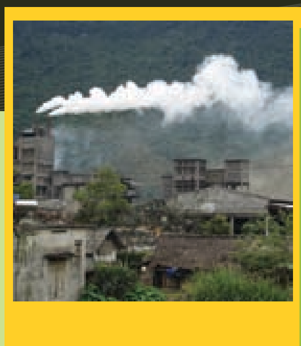
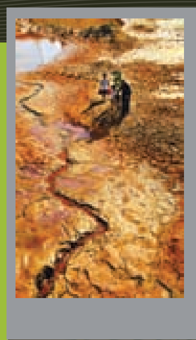
Institute of Strategy and Policy on Natural Resources and Environment

Ha Tinh Assessment Report on Climate Change



Ha Noi, 2009

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Institute of Strategy and Policy on Natural Resources and Environment

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"*Ha Tinh Assessment Report on Climate Change*" has been published by the Institute of Strategy and Policy on Natural Resources and Environment, Viet Nam, with technical and financial support from the United Nations Environment Programme (UNEP).

ISBN: 0-893507-779131

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Graphic, Layout and Printing: Kim Do Publishing House, Viet Nam

Van hoa - Thong tin Publishing House

Publishing permission number: 270-2009/CXB/21/06-14/VHTT.

Acknowledgement

The Institute of Strategy and Policy on Natural Resources and Environment would like to express our gratitude to the United Nations Environment Programme for both technical and financial assistance in preparing this report.

Our sincere appreciation is extended to all the concerned institutions who provided data, and scientific and technical information, including supporting documents used for the analysis and assessment. We would like to express our sincere thanks to the organizations and experts who contributed to the completion of this report.

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Foreword

ISPONRE's Director General

Climate change is affecting the lives of humans across the globe, including in Viet Nam. Together with temperatures increase and the sea level rises in the last decades, Viet Nam is likely to be one of the countries most adversely affected by climate change.

Locating in a coastal area of Central Viet Nam, Ha Tinh province experiences severe climatic conditions, including extreme weather events, such as storms, hot dry westerly winds, drought, heavy rain, and floods. Climate change is likely to impact seriously on agriculture, fisheries, forestry, biodiversity, water resources, and other key economic sectors in Ha Tinh.

The Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), under the Ministry of Natural Resources and Environment (MONRE), has, in collaboration with national and international experts, been primarily responsible for preparing the Ha Tinh Assessment Report on Climate Change, within the technical assistance framework of the United Nations Environment Programme (UNEP). This is the report typically developed under the guidance of the UNEP, with a view to providing an overview of climate change, analyzing climate change scenarios, assessing potential impacts of climate change on all sectors, and outlining strategies and measures for dealing with climate change in Ha Tinh province. The main contents of the report include: (i) Natural and socio-economic features of Ha Tinh; (ii) Natural disasters and impacts on Ha Tinh; (iii) Overview of climate change in Ha Tinh; and, (iv) Climate change impacts, mitigation and adaptation policies and measures for climate change in Ha Tinh. The purpose of the report is to provide some basic information and knowledge of climate change to policy-makers, environmental researchers and managers, and other professionals working in climate change related fields.

ISPONRE wishes to express its sincere thanks to UNEP for its financial and technical support, and to national and international experts and relevant agencies and organizations for their contributions to the development and refinement of the report.

Dr. Nguyen Van Tai

Director General
Institute of Strategy and Policy on Natural Resources and Environment
November 2009

Foreword

UNEP'S Representative for the Asia and the Pacific

The United Nations Environment Programme (UNEP) is mandated to regularly assess major environmental developments and trends. This mandate is implemented through the Global Environment Outlook (GEO) process, which involves global, regional, subregional, national and city-level assessments. The GEO process is participatory and consultative, with capacity-building at its core. This results in scientifically authoritative information for environmental management and policy development tailored to a wide target audience. The Ha Tinh Assessment Report on Climate Change is one of the outputs of this capacity-building programme, conducted by the Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), and Ha Tinh Provincial Authority. The purpose of the report is to assess climate change impacts, to inform decision makers so that they understand the need for urgent action, and to mobilize public awareness and participation.

The Report highlights the trend in observed climate during the past 100 years in Ha Tinh Province, outlines future scenarios, and also includes the potential impacts of projected regional and local climate change on water resources, aquatic products, forestry, biodiversity, agriculture and other key economic sectors. It also reviews the vulnerability of ecosystems that are likely to be at risk from climate change. Ha Tinh is one of the North Central coastal provinces of Viet Nam, occupying about 1.8% of the total area of the country. Agro-forestry is an important socio-economic activity, with total production in 2006 valued at 6,424 billion VND (US$359 million), and an average annual GDP growth rate of 15.63% in the period 2001-2006. Most coastal provinces in Viet Nam are affected by tropical low pressure, cyclones and storms. Over the past 50 years, 47 storms have affected Ha Tinh, extending from Quynh Luu (Nghe An) to Le Thuy (Quang Binh), of which 18 storms hit the province directly. Peak storm frequency has been reported in August and September (54%), followed by in July and October (30%). Between 2000 and 2008, the total economic loss suffered by the Province due to infrastructure damage from tropical cyclones has been estimated at up to 2,697 billion VND (US$150 million).

Based on the scenarios developed, under the A1FI emission scenario, the rise of surface air temperature in Ha Tinh Province during the 2050s and the 2090s is projected to be in the range of 1.4-1.8^{0}C and 3.5-4.2^{0}C respectively. Total rainfall during the rainy season in Ha Tinh Province is projected to increase by 5-8% by the 2050, and 13-19% by the year 2100, whereas total rainfall during the dry season is projected to decrease by 1-5% by the year 2050 and 3-12% by the year 2100. Sea level rise along the Province's coastline is projected to be about 30 cm by the year 2050 and 65 cm by the year 2100. This translates into a rise in sea level of 6-7cm every decade, or 0.6-0.7cm every year. Finally, particular recommendations are made regarding coastal traffic, which needs to monitor and take into account the projected sea level rise. Mountain infrastructure, especially the North-South railway, will be at risk from increased flooding, flash floods and associated landslides in the mountain areas in the South West. All mineral extraction and industrial production in the coastal plain would suffer from an increase in storm frequency, flooding and the rise in sea level. The vulnerability of all socio-economic activities to climate change, especially the coastal regions is likely to increase in the future.

UNEP's Medium-term Strategy (2010-2013) directs the organization to strengthen the ability of countries' to integrate climate change responses into their national development processes, supported by scientific information, integrated climate impact assessment and local climate data. I believe this report responds to this mandate and provides important information and policy options for the government of Ha Tinh Province, Viet Nam, through MONRE, to help sustain the quality of life and livelihoods of the province's residents.

Young-Woo Park

Dr. Young - Woo Park
Regional Director and Representative
United Nations Environment Programme
Regional Office for the Asia and the Pacific
November 2009

Acronyms

CC	Climate Change
CMHE	Center for Meteorolory, Hydrology and Environment
GEF – SGP	Global Environment Facility's Small Grants Programme
GHG	Green House Gases
GEO	Global Environment Outlook
IPCC	International Pannel on Climate Change
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
IMHE	Institute of Meteorolory, Hydrology and Environment
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP/ROAP	United Nations Environment Programme - Regional Office for Asia and the Pacific

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Natural and socio-economic features of Ha Tinh province

1.1 Natural features

Ha Tinh is one of six provinces situated in North Central coastal provinces with the total area of 6,026km^2, occupying about 1.8% of the total area of the nation, within the geographic co-ordinates of 17^{0}54' -18^{0}38' latitude North, 105^{0}11' - 106^{0}36' longitude East. Ha Tinh borders Nghe An to the North, Quang Binh to the South, Lao People's Democratic Republic to the West and the East Sea to the East, with more than 137km of seashore.

Located in the East of Truong Son Bac range, topography of Ha Tinh slopes from the West to the East with the average slope of 1.2%, forming three adjacent natural geographic zones: high mountainous zone; hilly, moutainous zone and coastal plains.

The West mountainous zone has rather high peaks, the highest one is Rao Co with the height of 2,235m. Hilly and mountainous zone where Ngan Sau and Ngan Pho River flow through is about 200-300 m in height. Coastal plains along Highway 1A is separated by some mountains close to seas, estuaries, gulfs, and bays.

There are two main soil categories in Ha Tinh:

- Coastal plain soil includes sand dunes, sand banks (38,222ha), saline soil (5,140ha), saline and acidic sulfate soil (17,265ha), alluvial soil (103,201ha), soil near hills and mountains (12,963ha).
- Mountainous soil includes yellow brown feralit soil on the old alluvial mound (6,135ha), yellow grey feralit land growing on claystone (148,642ha), yellow grey feralit land growing on sandstone (27,716ha), yellow grey feralit soil developed on granite rock, riolit soil (29,720ha), feralit soil on high mountain (155,261ha) and grain bareness erosive feralit soil (34,724ha).

Apart from the two soil categories, there are also 23,376ha of rivers and streams, ponds and lakes, rocky mountains without vegetation cover.

Ha Tinh has monsoon tropical climate of a coastal province which totally lies in the internal tropic.

In Ha Tinh, regardless of high or low zones, there is high solar altitude, uniform illuminating time, the ideal total radiation amount is up to 230-240 kcal/cm^2/year. It is even up to 23-25kcal/cm^2/month. Due to the influence of the real total radiation cloud is about 140-160kcal/cm^2/year, radiation balance is around 80-90 kcal/cm^2/year.

Atmospheric circulation in Ha Tinh is a component of the monsoon circulation in Viet Nam, which not only has close relation with South Asia monsoon, especially in summer, but also is affected by East Asia monsoon, especially in winter. In winter, each month has 2 to 4 occasions when the cold air moves to, the temperature decreases 2-4^{0}C on average each time; there is more rain in the first half of the season and drizzling rain in the second half of the season. In summer, there are about 15 to 22 occasions when dry hot weather is dominant generally at the beginning and middle of the season, about one storm and synoptically active inter-tropical convergence zone occur at the end of the season, lasting to the early winter causing heavy continuous or intermittent rains.

Average wind speed is about 1.5 to 2.5m/s; the strongest wind recorded in a storm is up to over 40m/s, and may even approach 48m/s in some places.

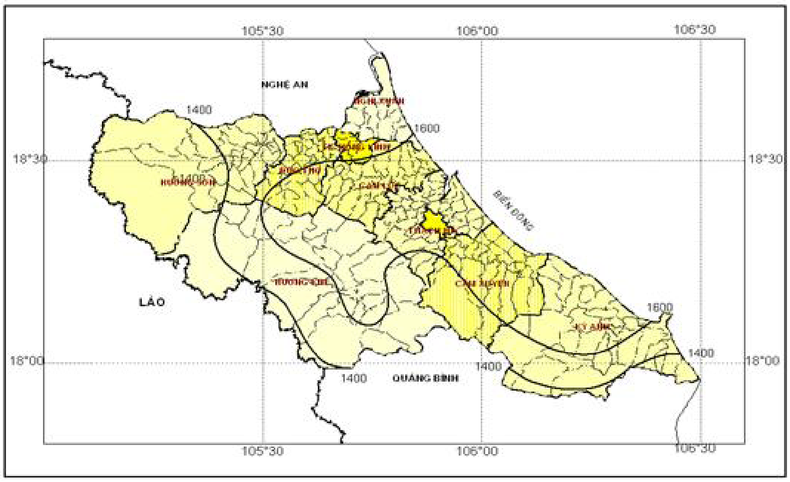
Every year, there are 1,350-1,700 sunshine hours on average. Sunny season lasts from April to September, and early October. In several months of the season, there are dry, hot westerly winds with over 200 sunshine hours each month.

