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AGRICULTURAL PRODUCTION MODEL ADAPT TO CLIMATE CHANGE BASED ON INDIGENOUS KNOWLEDGE OF ETHNIC MINORITIES IN BAC KAN PROVINCE, VIETNAM

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ABSTRACT

Indigenous knowledge and practices were investigated in the local communities that have been severely affected by the impacts of climate change in recent years in Bac Kan province. The manifestation and impact of climate change to agricultural production and livelihood of local people were identified and clarified in this area. Indigenous knowledge and practices in prediction, response and adaptation to extreme weather phenomena and climate change for agricultural production of the local communities were clarified and documented. Findings from the study showed that ethnic minority groups in the research area have a lot of indigenous knowledge and practices in agriculture production copping with extreme weather phenomena and climate change. Various local cultivars which are resistant to drought and cold are used by local ethnic minorities such as banana (Tay variety), rice (Bao Thai), mungbean (moc), local ginger cultivar and potato. Therefore banana, potato, ginger and mungbean are recommended for farmers in the Bac Kan province to grow as crops adapting to climate change. Many traditional practices in agriculture production coping with drought and cold conditions were also investigated such as indigenous practices in banana cultivation on sloping land; appropriate arrangement of the crop growing season in accordance with climate change conditions; weather forecast based on symptoms of natural condition etc. The study also reviewed agricultural policies relating to climate change at all levels and found that there was a big gap between current government policies with real problems occurred in the field due to climate change.

Keywords: climate change, indigenous knowledge, ethnic minorities, Vietnam, production model.

INTRODUCTION

Vietnam is one of the countries which will be affected the most severe by the effects of climate change (Dasgupta *et al*., 2007). Climate change variables have serious implications for economic development, particularly for agriculture, because agriculture is directly dependent on weather conditions and other natural conditions. Studies on Southeast Asia found that climate change could reduce crop yields up to 15-26% for Thailand, 2-15% for Vietnam, 12-23% for the Philippines, and 6-18% for Indonesia (Zhai and Zhuang, 2009).

Upland areas in Vietnam account for two-thirds of its natural area and one-third of its population. These uplands are characterized by heterogeneous and fragile ecosystems, a high incidence of poverty, severe deforestation and soil degradation. The Northern Uplands have almost 6.5 million people or 8.4% of the population which is made up of 8 major ethnic groups. These people are living in a rapid changing environment, often harshly caused by the recent dramatic climate change (CARE, 2010).

Bac Kan is one of the northern mountainous provinces in Vietnam. Severe weather in recent years has caused drought and floods here. About 282 ha of rice area in Nhan Mon, Cong Bang, Giao Hieu Commune is destroyed by drought (Department of Agriculture and Rural Development of Bac Kan, 2010). Also, flood in Pac Nam district had destroyed 50 hectares of rice and 93 houses (Phan, 2009). About 300 ha of Bac Kan orange is affected by climate changes, losing billions VND (VGP News, 2011). According to VOV news reported in 2008, about 4234 cattle died from cold damage, cold dark. Most of dying cattle are concentrated in the mountainous districts such as Pac Nam, Cho Don, Na Ri, Ngan Son and Ba Be (VOV News, 2008). Approximately 1,700 cattle died because of long-day cold in 2011 (Bac Kan Online, 2011).

The strong dependence of the local communities on the natural environment makes them particularly sensitive to the effects of climate change. To sustain life in harsh conditions, each ethnic group in northern mountainous areas in general and in particular of Bac Kan province has different ways to deal with the negative effects due to climate change. In fact, the ethnic minority communities which have local knowledge in the field of agricultural production can help them adapt to climate change and agricultural activity which is detected, documented and said widely to people in other areas.

MATERIALS AND METHODS

Research site

Mai Lap and Thanh Van communes of Cho Moi District - Bac Kan Province were selected as the project area. Mai Lap and Thanh Van are two hilly communes located in the northwest of Cho Moi District. Due to the hilly terrain, steep slopes, and deforestation, the communes have been increasing vulnerably to the impacts of climate change such as droughts, floods and landslides.

