spain. Ecol. Econ. 74, 153-160.

Carr, E.R., 2008. Men’s Crops and Women’s Crops: The Importance of Gender to the Understanding of Agricultural and Development Outcomes in Ghana’s Central Region. World Development. 36, 900-915.

Castella, J.C., Boissau, S., Trung, T.N., Quang, D.D., 2005. Agrarian transition and lowland–upland interactions in mountain areas in northern Viet Nam: application of a multi-agent simulation model. Agric. Syst. 86, 312-332.

Castella, J.C., Trung, T.N., Boissau, S., 2005. Participatory simulation of land-use changes in the northern mountains of Viet Nam: the combined use of an agent-based model, a role-playing game, and a geographic information system. Ecol. Soc. 10. 27-58.

Charlotte, B., 1997. The economic impact of natural disasters in Viet Nam. Working Paper 98. Results of ODI research presented in preliminary form for discussion and critical comment, April 1997, Overseas Development Institute, Portland House, Stag Place, London, pp. 1-122. Available for download at https://www.odi.org/resources/docs/7024.pdf.

Chadwick, A., Morfett, J., Borthwick, M., 2004. Hydraulics in Civil and Environmental Engineering. Spon Press, London, UK.

Chen, S-K., Liu, C.W. (2002). Analysis of water movement in paddy rice fields experimental studies. J. Hydrol. 260, 206-214.

Chong, J., 2014. Ecosystem-based approaches to climate change adaptation: progress and challenges. International Environmental Agreements: Politics, Law and Economics. 14, 391-405.

Cuong, V.N., Anh, N.T., 2016. The role of crop land during economic development: evidence from rural Viet Nam. European Review of Agricultural Economics. 43, 561-582.

Edge, B., Ewing, L., Erickson, K.M., Magoon, O., 2003. Application of coastal engineering in coastal zone management in Mohan. Advances in Coastal Structure Design. Amer Society of Civil Engineers, Virginia, USA.

FAO, 2006. The Role of Agriculture and Rural Development in Revitalizing Abandoned/Depopulated Areas. Document prepared under the supervision of the Policy Assistance Branch Regional Office for Europe, 2006. Food and Agriculture Organization of the United Nations, pp. 1-28. Available for download at http://www.fao.org/fileadmin/user_upload/Europe/documents/Publications/Abandoned_en.pdf.

FAO, n.d2. Agro-forestry and forest enrichment. Food and Agriculture Organization of the United Nations, pp. 1-14. Available for download at http://teca.fao.org/sites/default/files/news_files/Agroforestry%20and%20forest%20enrichment%20good%20practice%20options.pdf.

Few, R., Ahern, M., Matthies, F., Kovats, R.S., 2004. Floods, health and climate change: a strategic review. Tyndall Centre Working Paper 63, November 2014, pp. 1-65. Available for download at https://www.unisdr.org/files/1985_VL206506.pdf.

French, P.W., 2001. Coastal defences: Processes, Problems and Solutions. Routledge, London, UK.

Fukai, S., Trenbath, B.R., 1993. Processes determining intercrop productivity and yields of component crops. Field Crops Research. 34, 239-472.

Gebru, H., 2015. A Review on the Comparative Advantages of Intercropping to Mono-Cropping System. Journal of Biology, Agriculture and Healthcare. 5, 1-11.

Government of Viet Nam, 2008. Target programme to respond to climate change. Available for download at http://www.noccop.org.vn/Data/vbpq/Airvariable_Idoc_49enDecision%20158%20on%20approval%20of%20NTP.pdf.

Government of Viet Nam, 2011. National strategy on climate change. Available for download at http://chinhphu.vn/portal/page/portal/English/strategies/strategiesdetails?categoryId=30&articleId=10051283.

Ha Tinh Provincial People Committee, (2016). Report on the implementation of the Climate Change (CC) prevention and response in Ha Tinh province (Viet Namese). Available for download at http://qppl.hatinh.gov.vn/vbpq_hatinh.nsf/4b438b320dbf1cda4725719a0012432c/9D5C25374F934C5147257C84002F3BBE/$file/bao%20cao%2050.pdf.

