

## **Climate Change Impact Assessment and Strategies for Adaptation at Mountain Region: a Case Study in Da Bac District, Hoa Binh Province, Vietnam**

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**Abstract:** Adaptation strategies for climate change at the mountain region are often generalized using the low land result and therefore, unsuccessfully implemented. Among the key factors are the lack of understanding in the differences of diversity between mountain ecosystems. Thus, the climate change impacts are graver in degree at mountain ecosystem compared to the lowland area with the same list of factors. Field observation, data collection and field interview among local communities at mountain region using Rapid Integrated and ecosystem-based assessment of climate change Vulnerability and Adaptation (RIVVA) identified the evidences of climate change impact includes significant rise of temperature, more frequent natural disaster, extreme weather hot or cold and longer drought season. Adaptation towards climate change among the mountain communities include diversifying their plant and using environmental friendly pesticide and yet, this approach still insufficient to support their livelihood. Strategic adaptation comprises of information dissemination, capacity building and installation of weather monitoring system at several locations at this mountain region can prolong and improve livelihood of people in this mountain region. The adaptation strategies also seek the better role played by government, local stakeholders and local communities to ensure the successful implementation and application particularly at mountain region.

**Key words:** Climate change impact, mountain ecosystem, adaptation, Vietnam, adaptation, dissemination

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### **INTRODUCTION**

Mountain ecosystems are known to be among the most sensitive environment and greatly impacted by the changes in the environment (Tse-ring *et al.*, 2010). The changes in the environment includes changes in temperature due to changes in cloud movement or from today's global heating can greatly leave an impact in the sensitive mountain region that are known to be diverse and complex (Ives *et al.*, 1997; Ives, 1991). As much as climate shapes the mountain environment and determines its constituent characteristics, so do the mountains in turn influence the climate and related environmental features through altitude, continentality, latitude and topography, each of which affects several important climate variables (Tse-ring *et al.*, 2010). Due to the complexity of the topography and the orographic features, it is more difficult to understand climatic characteristics in the mountains than in the plains. It could be the same for the impact of climate change in this

area. Previous studies on mountain ecosystem identified that changes in the environment particularly due to global warming is the main contributor to climate change will affect weather, agriculture, wildlife and human health (IPCC 2007; Tse-ring *et al.*, 2010).

Vietnam has been identified as one of the populous nations in Southeast Asia along with Indonesia, Philippines and Thailand. It is known to be the one that has the highest density per square kilometer at 268 people (Hossain and Selvanathan, 2011). The populous nation will be greatly impacted by climate change as their environment, the natural resources will be used to accommodate the need of the growing population. The ability to sustainably use their natural resources for economic growth is a real challenge in the changing environment due to climate change. Besides, the nature of this country seems to be extremely vulnerable to climate change impacts given its extensive coastline and river deltas and highlands that have poor water retention capacity and are susceptible to severe erosion (ADB,

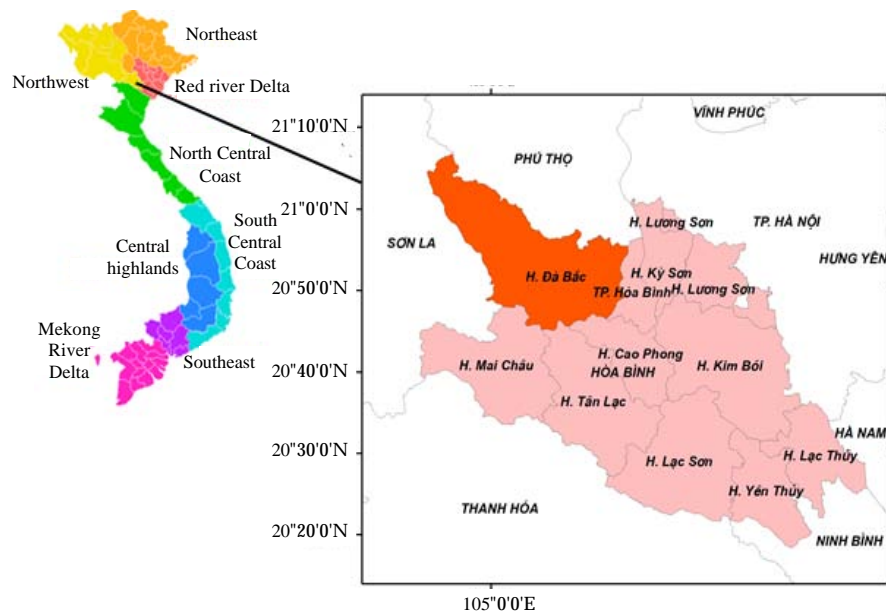


Fig. 1: The location of Da Bac District within the Hoa Binh province in the Northwest Region of Vietnam

