



Climate Change Impact Assessment on Agriculture of Hanoi Rural Area

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Abstract

Vietnam is among the most vulnerable nations to climate change impacts. Climate change (CC). CC which can lead to serious impacts on production, life, environment on a global scale, is one of the biggest challenges to human beings. According to some data and information collected from surveys and reports, CC in Hanoi rural area is shown by higher temperatures, the decrease of precipitation and extreme weather events which can bring about negative effects on agriculture and high risks to industry and social as well as economic systems in the future. CC has been continued leading to comprehensive and deep changes in global development and security, especially agricultural products such as livestock, cultivation, and aquaculture in Hanoi rural areas.

Keywords: Climate change, Agriculture, Breeding, Cultivation, Aquaculture, Rural area, Hanoi

1 Introduction

In the 21st century, climate change is considered to be the human's biggest challenge. Over the past few years, due to climate change, the frequency and intensity of natural disasters have increased, causing great human and property losses, damaging socio-economic and cultural infrastructure, and imposing negative impacts on the environment. The approach to studying climate change impacts is a way to achieve the sustainable development goals applied in many countries. Especially in the context of international efforts to mitigate and adapt to climate change in general and urbanization in developing countries like Vietnam particularly, the impact of climate change in rural areas is an urgent issue that needs proper attention.

In Vietnam, CC has strong effects in regions, fields, and regions, especially agriculture – rural areas, natural resources, and environment; coastal areas and two plains; farmers, the poor and their livelihoods. With an important role as a green corridor for inner-city areas, rural areas along Hanoi's suburbs are known as one of the sensitive environments and greatly are affected by environmental changes. The main cause of global CC is the rise of activities generating greenhouse gas emissions, overexploitation of sinks and greenhouse gas tanks such as biomass, forests,

marine, coastal and land ecosystems. Therefore, it is necessary to study the effects and impacts of CC in rural areas along the outskirts of Hanoi in order to have appropriate solutions or strategies promptly. Study area: The study area is Hanoi rural area which includes 17 districts and 1 town locate in the central region of the Red River Delta, Hanoi; bordering with Vinh Phuc and Thai Nguyen province to the North; Ha Nam and Hoa Binh to the South; Bac Giang, Bac Ninh, Hung Yen to the East; Hoa Binh and Phu Tho to the West. After the administrative boundary expansion in August 20018, the city covers an area of 3,324,92 km², located on both sides of the Red River, mainly on the right bank. The topography of Hanoi gradually lower from the North to the South and from the West to the East with the average height of 5 to 20 meters above sea level. 3/4 natural area is plain, locating on the right bank of the Dam river on both sides of Red River and tributaries of other rivers. The area of hills and mountains is mostly in areas of My Duc, Quoc Oai, Soc Son and Ba Vi districts, and which lower than 1000m.

Hanoi's climate is typical of the Northern region with a tropical monsoon weather, the average rainfall is quite large, about 114 rainy days per year. A characteristic feature is the change and difference of hot and cold season: the summer

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which lasts from May to September is hot and rainy with an average temperature of 29°C and the winter is cold and less rainy occurring between November and March of next year, and the end of the wet season with drizzle and $19,6^{\circ}\text{C}$ is the average temperature. Along with transition periods in April and October, Hanoi has a total of 4 seasons: spring, summer, autumn, and winter. Hanoi belongs to the tropics receiving abundant solar radiation all year round, high temperature and abnormal changes such as in May 1926 with a record high temperature of $42,8^{\circ}\text{C}$ while the lowest temperature is $2,7^{\circ}\text{C}$ in January of 1995.

The percentage of annual average relative humidity in Hanoi fluctuates from 83 to 85, moreover, the highest and lowest daily humidities are 98% and 64% respectively. Three months of summer are the wettest period with an average humidity of about 87% - 89% while the last months of autumn and early winter are the driest, the humidity can be below 80%. The average annual evaporation volume between the regions from 800mm to less than 1000mm. The first months of the rainy season (from May to July) have the largest amount of evaporation of the year, however, the last months of winter and spring (from January to April) have the lowest amount of evaporation with drizzle and high humidity. Hanoi has quite a heavy rainfall compared to other provinces in the Northern Delta, especially in the mountains. Ba Vi is the largest rain area in Hanoi because the average total rainfall is 2100mm while the least rain area is the Day dam, which is only 1500mm. In the delta area, the rainfall increases gradually from the North to the South with a relatively regular number of rainy days, about 130 to 140 days a year. Daily rainfall reaches 300-550mm and can increase to 5-15% in 2050 and 2100 according to the climate scenario (7).