Average annual temperature in the low mountainous plain area is about 23.5 – 24.5^{0}C which decreases to 14-15^{0}C on high peaks like Rao Co. The highest temperature is over 40^{0}C, and in some places it increases to 42.6^{0}C in April, May or June. The lowest temperature is around 7^{0}C, in some places it decreases to 0.7^{0}C normally in December and January. Cold season only lasts for 3 months: December, January, and February and hot season lasts for 6 months from April to September.

Average annual rainfall is about 2,300-3,000mm while the highest rainfall is reported up to 3,800-4,400mm. Rainy season lasts from April-May to November-December. It usually starts early; however, it is interrupted in between at several times in June and July due to dry, hot westerly winds.

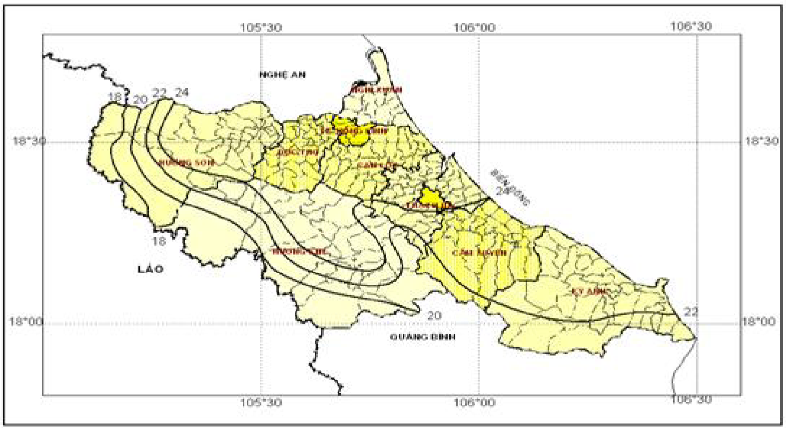
Average annual evaporation amount is within the range of

Figure 1.1. Distribution of average annual sunshine hours - Ha Tinh province



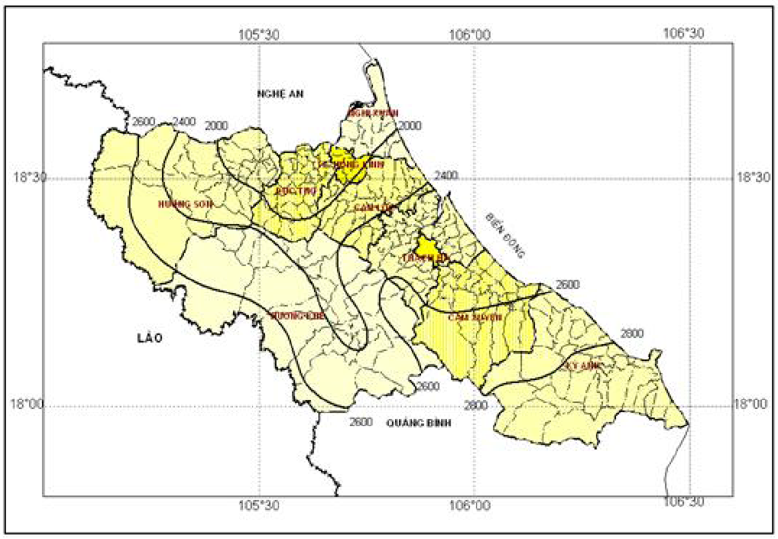
Source: Institute of Meteorology, Hydrology and Environment

Figure 1.2. Distribution of annual temperature - Ha Tinh province



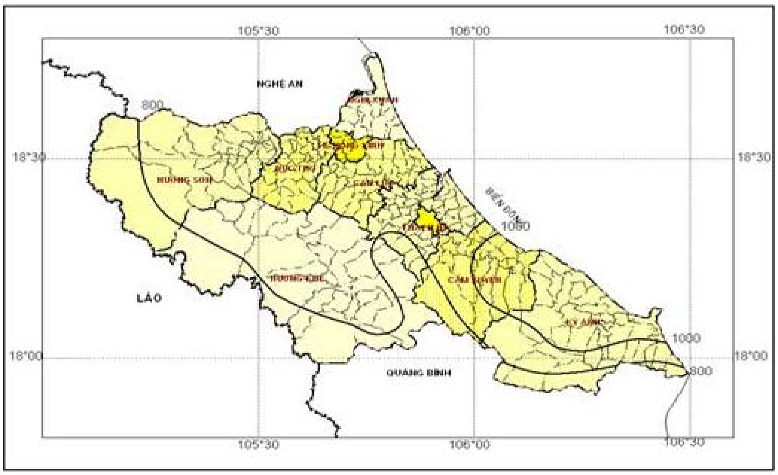
Source: Institute of Meteorology, Hydrology and Environment

Figure 1.3. Distribution of annual rainfall - Ha Tinh province



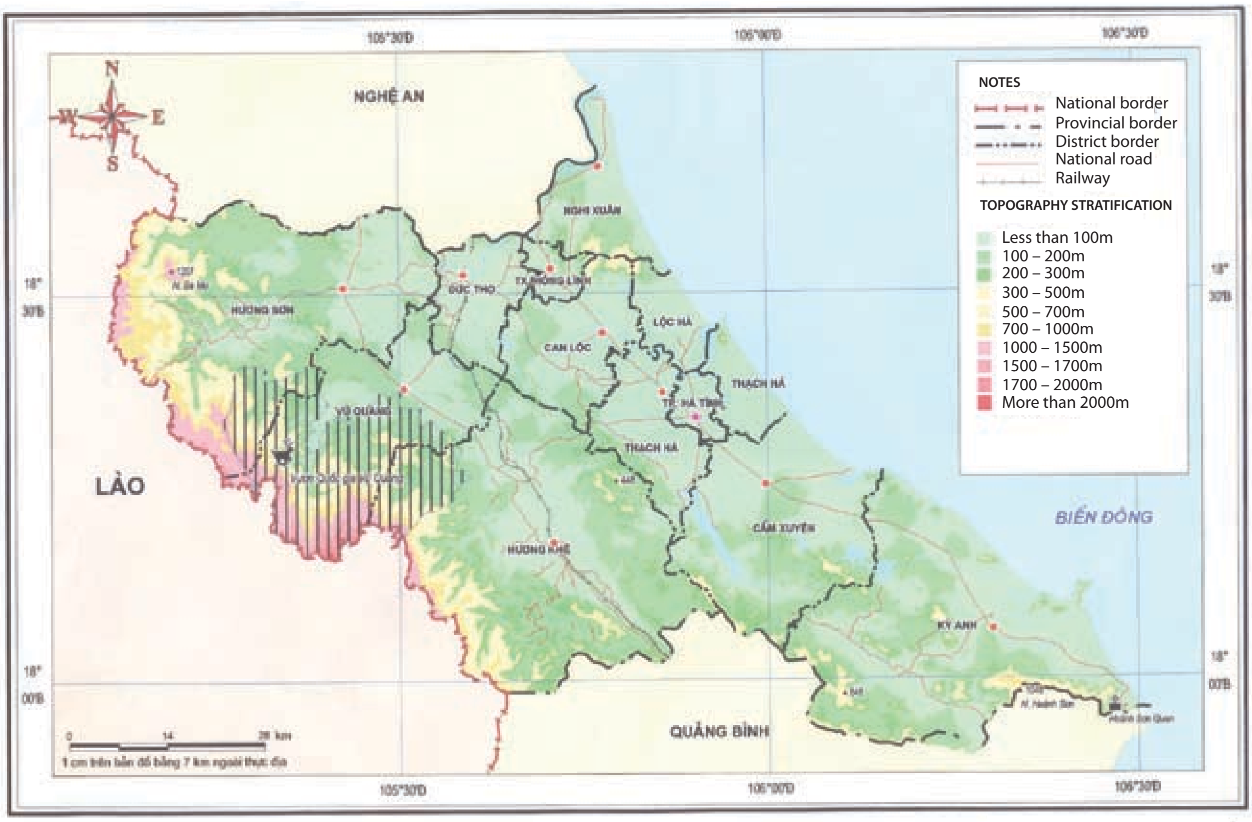
Source: Institute of Meteorology, Hydrology and Environment

Figure 1.4. Distribution of annual evaporation - Ha Tinh province



Source: Institute of Meteorology, Hydrology and Environment

Figure 1.5. Topography stratification map of Ha Tinh province



Scale 1: 700.000

Source: Institute of Meteorology, Hydrology and Environment

800-1,100mm. It does not exceed 100mm in most of the months, except for the higher sunshine months in mid-summer during May, June, July, August.

Annual humidity index is common from 2.2 to 3.3. Monthly humidity index is mostly over 1. It does even reaches up to 10-15 in some months, except for the months when westerly winds are active.

Main disasters in Ha Tinh are storms, dry hot westerly winds, droughts, heavy rains and floods.

Ha Tinh has 13 small and major rivers with the total length of more than 400km. The rivers in Ha Tinh originate from Truong Son and flow to the sea.

Ha Tinh four major river basins are La river, Cua Sot river, Cua Nhuong river and Cua Khau river. La river is made up of Ngan Sau river and Ngan Pho river with the basin area of 3,221km^2. Cua Sot river is made up of Nghen river and Rao Cai river with the basin area of 1,349km^2. Cua Nhuong river is made up of Gia Hoi river and Rac river with the basin area of 356km^2. Cua Khau river is made up of Tri river, Kenh river, Quyen river with the basin area of 510km^2.

Apart from the major rivers, there are some large lakes such as Ke Go, Rac, Cua Tho Trai Tieu lake.

The province has over 300,000ha of forest land, in which dense forest area accounts for 66%, including natural forests (164,978ha), production forests (100,000ha) and protective forests (63,000ha) with the coverage of 39.7%. Ha Tinh also retains some primeval forests with abundant and diversified fauna and flora such as Vu Quang nature reserve, protective forest zone of Ke Go lake.

1.2 Socio-economic features

1.2.1 Current socio-economic features

Ha Tinh has 4 mountainous districts namely Huong Son, Duc Tho, Vu Quang, and Huong Khe and 6 coastal districts namely Nghi Xuan, Can Loc, Loc Ha, Thach Ha, Cam Xuyen, Ky Anh, Hong Linh town and Ha Tinh city.

In 2006, the population stood at 1,280,549 people with more than 5 minorities, mainly the Kinh. Population in rural area accounts for 89% of the total which is higher than 74% nationwide. The population density is 213 people/km^2 which is higher than the average density of the North Central but lower than that of the nation as a whole.