2013). Previous research on climate change impact in the country are focusing on the plain area mainly Mekong Delta. Despite, the fragile environment and people of the mountain there is very limited research have been carried out to understand the depth of the climate change impact in this area.

**Study area:** The study area is Da Bac District in Hoa Binh Province. Located at the Northwest of Vietnam, approximately 90 km away from Hanoi. Da Bac is a mountainous district, bordering Phu Tho Province to the North, Son La Province to the West, Hoa Binh City to the East and the other districts: Tan Lac, Mai Chau to the South (Fig. 1). The average altitude of this district is 560 m with many high mountains over 1,000 m above sea level represented by mountain peaks at Phu Canh (1,373 m), Phu Xuc (1,373 m), Duc Nhan (1,320 m) and Bieu (1162 m). These mountain create hilly terrain, alternating rivers and streams, forming many narrow strips which were strongly cut out into steep land. The average slope in the area is 35° although, some distinctive vertical slope are common due to the nature of easy weathered limestone rock.

Da Bac District is located in subtropical monsoon climate zone which has two observable seasons every year, the cool dry season lasts from end of November-April next year and the humid hot season is from May-October. The average temperature is 23.5°C with the highest temperature at 38-39°C, the lowest

temperature is 12°C. The average rainfall is 1.570 mm/year but focuses primarily on the period from May-September which made up to 79% of the annual rainfall. Besides, hot dry wind are also common from June-September, sometimes occurs 2-3 days with an average of 5-10 days a years.

This district has the largest natural area in Hoa Binh province with 820 km<sup>2</sup> for conservation, approximately 17.6% of the total natural area of the province. Agricultural and human settlement occupies the rest of the area in the province. The local population are 50,960 people, accounting for 6.4% of the population with population density of 62 people/km<sup>2</sup> equal to 0.4 times the population density of the province.

The district's economy is mainly based on agriculture and forestry. Currently, the district's economy is located at lower category in the province with large gap in living standard among the resident. The attribute to lower income in agriculture which dominated by paddy planting are greatly influence by lack of water sources in the area (Fig. 2).

The challenge condition of livelihood in Da Bac District that has the possibility being impacted by the climate change trigger the need to study and understand the ecosystem extensively and identified the depth the impact to the area. Therefore, be able to propose adaptation strategies in the light of increasingly complex impact of climate change, reduce the impact of injury and improve livelihoods of the local community.



Fig. 2: Main economic activities in the area is terrace paddy planting often on the narrow area. In this photo is between two limestone hill at most Northern part of the Da Bac District

## MATERIALS AND METHODS

The study was carried out using Rapid Integrated and ecosystem-based assessment of climate change Vulnerability and Adaptation (RIVVA) as development and use by Tuan *et al.* (2012). The result from RIVVA approach was derived using secondary data analysis, field observation and survey method followed by specific analysis to assess the impact of climate change. Secondary data consist of meteorology data, extreme weather, natural disaster, main natural resources, community distribution and main economic income was collected at the local district and interview with the local leader. Some data, particularly meteorological data have been extracted from nearest hydro-meteorological station at Hoa Binh (approximately 15 km Northwest of the study area) due to the non-existence station at the Da Bac District.

These data was analyse to understand the changes in the environment indicated by changes in weather recorded by systematic machine and oral history by the local leaders. Open interview acquiring experience of possible extreme weather and natural disaster in the area are beneficial in this study and most of the event supported by documented evident. The field observation was focused on the ecosystem changes observed by several researchers of various expertise in ecologies. Field observation is pivotal in confirming the condition and the obvious site evident of the impact or changes. More gradual or subtle evident of climate change impact was assessed by Participatory Rural Appraisal method (PRA) as apply by CSRD (2010) is through selected and random interview with the local leaders and local community. This selected interview are using systematic field survey that have been develop by Nguyen (2009) and random interview to local people on specific topic such as livestock and wild animal distribution. Adaptation

strategies for mountain people of Vietnam was later recommended after analysing the primary and secondary data.