Research approach

The research team applied a holistic approach in this research. Various groups of people have been taken into research design such as group of different ethnic

minorities (Tay, Dao, Nung, Mong and Kinh); groups of men and women and groups of leaders at commune, district and province levels.

Indigenous knowledge and changes in weather and climate are main factors in identifying climate change adaptation models in this project. As a result, people-centered research approach with the elderly and experienced people is applied. In order to document the indigenous knowledge in agriculture production, some points of approach for paying attention including: (i) Collecting information from many target groups via different tools and cross checking (ii) Communicating with various communities through unofficial talking; and (iii) As facilitating to identify the indigenous knowledge, spending enough time for the informants to understand and provide adequate information because most of the informants are ethnic minority people.

The cross cutting issues of marginalised groups and gender such as labor allocation, health, participation in social activities, rights for decision making, understanding and practice of indigenous knowledge are carefully considered in research design, data collection and analysis.

Data collection

Information for this research was collected from various sources. In order to effectively facilitate and collect enough information for the research, secondary data including the area hydrometeorology Figures, relevant research and policies related to climate change of the province and district were gathered for analyzing. Primary information was collected via group discussion, in-depth interviews with the elderly, experienced people, officers and group discussion. Several tools from Care's CVCA handbook were used to collect information such as hazard mapping, seasonal calendar and vulnerability matrix. Other tools for gender and indigenous knowledge applied in the research were developed and presented in annex section.

Building a model of agriculture based on indigenous knowledge of ethnic minority

The model chosen for the area will be constructed from the results of field studies and meta-analysis, and will be suitable for local conditions in capital markets, and ecological conditions. The model will be designed by a participatory approach based on local knowledge of ethnic minority groups in both Thanh Van and Mai Lap Communes. The data relating to production models, crop growth, yield, and the response to climate change will be recorded for analysis.

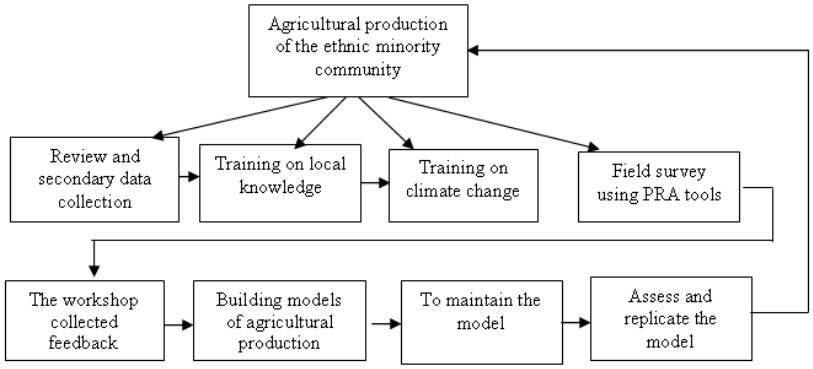

Figure-1. Summary of the research process.

RESULTS AND DISCUSSIONS

Climate change impacts and responses

The statistics figure on climate and weather of the research area provided by Bac Kan Meterology Station is limited in two main indicators that are temperature and rainfall (Figure-2 and Figure-3). The statistics figure of temperature show the significant difference in average temperature of the months in a year. From May to August are the months with high temperature and those from November to February have low temperature. However, there is not great variation in temperature of different months between the years, except for the significant disparity in temperature from January to March, the temperature is lower and lasts longer than before.