The population is primarily concentrated in the Eastern coastal plain. The people in the labor age are around 702,000. The total number of workers in the economic sectors is 642,700 people most of which are in agroforestry sector (73.8%). Labor force with professional skill is low; the rate of untrained workers is up to 92.7% which is higher than the the national rate of 75%.

The fraction of cultivated land, forestry land, special use land and housing land accounts for 43.60%, 56.40%, 7.55%, and 1.14%, respectively. The unused land is up to 63,415ha, accounting for 10.52% of natural land. Land use coefficient is still low, particularly in the mountainous districts.

Agroforestry production plays an important role in the socio-economic activities. Total value of production in 2006 is 6,424 billions VND, average GDP growth rate in the period 2001-2006 is 15.63%.

In agricultural production, cultivation accounts for over 60% of product value. The main plants is food crops (rice, corn etc.), short-duration industrial crops (bean, peanut, long-duration industrial crops (tea, rubber, etc.) and fruit plants with a variety of valuable specialties such as Phuc Trach pomelos, Bu oranges, sour oranges, sweet tangerines, etc. Main husbandry animals are cattle, poultry and especially deer.

As a result of growth in commercial foresty in recent years, Ha Tinh has reported more than 80,000ha of artificial forests, including eucalypti, acacias, casuarinas, rhamnoneurons and other species in the year 2006.

1.2.2 Socio-economic development orientation

By the year 2020, the main crops grown are still likely to be rice, corn, peanut, bean, rubber, tea, fruit plants (Phuc Trach pomelos, bù oranges, sour oranges), and forestry plants (acacias, eucalypti, rhamnoneurons, casuarinas). Cattle, poultry, especially deer will continue to be the major husbandry animals. There are likely to be about 45,000ha of winter-spring rice, and 40,000ha of summer-autumn and winter rice. Primary agricultural products in 2020 are targeted at about 500,000 tons of grain food; 80,000 tons of peanut, bean; 11,000 tons of dry rubber latex; 700,000 tons of material wood; and 100,000 tons of cattle, poultry etc.

The target in 2020 is set to be around 6,112 billions VND of agricultural production, with 63 millions USD of export.

1.3 Conclusions

1. Ha Tinh lies in the region of monsoon tropical climate with cold winter; the first half of winter has most of the seasonal rain while the second half has only little rain; and hot summer during which dry hot westerly winds are active. Storms and the inter tropical convergence zone are active at the end of the season. There are heavy and continuous rains, especially during the transition

period of the early cold air from hot season to cold season with the penetration towards the South.

2. Ha Tinh has abundant surface water sources with four small river basins from the North to the South; these rivers include La river, Cua Sot river, Cua Nhuong river and Cau Khau river respectively.

3. Socio-economic activities of Ha Tinh province at present and in the near future are mainly agroforestry and fisheries which is highly dependent on the climatic conditions. Therefore, Ha Tinh as well as the Central provinces are very likely to be vulnerable to impacts of climate change.

Chapter 2

Natural disasters and impacts to Ha Tinh

2.1 Storms

Ha Tinh as well as other coastal provinces in Viet Nam are affected by the tropical cyclones and tropical low pressure (generally called storms) which have their origin in the Pacific Northwest and/or in East Sea. Not all tropical cyclones forming in Pacific Northwest and East Sea affect Ha Tinh; nevertheless, the length of the storm season and storm frequency which affect Ha Tinh depend on the cyclonic activity in these two locations of strong cyclogenesis.

The main track of Pacific Northwest storms is Southeast – Northwest or Southeast East – Northwest West direction throughout the area within the geographic co-ordinates of 13^0 – 19^0 latitude North and 113^0 – 132^0 longitude East.

Pacific Northwest storm frequency gradually increases from January, February to August, then gradually decreases until with the lowest frequency in December. Pacific Northwest storm season is considered to be the months with more than two storms on average, lasting from June to November and focusing in July, August, September and October.

East Sea storms originate in general from Pacific Northwest and focus in the area within the geographic co-ordinates of 10^0 – 13^0 latitude North and 112^0 – 118^0 longitude East; these are known to rarely occur in early months (January, February, March, April), gradually increasing in frequency from May, June, peaking in during July, August, September and October, and then gradually decreasing in November and December.

Over the past 50 years, Ha Tinh has been frequented by 47 storms hitting or getting close to the coastal zone extending from Quynh Luu (Nghe An) to Le Thuy (Quang Binh), of which 18 storms directly hit into Ha Tinh province.

On average, Ha Tinh has been affected by 0.90 storm each year, even 2 – 3 storms in several years, and frequented by as many as 4 storms during 1984. However, there have been more than a half of the years without storms (1959,1963, 1966, 1967, 1968, 1974, 1976, 1977, 1979, 1982,1983, 1984, 1986, 1988, 1989, 1990, 1991, 1993, 1994, 1995, 1997, 1998, 1999, 2002, 2003, 2004); at times 3 successive years were without storms (1966 – 1968; 1982 – 1984, 1993 – 1995, 1997 – 1999, 2002 – 2004), and once even four continuous years passed by without a single storm (1988 – 1991).

These tropical cyclones in the region have only appeared during the period from June to October, the storm season of Pacific Northwest. Peak storm frequency has been reported in August and September (54%), followed by in July and October (30%).

Noticeably, in recent two half decades (1996 – 2000, 2001-2005), there were only 4 storms which means 0.4 storm each year on average, much lower than the average value of long term trend. As is common in most other regions also, primary effects of storm are causing widespread damage due to strong winds, heavy rain and coastal inundation due to high waves. The commonly reported strength of the wind in the storms is in the range of 16-30m/s. A record of strongest wind of up to 40m/s was observed during the storm which directly hit into Ky Anh in 1964.

Exceptionally heavy rains have occurred not only during the touch down of the storm, but also during 1-2 days before or after the storm traverses the area. In Ha Tinh, the total rainfall associated with a storm is in the range of 150-250mm on average. The rainfall associated with the storm is especially heavy and is usually accompanied with cold air from the North.

The strong winds associated with tropical cyclones lead to collapse of houses and other infrastructures, cause diluvia rain (seemingly endless rain) within basins of rivers, and also cause coastal landslides killing a large number of in

Table 2.1. Frequency of storm hitting or directly affecting the coastal line of Nghe An – Ha Tinh – Quang Binh

Months	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Frequency	0.00	0.00	0.00	0.06	0.13	0.19	0.30	0.15	0.02	0.00	0.85

Source: Institute of Meteorology, Hydrology and Environment

habitants living along the sea coast. From 2000 to 2008, the total economic loss suffered by the province due to infrastructure damage from tropical cyclones is up to 2,697 billions VND, a large share of which was incurred particularly the years: 2000 (200 billions VND), 2002 (824 billions VND), 2005 (140 billions VND), 2006 (110 billions VND), 2007 (1,135 billions VND), and 2008 (250 billions VND).

2.2 Dry and hot westerly winds

One of the special summer weather types of Central coastal provinces in general and Ha Tinh in particular is the dry, hot westerly wind, which was historically referred to as called Lao wind. Dry hot days are identified according to various standards in order to reflect very high temperature state and relatively low humidity at the same time. The number of dry hot days in this report is recorded according to the following standards:

1) Temperature at 13 hours (T_{13}) over 34^0C

2) Relative humidity at 13 hours (r_{13}) lower than 65%

Each year, about 15-22 dry hot waves are reported in Ha Tinh, some heat waves lasting only 1-2 days while others have their duration as long as 12-14 days (Ha Tinh, 1-12/ August/61 ; Huong Khe 1-14/ August/61); normally the heat wave duration is of 2-5 days on average.

It is evident from the above that, Ha Tinh normally has 30-40 dry hot days every year while records suggest less than 30 days in Huong Son, Thach Ha , Ha Tinh city, and over 40 days in Huong Son and Vu Quang. The activity of dry hot westerly winds in Ha Tinh is observed to be more than that in Thanh Hoa and North provinces, but approximately similar to that in Nghe An, Quang Binh and marginally lower than Quang Tri and Thua Thien Hue provinces.

Dry hot westerly winds occur from February or March and last till August or September (Table 2.2). However, dry hot

Table 2.2. The average number of monthly and annual mean occurrances of dry hot westerly winds

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Annual
Ha Tinh	0.02	0.06	0.51	1.09	2.91	3.61	3.83	3.17	0.89	0.04	0.00	16.1
Huong Khe	0.02	0.15	1.04	2.34	3.81	3.94	4.09	3.45	1.28	0.17	0.04	20.3

Source: Institute of Meteorology, Hydrology and Environment

Table 2.3. The number of dry hot days in Ha Tinh and some other places nationwide

Region	Station	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Average
North West	Lai Chau	0.1	3.0	7.	7.3	3.0	2.4	3.3	1.3	2.82
	Yen Chau	0.7	5.2	8.9	10.5	5.2	4.4	2.0	0.3	37.2
	Lang Son	0.0	0.1	0.9	0.8	1.4	1.8	0.5	0.1	5.0
North East	Thai Nguyen	0.0	0.0	0.1	2.7	4.0	4.8	2.8	0.5	15.0
	Ha Noi	0.0	0.1	0.1	2.8	4.6	5.4	1.8	0.1	14.9
North Delta	Thanh Hoa	0.0	0.0	0.2	4.0	5.7	7.4	3.0	0.1	14.9
North Central	Tuong Duong	0.8	4.3	7.8	15.3	13.3	15.8	8.9	2.7	68.9
	Vinh	0.3	1.2	7.9	9.9	13.4	6.4	0.7	0.0	39.2
	Huong Son	0.0	0.6	3.4	4.0	8.4	9.6	2.2	0.6	28.8
	Ha Tinh	0.0	0.8	1.8	3.8	11.0	10.2	1.8	0.4	29.8
	Huong Khe	0.4	1.4	5.4	8.8	14.4	14.4	3.4	0.8	49.0
	Ky Anh	0.0	1.0	3.0	6.0	9.0	9.2	2.6	0.0	30.8
	Tuyen Hoa	0.5	2.3	5.8	11.2	8.4	11.6	6.0	1.6	47.4
	Dong Hoi	0.0	0.3	1.2	7.3	9.9	13.4	6.4	0.7	39.2
	Hue	0.1	1.4	4.3	10.7	13.1	14.9	10.9	2.6	58.0
Central Highlands	Da Nang	0.5	1.0	1.3	8.2	9.6	12.6	9.6	1.4	44.2

Source: Institute of Meteorology, Hydrology and Environment

westerly wind season which is considered the months with more than 2 dry hot days on average in Ha Tinh is normally from April to August, similar to Nghe An, and Thanh Hoa provinces and earlier than Quang Binh, Quang Tri, and Thua Thien Hue. The peak of dry hot westerly winds occurs in June, and July, after a brief flooding period and prior to the main rainy season.

Dry hot westerly winds play a key role in causing drought conditions and water shortage which seriously affect the growth of many plants, especially rice. In terms of climate, dry hot westerly winds also results in causing breaks in favourable rain mechanisms in the atmosphere making the convective activity and rainfall during the season interrupt for 1-2 months, even 3 months in mid-summer. After that there are continuous rains in the months of late summer and early winter.