## RESULTS AND DISCUSSION

The result and discussion are arrange according to approach taken from secondary data analysis followed by survey and interview. The secondary data analysis includes climate and extreme weather phenomenon, local community livelihood and the vulnerability matrix of the area against the natural disaster. Meanwhile, the result of survey and interview was table using Strength, Weakness, Opportunity and Threat (SWOT) analysis of the area.

**Climate and extreme weather phenomena:** According to the 40 years expand of meteorological data from 1975-2015 there is a 2.88°C of temperature increase from 22.22-25.1°C. Assuming this as a gradual temperature increase and it is 0.72°C per decade and this increase is significant as it almost exceed the prediction of 4°C in 2100 by IPCC in 2007 (IPCC, 2016). This data also high compared to the average increase of ~0.5°C temperature at North central region as reported by Ngo-Duc *et al.* (2014).

The increase of temperature also supported by the decrease of precipitation recorded in average annual rainfall and rainy days the area. The average annual rainfall have shown a decrease from April 1975-December 2015 in four decade (1975-2015). This decreasing precipitation resulted extreme weather events includes droughts and floods. According to, the report by Ministry of Agriculture and Rural Development, Institute of MARDIAE (2009) and supported by research on climate change in Vietnam by Nguyen (2009) this extreme drought and flood are the evident of climate changes in the country (Fig. 3).

In the area with agriculture as the sources of income, this changes influence the season ensued low yield of main agriculture produce of rice, corn and sugarcane. This is backed by the report on the socio-economic and anti-flood report of Da Bac (from 2005 to present) by people's committee district and flash flood study in the mountain region by Bui *et al.* (2013). These report recognized not just the extreme weather phenomena of flood and drought but also damaging cold that are common in the mountain region.

**Local community livelihood:** Targeted interview with the 15 local commune officers, 15 local village staffs and 4 district officer followed by random interview with another 190 households identified that mountain of Da



Fig. 3: The decrease water level in this lake is indicated by the expose bare soil (yellow) and a long period of decrease as short green grass on the muddy and sometime fill with sinkhole area as observed in this commune

Bac is among the poor group with 2-3 million VND/person/year. The poor group often involved in agriculture production account for 75% of the correspondent while others, 25% are contribute by providing services and serve as government and local officer. Most of the agriculture production, made up of 80%, practices mixed cropping system in which the farmer sow two crops at the same time while another 20% are ventures to livestock breeding (GSOHB, 2014). The mixed cropping agriculture practices are viable in this mountain as the seasonal crop and livestock breeding calendar of Da Bac District (Table 1) shows that some of the plant such as sugarcane and cassava are all season while the staple plant, paddy, only can be planted and harvest within 7 months while maize and potato for 8 month and canna tubes for 9 month. Livestock breeding become the next alternative as the raising of pig, buffalo, cow as well as aquaculture are also practical all year round.

Although, agriculture have the possibility of great return as a sources income, the surveys also found that poor households are hindered by limited resources includes shortage of cultivation land, lack of pulling power, poor transport facilities and linkages and limited access to relevant information.

**Vulnerability matrix:** Vulnerability matrix analysis is to demonstrate and understand the correlation between the impacts of natural disaster and economic activities in the area. This study identified the occurrence of common natural disaster at the mountainous area such as landslide, flash flood, storm, tornado and drought and prolong hot in Da Bac District. According to Bui *et al.* (2013) in the recent year landslide in the regionb become frequency due to the heavy rainfall. The possible differences with other mountain region is the frequencies and level of disaster impact as shown in Table 1. In Da