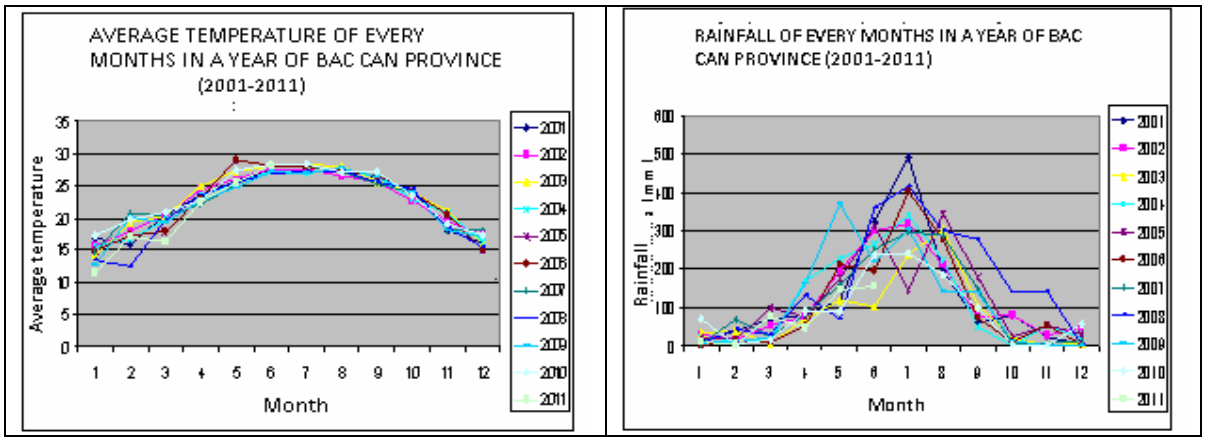

Figure-2, 3. Average temperature and rainfall of the months within a year at Bac Kan from 2001 to 2011.

Source: Bac Kan Meteorology, 2011

There is a disparity in rainfall and rainy season that does not follow the rules. Generally, we can see that there is an increase in rainfall in Bac Kan and the rainy season lasts longer. Besides, the climate change senarios developed by Ministry of Natural Resources and Environment (MONRE) indicated that with the average emission level (level B2) the North-East, North Central region and Central Highlands are classified in group of the regions that annual average temperature is increased faster than other areas. The annual average temperature increases about 2.5^{o}C in the late 21st century. For rainfall, according to the scenarios, total annual rainfall in the North-East region rises from 1.4% in 2020 to 7.3% in 2100. For most of other areas, the popular rising level is from 10 to 20%. Although the total rainfall per year is increased, the rainfall in the middle of dry season (from March to May) decreased from 3 to 9%.

It can be seen that data from the meteorology station and the senarios developed by MONRE idicate significant changes in the weather and climate phenomenons. There is a tendency that the temperature will be gradually increased but it is colder in winter and drier and hotter in summer. The rainfall grows increasingly but distributes unequally. It will have a lot of rain in rainy season but less rain during dry season. However, these figures are just represented for the whole North-East region. Therefore, the figures do not have specific meaning for identifying extreme weather events as well as manifestation of climate change at particular locality, especially at the area having complex terrain separated by hills and mountains. In order to define the extreme weather events and manifestation of climate change locality, opinions of local people were applied (Table-1).

Table-1. Opinions of local people at Thanh Van Commune on the extreme weather events at the locality during the last 10 years.

Weather extreme events and bad weather pattern	Changes in frequency	Changes in intensity	Change in duration	When	Ranked
Hot temperature, lack of rain - long-lasting drought	++	+++	+++	2000	1
Extreme and damaging cold	+++	+++	+++	2006-2007	2
Flashflood and landslide	-	+++	-	2006-2007	3
Abnormal weather patterns	++	++	+++	2007-2008	4
Whirlwind	-	++	-	2007	5
Hail		+++		2008	6
Lighting/thunder - no rain	-	++	-	2010	7

Abbreviations: - : low, ++: high, +++: very high
Source: Field survey 2011

Results in discussion with local people at Thanh Van and Mai Lap Communes show that long-lasting drought, freezing cold and abnormal weather patterns are the obvious manifestation of climate change at the locality. Drought has been increased in both intensity and duration. Drought lasted from January to March around 10 years ago, but it extends to April and May recently.