2.3 Droughts

Drought condition in Ha Tinh is evaluated on the basis of drought index which is derived from climatic drought severiety and drought frequency and reflects drought probability.

2.3.1 Drought index

Monthly or annual drought index in Ha Tinh is evaluated as follows: $H_t = \frac{P_t}{R_t}$

where P_t is monthly or annual evaporative loss of water, and

R_t is monthly or annual rainfall amount representing for the income of water.

Annual drought index in Ha Tinh is normally 0.30 - 0.45, lower than Thanh Hoa, Nghệ An in the North and many places in Quang Binh, Quang Tri provinces in the South. In Ha Tinh, only Huong Son mountainous area in North West is the place where the drought index is of approximate level to that of Nghe An (Table 2.4).

Temporal development of drought index depends on the annual variation of and seasonal change of the rainfall and evaporation amounts. Generally, drought index in January is below 0.5 in main rainy season and still below 1 in the second half of winter. When the dry hot westerly wind is active, rainfall decreases and the evaporation increases. Thus, the places in Ha Tinh have one, two or three months with drought index as more than 1, especially in coastal areas of Cam Xuyen, and Ky Anh in the Southeast. Drought season which is defined as the months with drought index of more than 1 is from April to July in Ha Tinh.

2.3.2 Drought frequency

In order to evaluate the drought probability, we use monthly drought standard (Ha Tinh) with the following specific conditions:

H_t winter (November - February): $R_t \leq$ 10mm

H_t spring (March - April) : $R_t \leq$ 30mm

H_t summer (May - August) : $R_t \leq$ 50mm

H_t autumn (September-October): $R_t \leq$ 30mm

Table 2.4. Monthly and annual drought index

Weather station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Ha Noi	3.25	2.16	1.21	0.63	0.53	0.37	0.38	0.29	0.38	0.63	1.23	4.50	0.59
Thanh Hoa	2.50	1.55	0.97	0.74	0.62	0.52	0.57	0.28	0.17	0.27	0.89	2.70	0.48
Vinh	0.70	0.67	0.81	0.79	0.77	1.28	1.53	0.56	0.13	0.11	0,30	0.71	0.45
Huong Son	0.48	0.45	0.67	0.57	0.58	1.18	1.27	0.59	0.16	0.09	0.18	0.36	0.44
Ha Tinh	0.35	0.41	0.65	0.70	0.65	0.81	1.22	0.45	0.12	0.07	0.15	0.27	0.30
Huong Khe	0.87	0.72	0.80	0.70	0.55	0.79	1.14	0.43	0.13	0.10	0.24	0.61	0.39
Ky Anh	0.39	0.44	0.78	1.06	0.88	1.37	2.15	0.71	0.14	0.08	0.14	0.26	0.38
Dong Hoi	0.96	1.01	1.27	1.27	1.03	1.47	2.35	0.83	0.17	0.10	0.22	0.52	0.49
Hue	0.36	0.65	1.48	1.46	1.13	1.20	1.70	0.18	0.21	0.08	0.08	0.13	0.36
Da Nang	0.83	2.75	4.16	2.60	1.30	1.34	1.55	1.02	0.29	0.12	0.16	0.32	0.51

Source: Institute of Meteorology, Hydrology and Environment

Following these standards, droughts in the areas of Ha Tinh are mainly identified as summer droughts (Table 2.4). Droughts can appear from February to August. Predominant drought frequency in the Province is below 5% in February; between 5 to 25% in March, April, May; within the range of 15-60% in June, July and below 30% in August (Table 2.5).

As well as other provinces in the North Central, the summer drought in Ha Tinh causes a serious set back for crop cultivation. Droughts cause not only rainfall deficiency but also is accompanied by salinity penetration deep into mainland along the main rivers.

In past few decades, serious droughts are known to have occurred in the years 1982, 1983, 1984, 1988, 1992, 1993, 1995 and 1998. In the recent years, drought area for each crop has increased up to thousands of hectares; for example, 12,680ha in 2003, and 3,360ha in 2005.

2.4 Heavy rains - Floods

Heavy rain is characterized by the highest numeric value of daily rainfall, monthly rainfall, annual rainfall and frequency of heavy rain days, heavy rain months and heavy rain years at levels.

2.4.1 Highest rainfall

Highest daily rainfall

The highest daily rainfall sequence of the main weather stations has arithmetic average of about 240-290mm and standard deviation of about 80-125mm.

The numeric value of the highest daily rainfall sequence is 657.2mm in Ha Tinh city (October – 1992), 492.6mm (October – 1983) in Huong Khe and 790.1m (October – 1967) in Ky Anh.

According to the reliable estimates, the highest daily rainfall at the selected weather stations (Table 2.6) can be identified up to 530-680mm in the cycle of 50 years and 580-770mm in the cycle of 100 years.

In recent 50 years, there have been 15 occasions when the daily rainfall of more than 300mm have been recorded in Ha Tinh city, with 9 occasions in Huong Khe and on 17 occasions in Ky Anh.

Table 2.5. Monthly drought frequency (%)

Meteorology station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ha Noi	17	17	43	9	2	0	0	4	0	11	14	17
Thanh Hoa	38	15	47	22	25	16	12	7	4	0	0	28
Vinh	4	5	32	18	25	40	45	18	0	2	3	8
Kim Cuong	6	6	4	8	8	22	52	4	0	0	0	12
Ha Tinh	0	4	8	18	22	41	48	26	0	0	0	4
Huong Khe	0	0	21	18	11	14	41	15	0	0	0	4
Ky Anh	0	0	13	21	19	42	58	26	0	0	0	0
Dong Hoi	4	9	51	37	48	53	65	41	0	0	0	0
Hue	2	11	46	40	60	54	62	40	0	0	0	0

Source: Institute of Meteorology, Hydrology and Environment

Table 2.6. The highest daily rainfall corresponding with the cycles (mm)

Cycle (year)	20	30	50	70	100
Ha Tinh	554	599	658	697	737
Huong Khe	452	486	530	559	589
Ky Anh	562	613	677	719	763

Source: Institute of Meteorology, Hydrology and Environment

Highest monthly rainfall

The highest recorded monthly rainfall is reported to be 2,047.8mm in Ha Tinh city (October – 1983), 1,614.6mm (October – 1983) in Huong Khe and 2,218.4mm (October – 1983) in Ky Anh.

In recent 50 years, there have been 14 occasions when the monthly rainfall of over 1,000mm have been observed, on 4 occasions over 1,500mm and once over 2,000mm in Ha Tinh city. Corresponding frequency of the occurance of these rainfall amounts is 5; 2; 0 in Huong Khe and 17; 7; 1 in Ky Anh.

Highest annual rainfall

The highest annual rainfall is reported to be 4,391.3mm (1989) in Ha Tinh, 3,784.4mm (1989) in Huong Khe and 4,386.1mm (1978) in Ky Anh.

In recent 50 years, there have been 13 events of the monthly rainfall of over 3,000mm in Ha Tinh city, including one event over 4,000mm. Corresponding frequency is 4; 0 in Huong Khe and 20; 1 in Ky Anh (Table 2.7).

2.4.2 Floods

In Ha Tinh, floods usually begin in August and occur most frequently in September, October and November. Flood often originates from the following forms:

- Tropical cyclones
- Cold airmass incursions
- Active inter-tropical convergence zone
- Storm combined with cold air or tropical cyclone combined with active inter-tropical convergence zone
- Cold airmass combined with active inter-tropical convergence zone

Floods in Ha Tinh are mainly in La river basin within the confluence zone of Ngan Sau and Ngan Pho rivers. On

Figure 2.1. Residents are evacuated the death-trap

Source: vietnam.net

Figure 2.2. Storm No 9 in the Central

Source: vietnam.net

Figure 2.3. Road of storm No 7 namely DAMREY in 2005

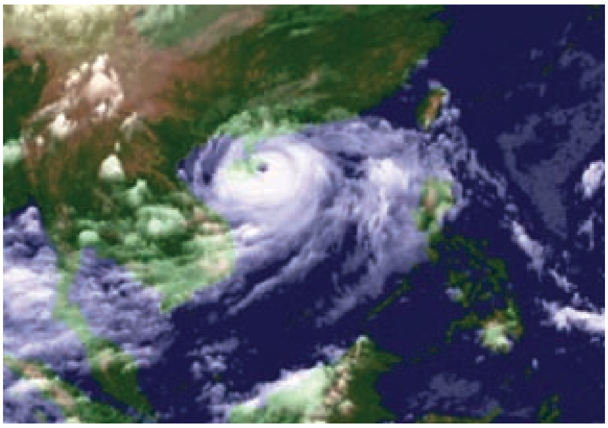
Source: Website of Nghe An province

Table 2.7. Frequency of heavy rain of different levels in 1958 – 2007 period

Values	Ha Tinh	Huong Khe	Ky Anh
Over 300mm daily rainfall	15	9	17
Over 1000mmm monthly rainfall	14	5	17
Over 1500mmm monthly rainfall	4	2	7
Over 2000mmm monthly rainfall	1	0	1
Over 3000mmm annual rainfall	13	4	20
Over 4000mmm annual rainfall	1	0	1

Source: Institute of Meteorology, Hydrology and Environment

Figure 2.4. Photograph of storm No 7 in 2005 is taken from satellite



Source: Website of Nghe An province

Figure 2.5. Huong Son town after flash flood in September 2002

Source: Website of Nghe An province

average, there are has two floods each year which cause serious loss to the economic activity and human lives in the mountainous districts of Huong Son, Vu Quang, Huong Khe and Đuc Tho. Especially, in the year 2002 heavy rain and flash flood that occurred in Ha Tinh had a devastating impact on human lives and infrastructures.

2.5 Conclusions

1. Ha Tinh is one of the Central provinces which has witnessed a severe climate in past decades with a number of serious weather related disasters which includes tropical storms, dry hot westerly winds, droughts, heavy rains and flash floods.
2. Disasters in Ha Tinh have contributed to creation of many climatological records of windstorm speed, dry hot westerly wind strength, long lasting droughts and continuous spells of heavy rainfall episodes.
3. In the forthcoming climate change context, disasters in Ha Tinh are likely to be more serious both in frequency as well as in strength.