Henstra, D., McBean, G., 2009. Climate Change Adaptation and Extreme Weather Making Canadals Communities More Resilient to the Impacts of Climate Change and Extreme Weather: Summary recommendations. Summary report, 9 September 2009. Simon Fraser University, Canada, pp. 1-20. Available for download at https://www.weadapt.org/knowledge-base/disaster-resilience/climate-change-adaptation-and-extreme-weather-summary-recommendations.

Intergovernmental Panel on Climate Change, 2015. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, pp. 1-151.

Jahn, M, 2015. Economics of extreme weather events: Terminology and regional impact models. Weather Clim. Extremes. 10, 29-39.

Jones, H.P., Hole, D.G., Zavaleta, E.S., 2012. Harnessing nature to help people adapt to climate change. Nat. Clim. Change. 2, 504-509.

Kamel, A.S., Sahar, A.S., Ibrahim, S.T., 2004. New agro-techniques in intensive crop rotations under marginal conditions of Upper Egypt. New directions for a diverse planet. Proceedings of the 4th International Crop Science Congress in Brisbane, Australia, 26 September - 1 October 2004. Available for download at http://www.regional.org.au/au/asa/2004/poster/2/1/1/1937_kamelas.htm.

Lai, R., Iivari, T., Kimble, J.M., 2004. Soil Degradation in the United States: Extent, Severity, and Trends. CRC Press LLC, USA.

Landreth, N., Saito, O., 2014. An Ecosystem Services Approach to Sustainable Livelihoods in the Homegardens of Kandy, Sri Lanka. Australian Geographer. 45, 355-373.

Liebman, M., Dyck, E., 1993. Crop rotation and intercropping strategies for weed management. Ecol. Appl. 3, 92-122.

Linham, M.M., Nicholls, R.J., 2010. Technologies for Climate Change Adaptation - Coastal Erosion and Flooding. Magnum Custom Publishing, New Dehli, India.

Longhurst, R., 2009. Cash Crops, Household Food Security and Nutrition. Institute of Dev. Studies Bulletin. 19, 28-36.

Matsuno, Y., Nakamura, K., Masumoto, T., Matsui, H., Kato, T., Sato, Y., 2006. Prospects for multifunctionality of paddy rice cultivation in Japan and other countries in monsoon Asia. Paddy and Water Environment. 4, 189-197.

Mohri, H., Lahoti, S., Saito, O., Mahalingam, A., Gunatilleke, N., Irham,. Hoang, V.T., Hitinayake, G., Takeuchi, K., Herath, S., 2013. Assessment of ecosystem services in homegarden systems in Indonesia, Sri Lanka, and Viet Nam. Ecosyst. Serv. 5, 124-136.

Munang, R.I., Thiaw, K., Alverson, M., Mumba, J., Liu, & Rivington, M., 2013. Climate change and ecosystem-based adaptation: a new pragmatic approach to buffering climate change impacts. Current Opinion in Environmental Sustainability. 5, 67-71.

Natural Resources Canada, 2016. Forest ecosystem products and services. Available for download at http://www.nrcan.gc.ca/forests/canada/sustainable-forest-management/13177.

Organization for Economic Cooperation and Development., n.d. Poverty and Climate Change. Reducing the Vulnerability of the Poor through Adaptation. Available for download at http://www.oecd.org/env/cc/2502872.pdf.

Paquette, A., Hawryshyn, J., Senikas, A.V., Potvin, C., 2009. Enrichment Planting in Secondary Forests: a Promising Clean Development Mechanism to Increase Terrestrial Carbon Sinks. Ecol. Soc. 14, 31-46.

Schmidt-Thomé, P., Nguyen. T.H., Pham, T.L., Jarva, J., Nuottimaki, K., 2015. Climate Change Adaptation Measures in Viet Nam. Springer International Publishing, Switzerland.

Sein, C.C., Mitlöhner, R., 2011. Acacia hybrid. Ecology and silviculture in Viet Nam. Center for International Forestry Research. Available for download at http://www.cifor.org/publications/pdf_files/books/bcifor1104.pdf.

Turner, R.K., Daily, G.C., 2007. The Ecosystem Services Framework and Natural Capital Conservation. Environmental Resource Economics. 39, 25-35.

Wilkinson, C., Saarne, T., Peterson, G.D., Colding, J., 2013. Strategic spatial planning and the ecosystem services concept - an historica