It is presented by local people at two surveyed communes that in the current tendency of climate change, with the increase of drought, in next 20 to 30 years (2030-2040), the riverhead streams in the area of Con Minh Lake will be dry and water level in Na Don Lake will decrease. As a consequence, local people at three villages of Quan Lang 1, Quan Lang 2 and Khau Chu will lack water for living and production. Also, a part of production land area of Na Kham village will be affected seriously. In addition, about 3 to 5 ha one-crop land area will be unable to produce and a part of production land area (about 3 ha) of Phieng Khao village will be seriously affected by drought. The one-crop field of Ban Ra village of Mai Lap commune will be under water exhaustion.

To conclude, according to statistics on local climate and the scenarios as well as opinions of local people, it can be seen that climate change has shown the clear manifestation at the study area. The main manifestations are drought with the gradually increase in duration and intensity, more freezing cold lasts longer and abnormal weather patterns appears. These changes have had particular impacts on daily lives and agriculture production of local people.

Impacts of climate change on agriculture production in the research areas

As for crop cultivation, since rice is the main crop covering a large area, it is judged as being affected mostly by climate change, follows is maize. Long-lasting hot weather combining with lack of rain caused underdevelopment of rice and the change of crop diseases. During 5-6 years recently, on the area of two communes, because of long-lasting drought, harmful pestilent insects such as blast, rice leaf folder, and brown backed rice hoppers have developed quickly. Some of new diseases such as black tripes, yellow spiders, black bug cause a lot of damage on rice yield. In 2010, the two communes lost 100% area of Lao sticky rice because of black bug. Bao Thai is a kind of local rice seed that has high resistance capacity; however, its productivity was reduced 60% in comparison with previous years due to black bug.

Table-2. Impacts of climate change on major cops and animals in the study area.

Crops/ animals	Weather extreme events/ bad weather patterns	Impacts
Rice	Long-lasting drought	Lots of diseases: Black bugs (not happened before) appear on the entire commune, especially on cross-bred rice and the sunny rice area - Blast - Yellow spiders (not happened before) causes little damage - Borers developed: less damages before but in 2010, it caused 4-5% damages - Production costs increased: fertilizers, pesticide, gasoline for two or three times of water pumping
Maize	Long-lasting drought	Less kernels due to lack of water during flowering period Maize without kernels
	Cold	Time for producing maize ears is delayed Fewer kernels
	Abnormal weather pattern	Right before the flowering period, the plant is rotten to its roots and dies. This disease did not happen before
Green bean	Drought	The dark blue bug developed a lot that shortens the plants to die. This disease happens in May and June
	Abnormal weather pattern, a large amount of rains in February and April	Flower falling, flowering in many turns Many leaves and tillers developed
Peanut	Drought	Red ants develop and eat the seeds
	Cold	Can not sprout
Potato	Drought Long-lasting freezing cold	Red ants damage the tubers Lack of humidity affects to development and growth Leaf curled
Pig	Abnormal weather pattern	Foot rot Staphylococcus Foot and mouth disease
Goat, buffalo, cow	Abnormal weather pattern	Foot and Mouth disease
	Freezing cold	Cattles die

Source: Field survey, 2011

Long-lasting drought creates favorable conditions for the development of diseases in maize, and beans. Maize root Aphids and Borers develop that affects seriously to maize yield and productivity. Due to being affected by drought, productivity decreased, the area of maize field declined sharply. In 2011, the area of maize at two communes is about 40% in comparison with 5 to 7 years ago. Besides, in the flowering period, if it is drought, maize will have less kernels or no kernels. In 2010, the proportion of maize without kernels account for 80% of maize areas.

Peanuts and potatoes are prone to drought. Ants often damage the potatoes' tubers if drought happens. Therefore, drought not only affects to potato development and growth but it also impacts on its productivity. Besides, potato plants have good resistance to cold; yet, long-lasting freezing cold affects to its development and growth as well as causes leaf curled. Therefore, 5-7 years recently, the number of households growing potatoes decreased remarkably (more than 80%).