Table 2.8. List of storms hit into the area of Nghe An – Ha Tinh – Quang Binh in 1956 – 2005 period

No	Storm	Year	Month	Origin day	Landfallday	Landfall location	Latitude	Longitude
1	-	1956	8	10/8	12/8	Ky Anh	17.9	108
2	CHARLOTIE	1956	9	25/8	1/9	Ha Tinh	18.2	106
3	-	1957	7	2/7	5/4	Quynh Luu	19.2	106
4	-	1958	6	27/5	6/6	North of Quynh Luu	19.2	106
5	-	1958	8	23/8	28/8	Ha Tinh	18.2	106
6	-	1958	9	6/9	7/8	Dong Hoi	17.8	106
7	IRMA	1960	9	16/9	26/9	Ha Tinh	18.2	106
8	LOLA	1960	10	8/10	17/10	Dong Hoi	17.3	107
9	CORA	1961	6	27/6	25/6	Nghe Tinh Coast	17.5	107
10	-	1961	8	19/3	21/8	Dong Hoi	17.6	107
11	-	1962	7	10/7	11/7	Dong Hoi	17.2	107
12	-	1962	9	23/9	28/9	Nghe An	18.0	107
13	TILDA	1964	9	12/9	22/9	Quang Binh	17.24	107,5
14	BILIE	1964	10	25/9	1/10	Dong Hoi	17.2	107
15	CLARA	1964	10	1/10	8/10	Ky Anh	18.1	106
16	GEORGA	1964	10	19/10	23/10	Ky Anh	18.0	107
17	NADINE	1965	8	14/8	18/8	Nghe An	18.0	106
18	ROSE	1965	9	30/8	2/9	North of Quang Binh	17.7	107
19	TESS	1969	7	6/7	11/7	Dong Hoi	-	-
20	DOIRS	1969	9	29/8	2/9	Dong Hoi	17.2	107
21	-	1970	8	18/8	19/8	Ha Tinh – Quang Binh	17.8	106
22	MARGE	1970	11	27/10	8/11	Quang Binh Coast	16.9	109
23	KIM	1971	7	9/7	13/7	Vinh	18.5	106
24	HARRIET	1971	7	30/6	7/7	Dong Hoi	19.8	107
25	ELAINE	1971	10	1/10	9/10	Ky Anh	18.0	106
26	LORNA	1972	10	27/9	2/10	Ky Anh	17.8	107
27	ANITA	1973	7	5/7	8/7	Ha Tinh	18.2	106
28	-	1973	9	20/9	25/9	Nghe An	19.0	106
29	-	1995	8	24/8	26/8	Nghe An	19.0	102.4
30	KIT	1978	9	20/9	26/9	Ba Don	-	-
31	BONNIE	1978	8	9/8	12/8	Đong Hoi	-	106.3
32	NANCY	1978	9	15/9	22/9	Đong Hoi	-	-
33	-	1980	9	4/927/6	5/9	Quang Binh	-	-
34	KELLY	1981	7	9/9	4/7	Nghe An	-	-
35	-	1985	9	24/9	10/9	Nghe Tinh	-	-
36	ANDY	1985	10	11/10	1/10	North of Quang Binh	-	-
37	DOT	1985	10	8/8	12/10	Vinh		
38	BETTY	1987	8	16/8	16/8	South of Deo Ngang		
39	CARY	1987	8	11/8	22/8	Vinh		
40	FRED	1987	8	22/8	17/8	Ky Anh		
41	WINONA	1993	6	7/9	29/8		18	105
42				19/9	13/9	Nghe An – Thanh Hoa	19.0	
43	-	1992	9	15/9	20/9	Ha Tinh		106,0
44	WILLE	1996	9	4/9	22/9	Nghe An	19.9	111
45	WUKONG	2000	9	8/8	10/9	Ha Tinh	18.4	107
46	USAGI	2001	8	15/9	10/8	Ha Tinh	18.2	108
47	VICENTE	2005	9		18/9	Nghe An – Ha Tinh – Quang Binh	17.8	107

Source: Institute of Meteorology, Hydrology and Environment

Table 2.9. Average values of some climatic parameters in Hà Tĩnh (1961-2005)

Factors	Weather station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Average sunshine hours (hour)	Huong Son	65.4	50.8	73.5	132.9	202.1	17.3	199.8	149.1	140.1	119.0	82.9	75.1	1463.0
	Ha Tinh	75.5	51.0	74.4	136.2	216.8	206.6	226.7	189.0	155.9	134.2	95.7	78.9	1624.6
	Huong Khe	67.0	49.7	76.9	131.6	179.3	180.0	203.0	160.9	120.5	99.3	73.6	58.5	1371.6
	Ky Anh	77.7	58.5	92.9	150.1	219.7	217.8	237.8	192.3	162.2	125.9	82.4	73.2	1657.9
Average temperature (^{0}C)	Huong Son	16.9	17.8	20.6	24.4	27.4	28.6	28.7	27.8	25.7	23.6	20.4	17.7	23.3
	Ha Tinh	17.7	18.4	20.8	24.5	27.8	29.5	29.7	28.7	26.8	24.4	21.5	18.7	24.1
	Huong Khe	18.0	19.0	21.6	25.1	27.6	28.9	29.1	28.0	26.1	24.0	21.2	18.8	24.0
	Ky Anh	17.9	18.7	21.0	24.7	28.0	29.7	29.9	28.9	26.9	21.7	21.7	18.8	23.5
Average rainfall (mm)	Huong Son	6.3	57.8	67.4	126.1	199.8	163.3	144.2	261.5	537.7	445.2	226.3	88.1	2383.7
	Ha Tinh	98.5	66.1	59.5	72.4	150.8	133.6	127.6	228.9	503.4	693.9	341.4	164.1	2634.4
	Huong Khe	41.9	47.5	62.9	94.4	213.5	162.3	144.1	294.6	491.4	549.1	190.5	71.8	2358.5
	Ky Anh	109.4	73.3	59.2	57.8	155.4	128.9	98.8	234.9	563.8	749.0	417.0	205.9	2842.1
Average evaporation (mm)	Huong Son	32.2	27.6	41.4	71.0	133.3	178.1	218.7	150.7	68.1	46.6	34.3	34.5	1036.5
	Ha Tinh	35.1	27.4	35. 6	55.0	95.5	122.3	137.7	100.8	63.9	55.5	49.8	45.2	820.7
	Huong Khe	37.4	32.4	48.6	72.9	112.4	135.9	163.1	106.7	62.2	52.5	47.3	41.9	907.9
	Ky Anh	41.4	32.0	44.1	65.1	122.9	178.3	208.6	152.1	78.1	64.6	60.3	53.2	1094.9
Average relatively humidity (%)	Huong Son	90	91	90	86	79	75	71	78	87	89	90	90	85
	Ha Tinh	91	92	92	88	81	77	74	80	87	89	89	88	86
	Huong Khe	91	91	90	86	80	78	74	81	87	88	88	89	85
	Ky Anh	90	92	91	87	79	74	70	76	82	88	88	88	84
Average wind speed (m/s)	Huong Son	1.9	1.0	1.1	1.3	1.9	2.7	3.2	2.2	1.1	0.8	0.7	0.7	1.5
	Ha Tinh	1.8	1.6	1.4	1.5	1.6	1.6	1.9	1.5	1.6	2.0	2.0	1.9	1.7
	Huong Khe	1.5	1.5	1.4	1.5	1.7	1.8	2.1	1.5	1.4	1.6	1.7	1.6	1.6
	Ky Anh	2.2	2.1	1.8	1.6	2.3	2.8	3.4	2.4	1.9	2.3	2.6	2.4	2.3

Source: Institute of Meteorology, Hydrology and Environment

Chapter 3

Overview of Climate Change in Ha Tinh

3.1 Climate change evidences in Ha Tinh

3.1.1 Level of change of some basic climate factors

Parameters expressing the level of change in climate

Sequence $\{x_t\}$

Sequence $\{x_t\}$ is the set of temporal numeric values of element X, from year 1, year 2 to year n:

$\{X_t\}$: $x_1, x_2, \dots x_{n-1}, x_n$

Arithmetic average

Arithmetic average is the estimated numeric value from many years of the climatic element (conventionally 30 years).

$$\bar{x} = \frac{1}{n}\sum_{t=1}^{n} x_t$$

Standard deviation (S)

Standard deviation is the estimated average level of temporal change of the climatic climatic element

$$S = \left[\frac{1}{n}\sum_{t=1}^{n}(x_t - \bar{x})^2\right]^{\frac{1}{2}}$$

In many cases, common oscillation scale of element X can be considered to be $\bar{x} \pm S$

Relative changing rate (Sr)

Relative changing rate is the estimated relative change of climate element:

$$Sr = \frac{S}{\bar{x}} * 100\%$$

Maximum of the sequence (Max)

Maximum of the sequence is the highest numeric value in the temporal sequence $\{x_t\}$

Max X = Max $(x_1, x_2, \dots x_n)$

Minimum of the sequence (Min X)

Minimum of the sequence xt is the lowest numeric value in the temporal sequence $\{x_t\}$

Min X = Min $(x_1, x_2, \dots x_n)$

Change of average elements and total quantity

Level of change in sunshine hours

Standard deviation of sunshine duration in the Province is about 20-35 hours in January, 25-40 hours in April, 40-50 hours in July, and 36-42 hours in October. Relative rate of change in sunshine in January, April, July and October is 30-45% ; 20 – 45%; 19-21%, 30 – 37%, respectively. Therefore, the change in sunshine during summer is more than that of other seasons in terms of absolute numeric value, but it is less than that of other seasons in terms of relative numeric value. The number of annual sunshine hours has standard deviation of 150-200 hours but the relative changing rate is only 9-13% (Table 3.1). Record of the highest monthly sunshine hours is reported to be 306.3 (Ky Anh, June – 1977) and the lowest one is reported to be 4.5 (Huong Khe, February – 1984). The record of highest annual sunshine hours is 2,093 (Ha Tinh city, 1987) and the lowest one is 1,095.4 (Huong Khe, 2002).

Level of change in average temperature

Standard deviation of surface air temperature is 1.4^{0}C – 2.3^{0}C in January, 1.3^{0}C – 1.6^{0}C in April; 0.7^{0}C – 0.9^{0}C in July; 0.6^{0}C – 1.1^{0}C in October with the relative changing rate of 7 – 13%; 5 – 7%; 2 – 3.5% and 2.5 – 5.0% respectively in these months, which is relatively high in winter and relatively low in summer.

Annual average temperature has standard deviation of below 1^{0}C with the relative changing rate of not more than 4%.

The highest monthly average temperature is 31.8^{0}C (Ky Anh, June – 1993) and the lowest one is 13.7^{0}C (Huong Khe, Feburary – 1968).

The highest annual average temperature is 25.4^{0}C (Ky Anh, 1998) and the lowest one is 22.8^{0}C (Huong Khe, 1971).

The highest temperature is in recent decade of the past century (1991-2000) and the lowest one is in the decades 1961 – 1970 or 1971 – 1980.

Level of change in rainfall

Standard deviation of rainfall is about 20-50mm in January, 40-65mm in April, 120-140mm in July and 280-500mm in October with the relative changing rate within the range of 35-60%; 65-75%; 90–125%; 50-65% respectively, which is relatively low in January and relatively high in July. Annual rainfall has standard deviation of 500-700mm but the relative changing rate is only about 20-27%.

Record highest monthly rainfall is reported to be 2047.8mm (Ha Tinh city, October – 1983) and the lowest one is reported to be 0.1mm (Ky Anh, June – 1966).

Level of change of evaporation amount

Standard deviation of evaporation amount is 9-13mm in January, 13-24mm in April, 25-50mm in July and 10-15mm in October, with the relative changing rate within the range of 25 – 30%; 13 – 25%; 25 – 50%; 10 – 15% respectively, which is relatively high in July and relatively low in January. Annual evaporation amount has standard deviation of about 100-200mm and the relative changing rate of 10-20%.