Livelihoods are simply understood as a means to ensure human life. Livelihoods can be viewed at different levels, with the most common being household-level livelihoods (3). The main sources of livelihood of Hanoi people are agriculture, forestry, fishery, industry – construction and services. Among those living in a rural area, livelihoods from agriculture, forestry, and fishery play an important role and are the main source of family income. The sustainability of community livelihoods depends on many factors such as: the ability to equip capital, labor qualifications, relationships in the community and livelihood development policies (5). In Hanoi, the impacts of CC in recent years have been greatly affected the cultivation, husbandry and aquaculture industries.

The challenge condition of livelihood in Hanoi rural area that has possibility being impacted by the climate change trigger the need to study and understand the climate change extensively and identified the depth impact to the area. This take into consideration the connection between the environment (past, present) with the human as started by Feenstra (6). 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 (1,2,4,9,12,13,16).

2 Materials and Methods

The study carried out using Report “Weather and hydrological characteristics of Hanoi area in 2016, 2017, 2018”. The result 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 station and rain gauge station at Hanoi rural area (14).

These data were analyzed 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 is beneficial in this study and most of the event supported by documented evidence. The field observation was focused on the livelihood of breeding, cultivation and aquaculture changes observed by several researchers of various expertise. Field observation is pivotal in confirming the condition and the obvious site evident of the impact or changes. More gradual of subtle evidence of climate change impact was assessed by social and economic situation report and flood prevention report of Hanoi, especially between 2014 and 2018 (15).

3 Results and Discussions

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

Changing trend of some climate factors: By analysis of data on the annual average temperature, Hanoi's maximum temperature at three meteorological stations: Lang, Ba Vi, Ha Dong shows the temperature tends to gradually increase over 44 years from 1975 to 2018 which is appropriate with “The Climate change scenario and sea-level rise for Vietnam – MONRE 2016” (10).

According to the source of the hydro-meteorological data center, the average annual temperature obtained at Lang meteorological station from 1975 to 2018 has a fluctuation from $22,9^{\circ}\text{C}$ to $25,4^{\circ}\text{C}$. The equation depicts the annual heat as follows: $y = 0,0376x + 23,332$ ($R^2 = 0,5209$). The given chart below describes the upward trend of maximum temperature during Summer from $32,0^{\circ}\text{C}$ to $41,7^{\circ}\text{C}$ of Ba Vi meteorological station between April to September from the year 1975 to 2018.

On the other hand, the trend of temperature increase if more clearly shown by the decline of rainfall recorded in the average annual rainfall and the number of rainy days in the region from 1975 to 2018. The annual rainfall movement is downward trend, particularly the average annual rainfall at Ha Dong station tends to grow, showing an unstabilized change in rainfall among areas in Hanoi. The total number of rainy days of Lang, Ha Dong and Thach That station tends to

increase. Accompanying the report “Weather and hydrological characteristics of Hanoi area” from 2016 to 2018, it shows that the rainfall in Hanoi tends to be in shortage, leading to the lowest water level in the Red and Day River could drop to 0,4-0,6m in February and March each year, causing local water shortages and significant impacts on human activities, changing the seasonal calendar, crop structure, productivity and quality of crops such as rice, maize and sugarcane.