Animal is an important income source of people at two communes. However, changeable weather conditions and increased diseases cause significant impacts to livestock at the localities. The diseases such as foot and mouth disease, staphylococcus, and foot rot developed greatly and rapidly. Because of the changes in weather, many abnormal diseases on animal appeared. Gouts, buffaloes, cows easily caught mouth disease and poultry have white excrement underdeveloped. Due to the outbreak of epidemic diseases, animal husbandry faces with high risks, therefore, livestock at localities reduce significantly. In recent years, freezing and damaging cold appeared more frequently killing many buffaloes and cows. In 2008, the number of buffaloes died in Mai Lap was 32 and 46 in Thanh Van, and in 2011, the figures were increased to 43 and 39 cases in Mai Lap and Thanh Van respectively.

Autonomous adaptation activities

Autonomous adaptation activities are those developed by indigenous knowledge of local people and experiences. Research results showed that farmers in Mai Lap and Thanh Van commune are autonomously practicing various activities in agriculture production to adapt to climate change. The adaptation activities include: selecting seeding or kinds of plant that have high resistance to extreme weather patterns and pests caused by changeable weather; choosing cultivation techniques and caring that they adapt to climate change; and adjusting seasonal calendar to prevent extreme weather patterns.

At two surveyed communes, local people have selected pure rice seeding such as Bao Thai or Khang Dan to cultivate on a wide area. They are two kinds of drought resistant rice varieties and have fewer pests. Moreover, local people can produce and reserve seeding by themselves therefore they can control the seeding source, reduce cost and the seeding has high adaptation to local conditions. Apart from selecting plant seeding, local people also adjust cropping patterns to adapt to climate change. For drought land areas, people change to crops that require less water, for instance, transferring from two-crop rice to one crop rice with a maize or bean crop.

Besides, selecting resistant seedlings or kinds of plants, local people at two communes also practice various cultivation techniques to adapt to climate change. These techniques are much diversified and have significance mitigated impacts of climate change and reduced production costs including land processing technique, plant caring technique and pest prevention techniques. In order to adapt to drought, local people apply crop rotating or intercropping to enhance land coverage and reduce soil erosion. Using by-products in agriculture such as straw, plant matters for mulching crops to keep moisture and reform soil structure. In addition, there are some of indigenous knowledge that have significance in preventing pests such as using water mixed petroleum and light or utilizing urine keeping in 2-3 days to attract insects. These techniques have been used by local people in the outbreak of pests on maize and crop fields due to changeable weather.

Adjusting cultivation calendar is another adaptive activity that can be seen clearly at two study communes. As usual, cultivation calendar is made by authorities at different levels. However, at the study areas local people can not follow this cultivation calendar. Because the weather is so changeable among the years, people only cultivate when it is favorable (it has rain or not too cold).

Crop models adapting to climate change proposed by the two communes

Cold resistant crop model

The cold resistant potato model will utilize German potato variety that has yellow tuber flesh with tight structure and strong taste. The soil selected is sandy soil that is positive in water for 15-20 HHs. The model will apply experiences and indigenous knowledge of local people focusing on notices in cultivation techniques. Source of fertilizers is taken mainly from animal wastes combined with wild grass and rice husk that is decomposed by micro organic ferment EMIC 25G. As making bed, straw harvested from the rice crop will be supplied to take advantage of fertilizer and increase moisture and create softer soil for tuber development. The beds are made lower and applied caring techniques to increase growth and resistant capacity of potatoes. Specific criteria of cold resistant potato models are presented in Table-3.

Table-3. Criteria for selection of potato as a climate change adaptation model.