Record of the highest monthly evaporation amount is reported to be 285.0mm (Ky Anh, August – 1967) and the lowest one is reported to be 13.2mm (Ha Tinh city, March – 1980). Record of the highest annual evaporation amount is 1608.9 (Ky Anh, 1967) and the lowest one is 622.8mm (Huong Khe, 2000).

Level of change in extreme elements

Change in the maximum temperature (T_x)

Standard deviation of the maximum temperature is about 2.3^{0}C – 2.5^{0}C in January; 1.8^{0}C – 2.6^{0}C in April; 1.0^{0}C – 1.2^{0}C in July; 1.5^{0}C – 1.6^{0}C in October, with the relative changing rate in the range of 8 – 10%; 4 – 8%; 2 – 4%; 4 – 5% respectively, which is relatively high in July and relatively low in January. The maximum annual mean temperature has standard deviation of 0.9^{0}C – 1.0^{0}C and the relative changing rate of 2 – 2.5%.

Record of the highest recorded Tx is 42.6^{0}C (Huong Khe, 1992) and the lowest recorded Tx is 36.3^{0}C (Ky Anh, 1989).

Change in the minimum temperature (T_n)

Standard deviation of the minimum temperature is about 1.5^{0}C – 2.6^{0}C in January; 2.1^{0}C – 2.2^{0}C in April; 0.8^{0}C – 1.0^{0}C in July; 1.6^{0}C – 1.9^{0}C in October, with the relative changing rate in the range of 13 – 28%; 12 – 13%; 3 – 5%; 8 – 12% respectively, which is relatively high in January and relatively small in July. The minimum annual mean temperature has standard deviation of 1.4^{0}C – 2.4^{0}C and the relative changing rate of 14 – 31%.

Record of the highest recorded T_n is 13.8^{0}C (Ha Tinh city, 1958) and the lowest recorded T_n is 2.6^{0}C (Huong Khe, 1963).

Change in the highest daily rainfall (R_x)

Standard deviation of R_x is about 10-16mm in January, 22-29mm in April, 60-80mm in July, 80-140mm in October with the relative changing rate of 40 – 75%; 70 – 85%; 100 – 130%; 50 – 65% respectively, which is relatively high in July and relatively low in January.

The highest daily rainfall has standard deviation of about 80-125mm with the relative changing rate of 30-50%

Record of the highest R_x is 790.1mm (Ky Anh, 1967) and 101.2mm (Huong Khe, 1978).

Change in annual storm frequency

Annual storm frequency which affects Ha Tinh has standard deviation of 1.095 (storm) and the relative changing rate of 119%. The highest storm frequency is observed in 1964 (4) and the lowest one is 0 (several years)

Change in frequency of sunshine days

Standard deviation of the number of frequency of sunshine days is 3.78 in Ha Tinh and 3.86 in Huong Khe. The relative changing rate of this characteristic is 23.5% in Ha Tinh and 19.0% in Huong Khe.

The number of the most sunshine days in a month is 29 (1999) in Ha Tinh and 28 (1999) in Huong Khe. The number of the least sunny days at above locations is 10 (1963) and 17 (several years), respectively.

3.2 Trend of climatic parameters

3.2.1 Methods

The two following steps are taken to demonstrate the trends of climatic parameters in Ha Tinh:

Step 1: Calculate the values of the climatic parameter every five-year period and analyse the trend of each half-decade sequence of values.

A sequence of values of every five-year period is calculated as:

$$\overline{x}_{ntk} = \frac{1}{5} \sum_{cacn\ \ aacn\ k} x_t$$

The trend of a half-decade sequence of values is analysed by Spearman method as follows:

1. Form a half-decade sequence of values $\{x_t\}$

$\{x_t\}$: $x_1, x_2, \ldots x_n$

2. Form a sequence $\{y_i\}$ with increasing value of x_i

$\{y_i\}$: $y_1, y_2, \ldots y_n$

In which:

$y_1 < y_2 < \ldots < y_n$

3. Difference between two sequences

$$D = \sum_{t=1}^{n} [t(x) - i(y)]^2 \qquad (3.2)$$

4. Rank corelation coefficient

$$r^2 = 1 - \frac{6}{n(n^2-1)} D \qquad (3.3)$$

5. Analysis coefficient u

$$u = \left[1 - \frac{6}{n(n^2-1)}\right](\sqrt{n-1}) \qquad (3.4)$$

Table 3.1. Standard deviation (S) and relative changing rate (Sr %) of some main climatic elements

Factor	Station	I		IV		VII		X		Year	
		S	Sr	S	Sr	S	Sr	S	Sr	S	Sr
Number of sun hours (hour)	Ha Tinh	33.6	44.5	33.8	44.8	45.3	20.0	41.6	30.7	152.5	9.4
	Huong Khe	20.6	30.7	27.8	21.1	40.0	19.7	36.2	36.5	174.3	12.7
	Ky Anh	32.7	42.0	37.3	24.9	48.3	20.3	39.6	31.5	199.0	12.0
Average temperature (^{0}C)	Ha Tinh	1.4	7.9	1.3	5.3	0.8	2.7	0.8	3.3	0.5	2.1
	Huong Khe	2.3	12.8	1.6	6.4	0.9	3.1	1.1	4.6	0.9	3.8
	Ky Anh	1.4	7.8	1.3	5.3	0.7	2.3	0.6	2.8	0.6	2.6
Rainfall (mm)	Ha Tinh	45.8	46.5	52.9	73.0	136.4	106.8	411.2	59.7	605.3	25.9
	Huong Khe	23.1	55.1	65.3	6.92	130.3	90.4	292.2	53.2	515.8	21.9
	Ky Anh	40.7	37.2	42.5	73.5	121.8	123.3	479.8	64.1	6527	23.0
Evaporation (mm)	Ha Tinh	9.1	25.9	13.0	23.6	27.5	20.0	11.7	21.1	1038	12.6
	Huong Khe	9.7	25.9	23.4	32.1	47.0	28.8	12.5	23.8	1789	19.7
	Ky Anh	12.2	29.5	18.0	27.6	49.6	23.8	14.7	22.8	1580	1.44
Maximum temperature (^{0}C)	Ha Tinh	2.3	8.6	2.6	7.2	1.0	2.7	1.5	4.7	0.9	2.3
	Huong Khe	2.5	8.4	1.8	4.7	1.1	2.9	1.5	4.5	1.0	2.5
	Ky Anh	2.5	9.3	2.2	6.1	1.2	3.2	1.6	5.0	0.9	2.4
Minimum temperature (^{0}C)	Ha Tinh	1.6	15.2	2.1	12.1	0.8	3.3	1.6	8.8	1.4	14.7
	Huong Khe	2.6	27.4	2.1	12.4	0.9	8.9	1.9	11.0	2.4	30.8
	Ky Anh	1.5	13.6	2.1	12.0	1.0	4.2	1.6	8.8	1.4	14.0
Highest daily rainfall (mm)	Ha Tinh	15.5	50.8	27.8	81.3	75.8	128.5	135.8	62.7	112.8	39.8
	Huong Khe	10.9	71.2	26.3	72.5	62.5	108.5	88.0	53.8	84.6	34.0
	Ky Anh	13.8	43.9	22.9	79.0	68.6	112.1	130.2	62.3	124.3	47.1
Number of storms including those on the coastal line of Nghe An – Ha Tinh – Quang Binh										1.095	119
Number of heat waves	Ha Tinh									3.785	23.5
	Huong Khe									3.86	19.0

Source: Institute of Meteorology, Hydrology and Environment

6. Analysis

Analyse data with the following criterion 3.5:

U > 1.96: sequence with increasing trend

-1.96 < U < 1.96: sequence without trend (3.5)

U < - 1.96: sequence with decreasing trend

Step 2: Establish the trend equation of climatic factors

The trend equation of climatic parameters (x) and time (t) is formed as:

$X_t = b_0 + b_1 t$

In which:

$$b_1 = \frac{\sum_{t=1}^{n}(x_t - \bar{x})(t - \bar{t})}{\sum_{t=1}^{n}(t - \bar{t})^2} \qquad (3.6)$$

where:

$$\bar{x} = \frac{1}{n}\sum_{t=1}^{n} x_t \qquad \bar{t} = \frac{1}{n}\sum_{t=1}^{n} t \qquad b_0 = \bar{x} - b_1\bar{t}$$

b_1 is speed of trend and b_0 is the origin value of trend line.

3.2.2 Results of data analysis

Based on analysis value U, there are only 2 elements with a remarkable trend among 8 most important climatic elements, namely average annual temperature and annual heat wave frequency. Besides, the maximum temperature also shows a distinguis hable trend as compared to other elements

3.2.3 Climatic parameters over periods of 5 years

An overview of some the important climatic elements for most recent 50 years can be seen through the average of sequences in 5-year periods (Table 3.3).

Annual sunshine hours

The number of sunshine hours does not show a systematic difference between the previous periods (1961 – 1990) and the consequitive five-year periods (1991 – 2005). The fluctuation of sunshine hours in five-year periods has no trend.

Average temperature

The data collected from 3 weather stations of Ha Tinh, Huong Khe, Ky Anh shows a marked difference between five-year periods in the past and recent 15 years. The temperature trend over five-year periods in 3 stations is confirmed by Spearman method.

Maximum temperature

The maximum temperature of each five-year period at Ha Tinh and Huong Khe stations changes remarkably from the half of previous decade to the half of recent decade. Spearman analysis also comfirmed the trend in the maximum temperature at these two stations. At Ky Anh station only, the maximum temperature during the periods of 1976 – 1980; 1981 – 1985 and 1986 - 1990 is higher than three previous and three later five-year periods.

Table 3.2. Coefficient U of the climatic elements and analysis results (v; in trend, 0; no trend)

Station	Ha Tinh		Huong Khe		Ky Anh	
	U	Result	U	Result	U	Result
Annual sunshine hours	-2.20	v	-	-	-0.171	0
Average annual temperature	2.45	v	2.69	v	2.31	v
Maximum temperature	2.43	v	2.029	v	0.407	0
Minimum temperature	0.424	0	1.109	0	0.897	0
Annual rainfall	-1.302	0	0.637	0	-0.904	0
Highest daily rainfall	1.164	0	0.849	0	0.765	0
Annual evaporation	1.086	0	-0.801	0	-1.627	0
Number of annual heat waves	1.995	v	2.101	v	-	-

Source: Institute of Meteorology, Hydrology and Environment

Minimum temperature

The minimum temperature obviously increased abruptly in 2001 – 2005. However, according to Spearman analysis, the increasing trend in minimum temperature has not reached a significant level.

Average rainfall

The highest value of rainfall is observed in different periods: 1991 – 1995 at Ha Tinh station, 1986 – 1990 at Huong Khe station and 1981-1985 at Ky Anh station. Meanwhile, the lowest value is observed in 1961 -1965 at Ha Tinh station, 1966 – 1970 at Huong Khe station and 1991 – 1995 at Ky Anh station. From this analysis, no discernable trends are noticed in the rainfall at the selected locations.