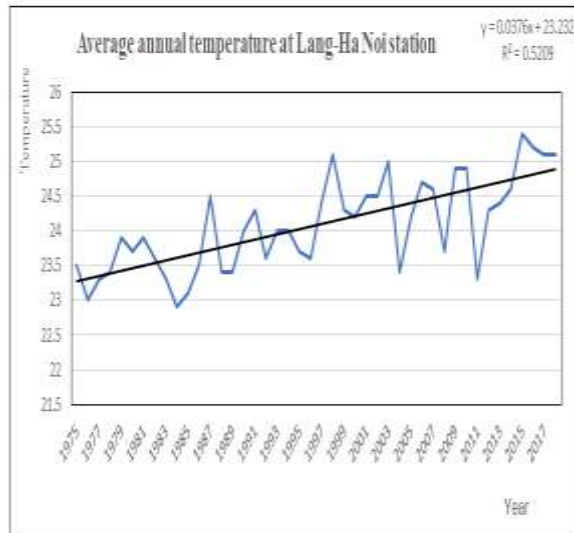


Figure 1: The average annual temperature of Lang meteorological station from 1975 to 2018

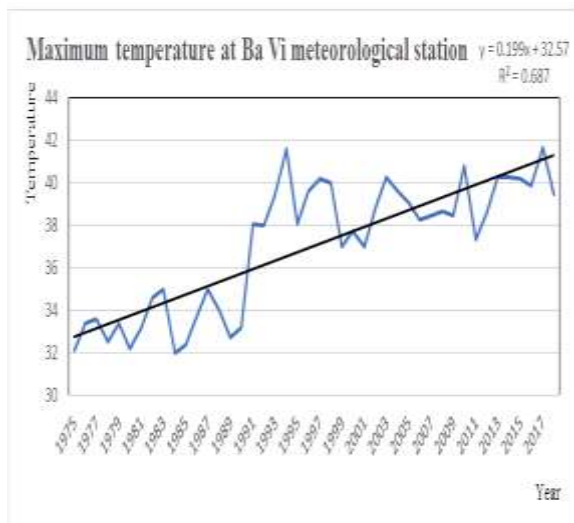


Figure 2: The maximum summer temperature of Ba Vi meteorological station from 1975 to 2018

It has a strong impact on the livelihoods of the community, especially the poor and vulnerable households (14). According to, the report by Ministry of Agriculture and Rural Development, Institute of MARDIAE and supported by research on climate change in Vietnam by Nguyen this extreme drought is the evident of CC in the country (8, 11).

Typically, the average annual rainfall and total number of rainy days in the year is lower from 1975 to 2018 shown in 2 line graphs below.

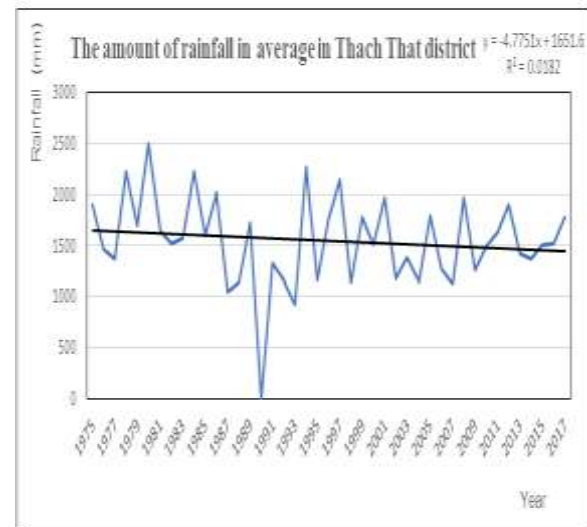


Figure 3: The average total annual rainfall of Thach That rain gauge station from 1975 to 2017

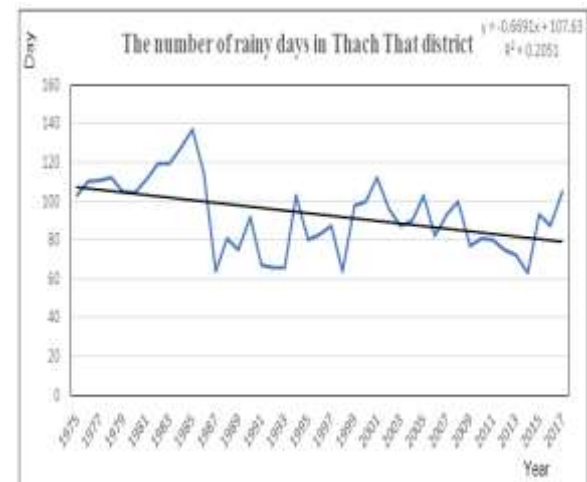


Figure 4: The total number of rainy days in the year of Thach That rain gauge station from 1975 to 2017