Bac, the cultivation and aquaculture are greatly impacted by natural disaster with Level 3 exposure that consider devastating and great lost to the small farming people. Each natural disaster which directly due to climate change or became rampant due to it, will impact both sector although, with different level of exposure. Among the impact record via the interview are drought reducing productivity, reducing the fertile area and increase pest in rice cultivation while reducing yield of corn and killing sugarcane during the period of planting. Heavy rain and flash flood often destroyed thousand of hectares of the planted area, reduce the value and productivity of rice, sugarcane and maize. Storm and tornadoes destroyed planted area with numerous stamped, uprooted and trees. However, storm and tornadoes still has no record of impact to livestock and employment rates and this probably due to impact at level 1. Extreme cold also reported in the area as it impede the livelihood particularly among agriculture people by delaying the growth or sometime kill the seed of plant such as sugarcane. Extra cost needed in supporting that farming by replanting.

**Local communities adaptation approach:** According to field observation and interview two main adaptation strategies was taken by the local communities in perspectives agriculture communities. Both adaptation approach are very basic resilience living in the changing environment. Most local people who involved with swinden agriculture diversified their plant according to the season to maximize the soil nutrient as shown in Table 2. However, two thing that pose as a limit includes the differences of temperature occur between mountain to the next and the mountain that made of limestone rock only has soil thickness often <1.5 m depth.

In area other than limestone, people try to minimize the used of inorganic pesticide by using environmental friendly pesticide made of local plant. Some plants under Fabaceae family or a mixture of garlic, chili, ginger and alcohol that can be used as pesticides. Through time they also realise the latex of this plant have several purposed as well. However, the effectiveness of this pesticide on reside in the mountain area as most of the local started to plant this plant in nursery for long term use.

**Adaptation strategies for mountain people:** Recommendation for adaptation strategies at the mountain region look at the possibilities of understanding the ecosystem as a basis. This take into consideration the connection between the environment (past, present with the human as stated by Feenstra (1998) and by Institute of Meteorology, Hydrology and Environment (IMHE, 2011). Although, the objectives of thriving at the

Table 1: Seasonal crop and livestock breeding calendar of Da Bac District

Months	1	2	3	4	5	6	7	8	9	10	11	12
Paddy	-	-	-	x	x	x	x	x	x	x	-	-
Maize and potato	-	-	x	x	x	x	x	x	x	x	-	-
Sugarcane	x	xx	x	x	x	x	x	x	x	x	x	x
Cassava	x	x	x	x	x	x	x	x	x	x	x	x
Canna tubers	-	x	x	x	x	x	x	x	x	x	-	-
Pig	x	x	x	x	x	x	x	x	x	x	x	x
Buffalo	x	x	x	x	x	x	x	x	x	x	x	x
Cow	x	x	x	x	x	x	x	x	x	x	x	x
Fish	x	x	x	x	x	x	x	x	x	x	x	x

Table 2: Vulnerability matrix show the number of exposure of the natural factors against the sensitivity of the livelihoods

Priority	Exposure level of the natural factors						Total
	Landslide	Flood	Storm	Tornados	Drought and prolonged hot	Extreme cold	
Cultivation	1	3	2	2	3	3	14
Livestock	1	2	2	0	2	3	10
Aquaculture	1	3	2	2	2	2	12
Others (hired labourer, building assistants, sale, etc.)	2	1	1	0	2	1	7

challenging environment ecosystem particularly mountain area will bear the same theme posed by Ballarin-Denti *et al.* (2013) to increase in the resilience of human activities and ecosystems to prevent or minimize the unavoidable impacts in the short-run (adaptation actions) the approach will slight difference as observed in this case study based on the amount of communities exposure towards information. The local communities are lack of exposure to information related to climate change, natural disaster, government policies or local planning despite the existence of widely active medium such as television and radio. Currently, the local communities are well connected with 45 broadcasting stations, 934 fixed telephones, 20,200 active mobile and 1,000 internet subscribers in the Da Bac District. The dissemination of information among local particularly individual who will take all the decision (e.g., crop selection, equipment purchase, skills training, contingency planning) should increase to be more adaptive to their environment and be more resilience.