Highest daily rainfall

Like annual rainfall, daily rainfall also shows complex progress: records of highest value and density are observed in 1991 – 1995 at Ha Tinh station while similar be havior is observed in 1981 – 1985 at Huong Khe station and in 1966 – 1970 at Ky Anh station.

Evaporation

In the recent two decades, the evaporation has increased considerably at Ha Tinh station, but it has remained rather low at Huong Khe station as well as at Ky Anh station. There has been no clear evidence of an increasing trend in evaporation at these locations although the increasing trend in evaporation is considered a common observation elsewhere.

Table 3.3. Average value and highest value of climatic parameters every five-year period at three selected locations

Factor	Station	1956-1960	1961-1965	1966-1970	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005
Sunshine hours (hour)	Ha Tinh	-	1674	1574	1620	1654	1674	1784	1622	1560	1482
	Huong Khe	-	-	-	-	-	-	-	-	-	-
	Ky Anh	-	-	-	1650	1678	1822	1860	1786	1770	1460
Average temperature (^0C)	Ha Tinh	-	23.8	23.7	23.7	13.8	23.7	24.1	24.1	24.4	24.5
	Huong Khe	-	23.5	23.4	23.4	23.6	23.7	24.1	24.1	24.2	24.3
	Ky Anh	-	23.9	24.1	24.0	24.3	24.0	24.6	24.4	24.5	24.5
Maximum temperature (^0C)	Ha Tinh	-	38.1	39.5	38.5	39.7	39.3	39.9	40.2	39.9	40.0
	Huong Khe	-	39.5	39.3	41.1	41.2	40.5	40.3	42.6	41.0	41.0
	Ky Anh	-	38.3	38.8	38.6	40.4	39.3	39.5	39.4	38.3	38.8
Minimum temperature (^0C)	Ha Tinh	-	7.6	8.6	7.6	8.2	7.3	8.2	8.1	7.5	9.0
	Huong Khe	-	2.8	5.9	2.6	6.5	5.5	6.5	5.4	3.6	8.5
	Ky Anh	-	8.3	9.4	6.9	8.9	7.5	7.8	9.2	8.4	10.4
Annual rainfall (mm)	Ha Tinh	-	2128	2438	2974	2541	2572	2938	3020	2188	2680
	Huong Khe	-	2552	2114	2336	2182	2462	2816	2280	2256	1862
	Ky Anh	-	2676	2912	2972	2736	3190	2828	2446	2866	2614
Highest daily rainfall Rx(mm)	Ha Tinh	-	244.7	308.3	456.1	502.4	434.9	546.0	657.2	266.1	401.6
	Huong Khe	-	274.6	290.3	411.2	313.2	492.6	347.0	294.4	357.3	302.6
	Ky Anh	-	206.3	790.1	377.7	475.8	519.1	367.8	484.2	480.1	359.0
Evaporation (mm)	Ha Tinh	320.1	768	8.8	832	784	730	74.2	820	884	908
	Huong Khe	-	722	906	946	1024	1068	840	672	774	760
	Ky Anh	316.6	1070	1328	1128	1086	1134	1033	1040	1072	984
Number of hot and dry days	Ha Tinh		62	77	68	72	89	93	79	103	81
	Huong Khe		94	99	96	96	94	116	115	103	100
Number of storms including those in the coastal line of Nghe An – Ha Tinh – Quang Binh	-	8	6	4	7	4	4	2	2	2	2
Average number of heat waves	Ha Tinh	-	912.4	15.4	13.6	14.4	17.8	18.6	15.8	20.6	16.2
	Huong Khe	-	18.8	19.8	19.2	19.2	18.8	23.2	23.0	20.6	20.0

Source: Institute of Meteorology, Hydrology and Environment

Storm frequency along the coast line of Nghe An – Ha Tinh – Quang Binh

Storm frequency decreased gradually during periods of 1956 - 1960; 1961 – 1965 (8 -10) and 1966 - 1970, 1971 – 1975, 1976 - 1980, and 1981 -1985 (4-7 per 5 year) and decreased the most in the recent five-year periods (2 per 5 year).

This is completely different from the storm distribution recorded in five-year periods for the entire coast line of Viet Nam taken together and needs to be further explored in terms of any change in preferred landfall location along the coast line.

Frequency of heat waves

The average frequency of heat waves in Ha Tinh, typically for coastal delta areas, is lower than 15 in periods prior to 1976 – 1980 and higher than that in the later five-year periods. Particularly, the frequency of heat waves in 1996 – 2000 is up to 20.6.

The numerical value of this parameter at Huong Khe, typical for mountainous areas, is lower than 20 in the period of 1981-1985 and higher than 20 in the later periods. The period of 1986 – 1990 witnessed the highest level of heat wave frequency.

Table 3.4. Trend speed of some climatic parameters

Factor	Station	Jan.	Apr.	Jul.	Oct.	Annual
Sunshine hours (hour/year)	Ha Tinh	-0.5328	0.1864	-0.5116	-0.5512	-1.5954
	Huong Khe	-0.3775	0.0532	-0.6167	-0.1823	-1.3067
	Ky Anh	-0.4645	-0.8086	-1.3019	-0.2269	-7.0834
Average temperature (^0C/year)	Ha Tinh	0.0224	0.0158	0.0212	0.0185	0.0142
	Huong Khe	0.0421	0.0295	0.0182	0.0168	0.0246
	Ky Anh	0.0270	0.0238	0.0112	0.0141	0.0251
Maximum temperature (^0C/year)	Ha Tinh	0.0459	0.0578	0.0133	0.0141	0.0213
	Huong Khe	0.0783	0.043	0.0148	0.019	0.0332
	Ky Anh	0.0309	0.0542	0.0445	-0.0615	0.0065
Minimum temperature (^0C)	Ha Tinh	0.0244	0.0368	0.0299	0.0134	0.012
	Huong Khe	0.0549	0.0282	0.2786	0.0158	0.0613
	Ky Anh	0.0617	0.0369	0.0043	-0.1019	0.0521
Rainfall (mm/year)	Ha Tinh	0.2396	0.0352	-0.8962	1.9445	7.5788
	Huong Khe	0.597	0.0466	-0.6266	1.2034	-0.5155
	Ky Anh	0.2195	0.0275	-1.2743	-5.211	-11.196
Highest rainfall(mm/year)	Ha Tinh	-0.0157	0.2853	-0.5425	1.1926	2.0354
	Huong Khe	-0.1629	0.1359	-0.3602	-0.4037	0.4188
	Ky Anh	0.0082	-0.2447	-0.7027	1.0691	1.3446
Evaporation (mm/year)	Ha Tinh	-0.1261	0.0264	0.2958	0.1334	2.6194
	Huong Khe	-0.1536	0.0356	-1.3501	-0.3542	-4.0604
	Ky Anh	-0.4411	0.0305	-1.8423	-0.1351	-6.4177
Storm frequency (storm/year)	Coastal line of Nghe An – Ha Tinh – Quang Binh	-	-		-	0.001
Heat waves (wave/year)	Ha Tinh	-	-		-	0.1047
	Huong Khe	-	-		-	0.0657
Hot and sunny days	Ha Tinh					0.2854
	Huong Khe					0.1872

Source: Institute of Meteorology, Hydrology and Environment

3.2.4 Trend of climatic parameters

Changing rate of climatic parameters with a clear trend

Only two parameters have been identified to have a discernable trend of change, namely average annual temperature and annual heat waves.

Changing speed of average annual temperature is 0.142^{0}C/decade at Ha Tinh station, up to 0.246^{0}C/decade at Ky Anh station and 0.25^{0}C/decade at Huong Khe station. Accordingly, within the past 45-50 years the average temperature in Ha Tinh have increased by 0.7-1.1^{0}C, which is among the highest levels in Viet Nam.

The number of frequency of annual heat waves has also increased at a rate of 1.047 waves/decade equivalent to 2.854 waves/decade in plain areas and 0.657 waves/decade in mountainous areas. The rate of temperature trend in Ha Tinh is around that of many places in the Central, higher than that of the North Delta and Mekong Delta, Central Highlands, and lower than that of the North West, North East.

Changing rate of climatic parameters with unclear trend

In reality, it is possible to consider coefficient b_1 in the trend equation of the parameters with an unclear trend as the coefficient of chronogical increase/decrease. As shown in Table 3.4, over the past fifty years, the sunshine hours in many locations have decreased by approximately 1–7 hours/year, rainfall increased or decreased by 1–12mm/year, evaporation increased/decreased by 2-7mm/year. The increase/decrease of the parameters with an unclear trend is approximately that of those changing in trend.

3.3 Climate change scenarios of Ha Tinh

3.3.1 General introduction

Ha Tinh's plausible climate change scenarios discussed here consist of projections of temperature change, rainfall change and sea level rise.

The future temperature and rainfall scenarios are developed by the software MAGICC/SCENGEN in analysing the global models adapted by the IPCC with 6 emission scenarios ranking from low to high, namely B1, A1T, B2, A1B, A2 and A1FI. The temperature and rainfall features presented in the scenarios are taken for the year and four seasons: Spring (March – May), Summer (June – August), Autumn (September – November), Winter (December – February). The scenarios in Ha Tinh as well as the North Central are applied for area of latitude of 15^0 – 20^0 north and longitude of 105^0 – 110^0 east. The estimated results on future projections of temperature and rainfall in Ha Tinh are devided to 3 groups: Low (B1, A1T), Medium (B2, A1B) and High (A1FI, A2).

The scenario of sea level rise in Ha Tinh is adapted from the global sea level rise scenario for the coastal areas of the Central in Viet Nam following the comparison of observed rate of sea level rise from 1983 to 1993 of Viet Nam Central with average global rate of sea level rise.

3.3.2 Temperature scenarios

The temperature scenarios of Ha Tinh are basically the same as those of North Central region. These scenarios (Table 3.5) show that the mean surface air temperature shall continue to increase gradually from the beginning to the end of the decade at relatively higher rate in summer than in winter.

Under the high emission scenarios, by the year 2050, the surface air temperature will rise within the range of 1.38^{0}C–1.74^{0}C depending on the season, 1.68^{0}C for the year as a whole. By the end of 2100, seasonal surface air temperatures will increase within the range of 3.50^{0}C – 4.19^{0}C, while annually averaged temperature rise is projected to be 3.88^{0}C.

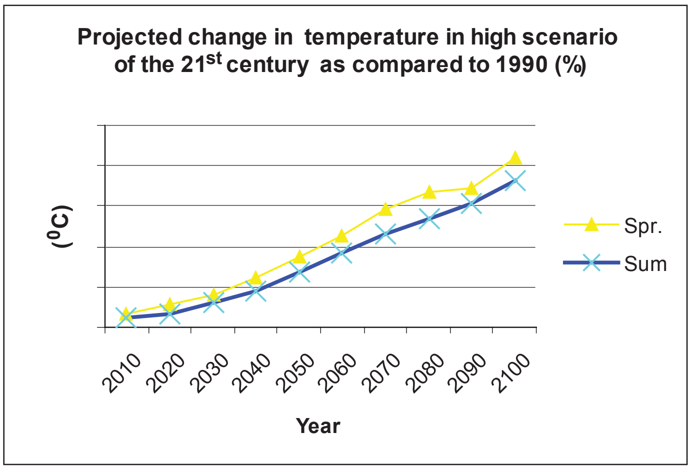
Under the medium emission scenarios, by the year 2050, the temperature rise will be in the range 1.19^{0}C–1.53^{0}C depending on the season, while the annual mean warming will be about 1.47^{0}C. By the end of 2100, seasonal surface air temperature will rise by between 2.23^{0}C–2.81^{0}C, while the annual temperature by 2.62^{0}C.