Extreme weather events: Community surveys combined with collecting data from the reports “Weather characteristics, hydrology in five areas of Hanoi” (from 2016 to 2018) shows that extreme weather events due to the impacts of CC related to meteorology and hydrology have abnormal changes, significantly affecting the livelihoods and activities of the people, especially poor households (14). These phenomena have been occurring in Hanoi with increasing frequency and intensity in recent years.

Deep freeze, severe cold in recent years usually occurs from December of previous year to March of next year, the temperature drops to below 10°C , the duration of prolonged periods is usually 4-7 days affecting the activities and life of households with young children, the old and households

lacking knowledge. Moreover, the heat often occurs from May to August every year, the highest temperature sometimes up to 42.5°C affecting life, health, activities and labor productivity, production of people in rural areas.

In addition, Hanoi often suffers from typhoons and floods occurring from May to August in about 4 – 5 days, and unexpected floods, strong winds, strong rainfall caused losses to households and neighbors and arable land near rivers. In recent years, there have been more heavy rains, unseasonal heavy rains, and floods have become more frequent with the frequency of 5-7 years. Floods and heavy rains not only affect daily life but also cause economic losses. In 2018, for example, the spillway caused prolonged flooding, thousands of households evacuated from their homes, and crops and livestock suffered heavy losses in many communes in Chuong My district.

Livelihood sources of citizen in Hanoi: Livelihood from agriculture, forestry and fishery plays an important role and is the main source of income for rural households in Hanoi rural areas from Report on social and economic situation 2014 – 2018. According to the table 1 from the Report on social and economic situation 2014 – 2018, agriculture, forestry, and fishery groups have a slower growth rate than the general growth. The process of urbanization, CC and extreme weather events (heavy rain, prolonged cold weather, etc.) have directly affected agricultural production, causing the added value decline causing the decrease of the growth rate of the region I continuously (15).

CC impacts on agricultural production: CC in Hanoi affects productivities, crop quality, even many crops are almost lost. In 2014, the effects of typhoons and tropical depressions caused moderate to heavy rainfall causing 14,732 hectares of rice to be overturned, over 36 hectares of fruit tree crops were affected and 633 hectares of other crops were crushed and broken. In 2015, the weather was unpredictable, the Winter-Spring crop sowed with warm sunshine, high average temperature, so when the rice paddy was completed, it grew up quickly until tillering, and then less rainfall together with local pests caused rice productivity decrease by 0.4% and sweet potato by 4.4% compared to the same period of past year.

Table 1: Main livelihood source of people in Hanoi

Crops (Unit: Hectare)	Total rice area	Corn	Sweet potato	Soybean	Peanut	Others	Old trees
2018	387,546	16,888	2,614	3,299	2,741	33,160	22,634
Breeds (Unit: Thousand individuals)	Pigs breeding	Poultry breeding	Buffalo breeding	Cattle breeding			
2018	1,772	31,500	25,500	136,000			
Aquaculture (Unit: Hectare)	Aquaculture area	Fish	Shrimp	Others			
2018	29,666	104,344	77	240			

Source: (15)

In the following year, extreme hot weather appeared, after that heavy rain caused widespread inundation, most of the suburban districts of Hanoi were damaged. 4 districts of Quoc Oai, Chuong My, Thach That and Phuc Tho have more than 275 hectares of rice and 907.4 hectares of winter crops were damaged; 76.8 hectares of fruit trees were flooded and

1 hectare of vegetables was deeply flooded. In 2018, the winter happens continued for many days, causing the process of cultivation to slow down compared to the seasonal framework, causing 8,478 kg of sowed rice and 163.1 hectares of transplanted rice to die. In addition, there are heavy rains in the rainy season, appearing suddenly and lasting on a large scale, making 5,684 hectares of crops, rice and fruit trees damaged in Quoc Oai, Ba Vi, Phuc Tho, and Chuong My districts.