Model criteria	Basic figures
Seeds/seedlings	Cultivated popularly in the Northern mountainous areas
Relevance	- Suitable for investment capacity of local people - Cultivation and seeding techniques based on indigenous knowledge and people's experiences - Being suitable for both women and men - Improving income in cold weather season
Indigenous knowledge	- Using organic fertilizers produced by local people - Making low beds with large surface for drought resistance - Using straw to increase moisture and softness for the beds
Climate change adaptation	- In condition of long-lasting cold - For short duration, leaves and stems can be used as organic fertilizers for spring crops
Effectiveness	- The land is currently unused in potato cultivation time - High economic effectiveness from 1.7 to 2 million/quintal
Sustainability	- Local people have clear awareness on impacts of climate change - Diversification in production activities to mitigate impacts of climate change - Land at two communes are available and suitable for potatoes - Good market

Source: Field survey, 2011

Potato is a psychrophilic plant. In winter season, the weather is cold in the Northern mountainous area therefore, potatoes can develop and grow well that brings high productivity (suitable temperature for the development and growth of potatoes is from $15\text{-}25^0$). Especially, at the fields where Bao Thai rice is cultivated and harvested lately (November 10^{th}), other traditional crops such as maize and sweet potatoes cannot develop and grow, potato gains the advantage and seems to be the best adaptation plant to cold. Therefore, potato needs to be piloted and replicated at the locality. In term of market, Bac Kan province is implementing pilot program on potato producing and consumption at Ba Be district. Thai Binh Seedling Company is the host company to consume all amounts of potatoes on the provincial areas providing that size and quality of potatoes are guarantee.

As for gender aspect, in winter season, people are free from farming. They cannot earn income for living and send children to school, therefore, some of them have to go to city to seek for work. As a result, they often get involved in social evils such as thief and perturbative elements of locality. These people become burden for their family, especially women. Several women have to work as hired labors at urban areas in winter season, and they also easily become victims of fraud and prostitution.

Cultivating potatoes in winter season would create local jobs and increase income for farmers. This also contributes partly to solve social evils that are a festering problem of today. Especially, when women do not have to leave their commune for working, the danger of vulnerability will be reduced and children will have more care.

Drought resistant crop model

Result from group discussion, in-depth interview and consulting opinions of professional divisions and sectors as well as experts on the drought resistant crop model for summer season one-crop land is green bean. That is local bean seeding with small seeds. Green bean is planted in late of March. It has short growing duration that takes about 60-70 days for harvesting. This helps release land in time for cultivating next crops. Cultivating green bean can save the water sources for irrigation; therefore, it is suitable with the area that is in danger of drought. The plant's by-products (roots, trunks and leaves) are source of fertilizers containing protein. It can reduce the amount of chemical fertilizers for crops, protect lands and enhance land fertilization. Techniques for cultivation and caring will consider to indigenous knowledge and notices in green bean planting techniques.

Table-4. Criteria for selection local bean as a climate change adaptation model.

Criteria of model	Characteristic
Green bean	Cultivated popularly in the Northern mountainous area
Relevance	- Low investment - Suitable with various kinds of land and able to reform the land - Products can be used in traditional festival or selling - Cultivation and seeding techniques based on indigenous knowledge and experiences of local people
Indigenous knowledge	- Using organic fertilizers produced by local people - Indigenous seeding and techniques to kill bug by ash
Climate change adaptation	- High resistant capacity to drought - Long-term crop, plant matters can be used as protein-riched fertilizers for next crops to reduce to amount of chemical fertilizers.
Effectiveness	- Improve income in unused land in spring season - Income 2.2-2.5 million VND/quintal
Sustainability	- Local people have clear awareness on impacts of v, necessity of diversification of production activities to mitigate impacts of climate change - Local people have demand to develop green bean - Local people can produce seedlings by themselves - Land fund at two communes are big (30 ha), therefore the model is possible to be replicated. - Short growing time that can release land for rice in main crop - Products are often used in traditional festivals at the locality

Source: Field survey, 2011

A majority of local people who have experiences in producing green bean (planting in small scale) as well as in preserving seeds. Moreover, policies of the province, district and commune encourage local people to transfer plant structure, increase effectiveness of land using and reduce uncultivated land in spring season. Therefore, it is necessary to establish the pilot models on green bean planting and replication in climate change condition.