According to Ballarin-Denti *et al.* (2013), vulnerability and adaptive capacity are context-specific, depend on the interaction of many socio-ecological factors and processes. Thus abilities to reduce exposure, recover from negative impacts or take advantage of opportunities of climate change impacts can be developed locally. In this case, government and local agencies even the NGOs can empowered the local community through continuous work of capacity building. Beside the government agencies the active NGO's such as WB, JICA and INGO should includes adaptation towards climate change in their national target programs such as: program for hunger alleviation and poverty reduction or partnering with oxfam international, since 1993 and action aid through their programme for supporting development of Da Bac, to improve livelihoods for people living in rural areas,

especially ethnic minorities and women; reduce vulnerability and increase adaptability to disasters and climate change; empower communities and civil society to take part in public policy, the social and economic development of the country, a strengthened governance (rule of law) and government accountability (MNRE, 2012; Phan, 2012; Oxfam, 2012).

In the case of Da Bac District government aid particularly installing several weather station in several location that shown anomal in tempreture such as Dong Nghe commine (the most coldest place at the mountain area) at Da Bac town (the warmest place at the mountain area) at Tan Pheo (the most common temperature-should be put back into operation) and at the natural reserved area. These various location will give better understanding or real weather changes and more locallized adaptation strategies.

Government agencies, local stakeholder and local communities are the people who will be able to change their adaptation approach. Since, climate change impacts happen locally and affect local livelihood, economic, health and social aspects by means of localized phenomena in response to local geographical, environmental, economic, social and political factors.

Da Bac District already taking prevention measure of of natural disasters by approving the plans for prevention and control of natural disasters by 2020 in 2015. Consequently, 95% of interviewed participant has reported their involvement in training on forest fire prevention. Training on prevention should be continuous and extended to climate change disaster related such as landslide, drought (prolong hot) and tornados. The lack of incharge officer can be tackle using existing measure implemented for flood and storm department by getting supported from the local people through commitee at the commune and district level.

At the level of local stakeholder, district leader can play greater role in promoting forest conservation as the component have been emphasis within land use planning and implementation by adding to the existing land requisitioned by the government that turn to create protected forest (48.2%), productive forest (43.2%) and just 8.5% is allocated for perennial crops. These protected forest will be add to greater genetic pull for diverse tropical forest ecosystems and rich vegetation to the existing Phu Canh nature reserve with 5,647 ha. Beside, the forest reserve also play a role of water catchment, provide forest services to people and animal and also a buffer to protect the people from storms and tornadoes.

Local government also can utilised the influence within land use planning by taking into consideration the topography of Da Bac District that aligned with the Black (Da) river with large water availability. There are two large hydroelectric plant along this river, Hoa Binh Dam was completed in 1994 and Son La Dam was completed in 2012. Construction of the Lai Chau Dam in the Muong Te District along the same river was started on January 5, 2011 will further leave the vast flooded area. The flooded area already been used as commodities for tourism utilize the scenic view along the river and the abundance of life for recreational fishing and services related to this industry as well as expansion of small scale aquaculture industry will be another income alternative.

## CONCLUSION

This study identified climate change impact in this region are originated from the global warming intensified by their location at mountainous area and human induced activities. Global warming manifested in the area in the form of changing trend in the temperature and intensified frequencies of natural disaster. Current record of temperature increase of 2.88°C is according to the nearest and existence meteorological station located at 198 m above sea level, probably not representative to the real mountain ecosystem that experience changes in temperature from mountain to mountain. The installment of meteorological system in the selected area will give more accurate and probably higher increase in temperature as noted by the local. The impact of climate change upon the mountain communities deepened the difficulty of life that exist with limited livable area on mountain slope and narrow flat valley in between the peaks, minimal running water or lack of natural drainage system, unpredictable and intensified frequencies of landslide,

flash flood, cyclones, drought, prolong hot season and extreme cold. All these disastrous event and human activities added to the changes in the seasonal crop calendar, trigger a rising of pests, killing the livestock and amount to a great loss of productivity definitely leave this people in the dire situation.

In the light of climate change impact upon livelihood of the people particularly the most fragile is undubitable it is pivotal to alert them of the need for adaptation in the rapid changing environment. Increase awareness programme on the impact via mass media and capacity building on the prevention, adaptation and mitigation of climate change through workshop and training courses is crucial to the local communities. Additionally, the role played by the government, local stakeholder and local communities in charting their adaptation strategies are crucial to the future of the local people in this mountain region.

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