In order to adapt to the flooding situation in the rainy season, the Hanoi Department of Agriculture and Rural Development has directed to accelerate the planting progress, implement the conversion of crop and livestock structure in low-lying areas to minimize the damages caused by floods. In the Winter-spring 2016 crop - the time Hanoi was greatly affected by climate change, the water slowed down compared to the year leading to rice and vegetables extending the growth period, fruit trees producing late-bearing fruit, localities were promote restructuring of crops, seasons, planting of summer vegetables and crops, and facilitating the expansion of the area of early winter crops, the thermophilic group will have higher yields and economic efficiency.

The impacts of CC directly affect productivity, production, and structure, not only for crops but also for livestock and aquaculture. Deep freeze, severe cold, and prolonged heavy rainfall caused both local floods and storms combined with major impacts on the number of cattle, poultry productivity and aquaculture area making difficulties for the livelihoods of most people in some suburban districts.

Table 2: Summary of crop losses by the impact of natural disasters occurring in Hanoi from 2014 to 2018

Year	2014	2015	2016	2017	2018
Impact factors	Rain and floods	Deep freeze and severe cold	Extreme hot weather	Deep freeze and severe cold	Rain and floods
Impact level	Heavy rain occurred at night on September 10/9/2014 in Thach That causing pipe floods, flash floods in mountainous communes	Lasted in a long period	The number of days lasted the temperature is from $38-40^{\circ}\text{C}$	There was a record cold occurring below $5-4^{\circ}\text{C}$ in Ha Dong. Ice and snow appeared in Ba Vi.	25/8/2016 rain with large amounts of water; 27/7/2016 the first storm caused heavy rain with heavy rainfall and strong winds

In 2016, due to the impact of the deep freeze, severe cold in early March 2016, 480 tons of fish were killed, estimated losses of nearly 15 billion VND. In 2017, heavy rain lasted in October 2017, causing 4,288 hectares of aquaculture submerged (Ung Hoa 2,982 hectares; Quoc Oai 325 hectares). It is estimated that losses range from 100 million VND to several hundred million for families with large scale aquaculture models. More than 8,400 ducks were killed and lost, and 325 and 126 hectares are lost in My Duc and

Chuong My respectively; thousands of cattle and poultry died. In 2018, heavy rains lasted on July 2018, causing 102 hectares of aquaculture and 2,242 m^3 of cages for fish farming district damaged or lost in the river of Ba Vi; both Quoc Oai and Chuong My districts had 1,013 hectares of aquaculture damaged and nearly 109,200 cattle and poultry died and swept away.

Table 3: Summary of losses in the livestock and aquaculture sectors under the impact of natural disasters in Hanoi from 2016 to 2018

Year	2016	2017	2018
Impact factors	Deep freeze and severe cold	Rain and floods	Rain and floods
Impact level	Cold weather lasted low temperatures below 10°C.	Heavy rains lasted in October 2017.	Heavy rains lasted in July 2018.

4 Conclusion

This study has identified the climate change impact in Hanoi rural area which originated from global warming intensified by their location in rural areas and human-induced activities. Climate change manifested in the form of changing trends in temperature, the amount of rain and intensified frequencies of natural disasters. Current record of reach to 42.5°C is according to Ha Dong in summer in the year of 2017. The installment if the meteorological system in the selected area will give a more accurate and probably higher increase in temperature as noted by the local. The impact of climate change upon the rural communities deepened the difficulty of life that exist with limited livable area, the decrease of productivity and quality of crops, damage of livestock and aquaculture, minimal running water of lack of natural drainage system, unpredictable and intensified frequencies of landslide, flash flood, cyclones, drought, prolong hot season and extreme cold. All these disastrous events 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 off productivity definitely leave these people in the dire situation. In the light of climate change impact upon livelihood off the people particularly the most fragile are indubitable, it is pivotal to alert them of the need for adaptation in the rapidly changing environment. Increase awareness program on the impact via mass media and capacity building on the prevention, adaptation, and mitigation of climate change through workshops and training courses is crucial to the local communities in Hanoi rural areas. 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 Hanoi rural area.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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