In term of gender, if land is uncultivated in spring seasons then it need to be supply more muck and chemical fertilizers in the main crop. It will take more costs and labors of women. As green bean is cultivated in spring season, it does not only increase income but it can also reform the soil effectively. After harvesting the tubers, all of roots and trunks of potato will be good instant fertilizers for rice in main season. This can reduce the burden of expenses for fertilizers in main crops and partly release women labors.

However, a problem noted by local people as developing the model are cattle wandering around. After harvesting rice, animals are grazed freely at uncultivated fields. If the model of green bean planting in spring season is developed, the village needs to set up regulation in protecting and managing cattle, and commune authority need to have intervention to better the management.

Agro-forestry model as climate change adaptation model

Similar to drought and cold resistant model, the model of agro-forestry as climate change adaptation model is defined based on results of group discussion for local people, consultants and agriculture officers at different levels of Bac Kan province. The general model reflects the adaptation and support to each other among cropping systems and cultivation techniques in various terrains of typical agriculture system of the region. The identified model is the cultivation system adapting to extreme weather events such as drought, cold and changeability of weather at the locality. The components of models and adaptation characteristics of each component in the model are presented in Figure-4.

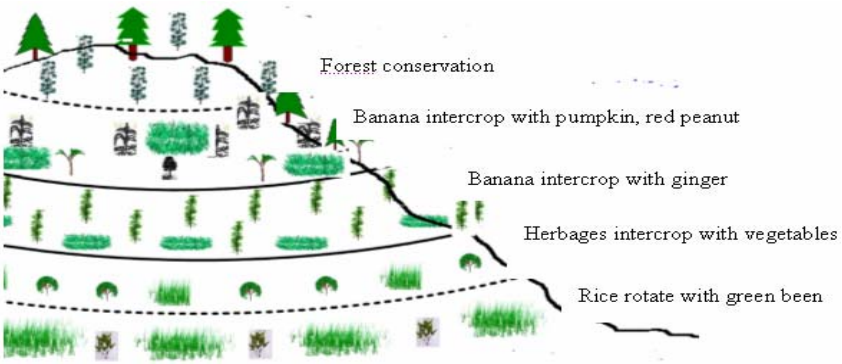

Figure-4. General cultivation model for climate change adaptation at Thanh Van and Mai Lap communes.

Table-5. Criteria for selection of agro-forestry model as a climate change adaptation model in Thanh Van and Mai Lap communes.

Criteria of the model	Characteristics
Relevance	- Suitable for cultivation habits on slope land - Suitable for intensive farming - Planting techniques based mainly on indigenous knowledge and experiences of local people
Indigenous knowledge	- Using organic fertilizers produced by local people - Planting trees used for remedy in the same contour - Digging ponds to take water - Making same contour - Using local cultivars: banana, green bean, ming aralia …
Climate change adaptation	Enhancing land vegetation cover Increase water keeping capacity and reduce erosion Diversifying income generation
Economic effectiveness	- Good market - Bringing income in short term and long term
Sustainability	- Local people are aware of impacts of climate change - Diversify production activity to reduce impacts of climate change - Land are available for replication - Maintaining cultivation habits and indigenous knowledge

Source: Field survey, 2011

CONCLUSIONS

People at two communes have much indigenous knowledge on cultivation techniques and seedling that have potential to apply for climate change adaptation. Technique for seeding green bean for high sprouting rate; technique for caring potatoes in drought and cold conditions for preventing ants; technique for separating banana shoots have been identified and applied in climate change adaptation at the locality. The local plants such as bean, banana and bitter cassava are among various potential indigenous plants for climate change adaptation. The production models adapting to climate change have increased income for people at research area.

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