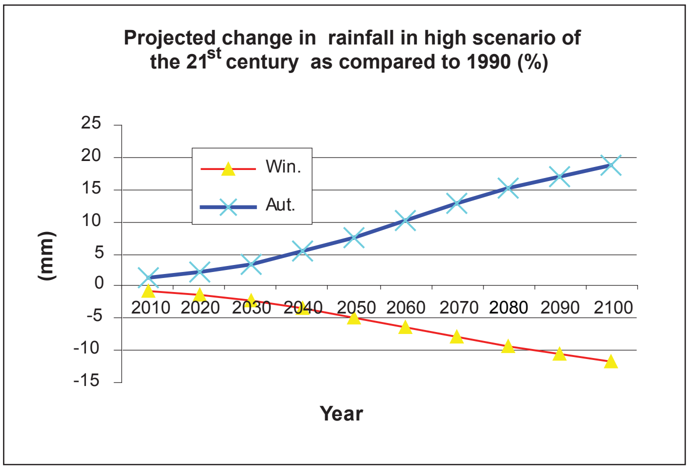
Under the low emission scenarios, by the year 2050, the surface air temperature rise is projected to be identical to that in the medium emission scenarios. By the end of 2100, the seasonal temperature will increase in the range of 1.76^{0}C–2.27^{0}C and annual mean temperature by 2.10^{0}C.

3.3.3 Rainfall scenarios

The rainfall scenarios of Ha Tinh (Table 3.6) are also adapted from climate scenarios of North Central region. According to these scenarios, rainfall change will not be uniform in all seasons as opposed to temperature. Rainfall will increase in summer and autumn and decrease in winter, spring. Like temperature, the increase or decrease in future rainfall becomes higher from the beginning to the mid and end of the 21st century.

Figure 3.1. Projected changed in temparature and rainfall in high scenario of the 21st century as compared to 1990





Source: Institute of Meteorology, Hydrology and Environment

For the high emission scenarios, by the year 2050 winter rainfall will likely decrease by 4.8% and during spring decrease will be limited to about 1.2%, summer rainfall amount will increase by 5.6%, while autumn rainfall amount will increase by 7.6%. By the year 2100, the projected decrease in winter and spring rainfall are -11.8%; -2.9% respectively while the projected rainfall increase during summer and autumn season are 13.8% and 15.8% respectively; the annual mean rainfall for the year will increase by 10.3%.

For the medium emission scenarios, the rate of change in rainfall by the year 2050 during winter, spring, summer, autumn and for the whole year will be respectively -4.3%; -1.1%; 5%; 6.8% and 3.7%. By the end of 2100, the corresponding decrease/increase in rainfall will by -7.9%; -2.0%; 9.3%; 12.7% and 7.0%.

For the low emission scenarios, by the year 2050, winter rainfall will decrease by 4.2%, and spring rainfall will decrease by only 1.1% while summer rainfall is projected to increase by 7.5% and autumn rainfall is likely to increase by 7.5%. Consequently, the annual mean rainfall is projected to increase 3.6%. By the end of this century, winter rainfall will likely decrease by 5.8%, and spring rainfall will decrease by 1.6%, while summer rainfall will likely increase by 6.8% and winter rainfall is projected to increase by 9.3%. The annual mean increase in rainfall is likely to be about 5.2%.

Table 3.5. Projected temperature rise in each decade of the 21st century as compared to 1990s (^0C)

Scenario	Average temperature	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
High	Dec.-Feb.	0.33	0.54	0.75	1.17	1.60	2.23	2.73	3.28	3.70	4.12
	Mar.-May	0.35	0.57	0.78	1.21	1.74	2.27	2.91	3.34	3.45	4.19
	Jun.-Aug.	0.25	0.35	0.63	0.91	1.38	1.85	2.32	2.70	3.08	3.64
	Sep.-Nov.	0.27	0.47	0.66	0.96	1.45	1.94	2.43	2.82	3.41	3.50
	Annual mean	0.31	0.52	0.73	1.05	1.68	2.20	2.73	3.15	3.57	3.88
Medium	Dec.-Feb.	0.33	0.54	0.75	1.17	1.49	1.81	2.12	2.44	2.54	2.75
	Mar.-May	0.35	0.57	0.78	1.21	1.53	1.85	2.17	2.49	2.70	2.81
	Jun.-Aug.	0.16	0.35	0.63	0.91	1.19	1.48	1.76	1.95	2.13	2.23
	Sep.-Nov.	0.17	0.37	0.66	0.96	1.25	1.55	1.84	2.03	2.23	2.43
	Annual mean	0.31	0.42	0.73	1.15	1.37	1.78	2.10	2.31	2.52	2.62
Low	Dec.-Feb.	0.33	0.65	0.96	1.17	1.49	1.60	1.81	1.91	2.02	2.12
	Mar.-May	0.36	0.64	0.99	1.21	1.53	1.63	1.85	1.95	2.06	2.27
	Jun.-Aug.	0.25	0.53	0.72	1.01	1.19	1.29	1.48	1.57	1.66	1.76
	Sep.-Nov.	0.27	0.57	0.76	1.06	1.25	1.35	1.55	1.64	1.74	1.84
	Annual mean	0.31	0.63	0.94	1.15	1.36	1.57	1.68	1.78	1.89	2.10

Source: Nguyen Van Thang, Hoang Duc Cuong, IMHE of Vietnam

Table 3.6. Projected change in rainfall in each of the decades of the 21st century as compared to 1990s (%)

Scenario	Average temperature	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
High	Dec.-Feb.	-0.9	-1.5	-2.2	-3.3	-4.8	-6.5	-8.0	-9.5	-10.7	-11.8
	Mar.-May	-.02	-0.4	-4.4	-0.8	-1.2	-1.6	-2.0	-2.6	-2.7	-2.9
	Jun.-Aug.	1.0	1.8	2.6	3.9	5.6	7.6	9.4	11.1	12.5	13.8
	Sep.-Nov.	1.4	2.3	3.5	5.3	7.6	10.3	12.8	15.1	17.1	18.8
	Annual mean	0.8	1.3	2.0	2.9	4.2	5.7	7.1	8.3	9.4	10.3
Medium	Dec.-Feb.	-0.8	-1.4	-2.3	-3.4	-4.3	-5.3	-.61	-7.0	-7.5	-7.9
	Mar.-May	-0.2	-0.4	-0.6	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.0
	Jun.-Aug.	1.0	1.7	2.7	4.0	5.0	6.2	7.2	8.0	8.7	9.3
	Sep.-Nov.	1.3	2.2	3.7	5.3	6.8	8.4	9.8	11.0	11.9	12.7
	Annual mean	0.7	1.2	2.0	3.0	3.7	4.6	5.5	6.1	6.3	7.0
Low	Dec.-Feb.	-1.1	-1.9	-2.7	-3.5	-4.2	-4.7	-5.1	-5.5	-5.7	-5.8
	Mar.-May	-0.3	-0.5	-0.7	-0.9	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6
	Jun.-Aug.	1.3	2.2	3.2	4.1	4.9	5.5	6.0	6.5	6.7	6.8
	Sep.-Nov.	1.8	3.0	4.4	5.6	6.6	7.5	8.2	8.8	9.1	9.3
	Annual mean	1.0	1.7	2.4	3.0	3.6	4.1	4.5	4.8	5.1	5.2

Source: Nguyen Van Thang, Hoang Duc Cuong, IMHE of Vietnam

Table 3.7. Projected sea level rise in the decades of the 21st century as compared to 1990s (mm)

Annual scenario	2020	2030	2040	2050	2060	2070	2080	2090	2100
High (A1FI)	12	17	24	33	44	57	71	86	100
Medium (B2)	12	17	23	30	37	46	54	64	74

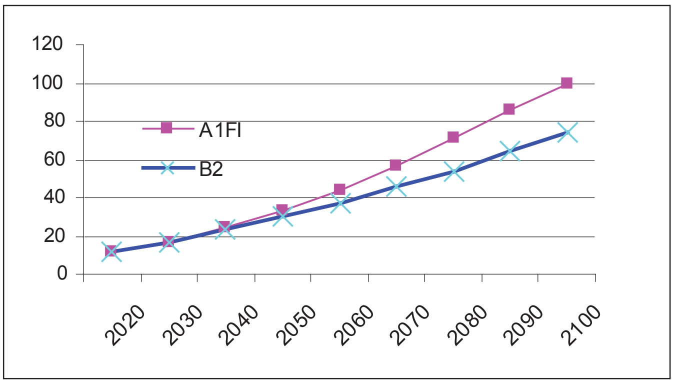
Source: Institute of Meteorology, Hydrology and Environment

3.3.4 Sea level rise projections

Under the high emission scenarios, by the year 2050, sea level is projected to rise by about 33cm by the mid 21st century and by about 100cm by the end of 21st century.

Under the medium emission scenarios, sea level is projected to rise by about 30cm by the mid 21st century and by about 74cm by the end of 21st century (Table 3.7).

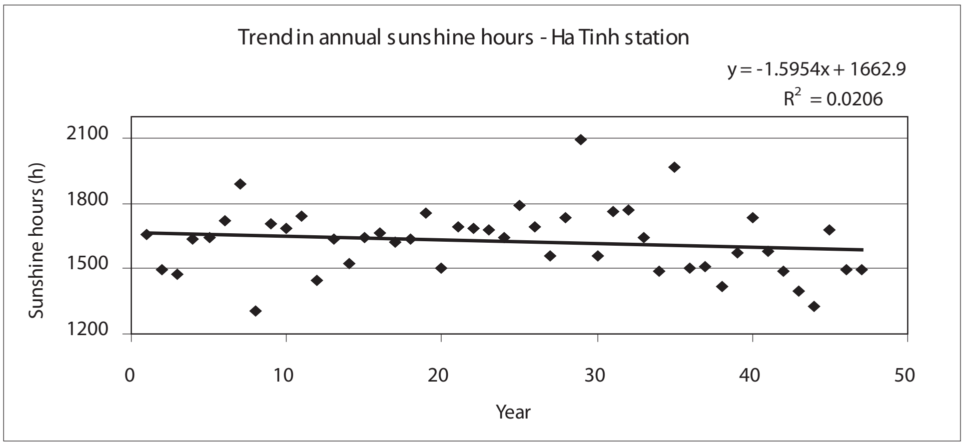
Figure 3.2. Projected sea level rise in the decades of the 21st century as compared to 1990s (mm)

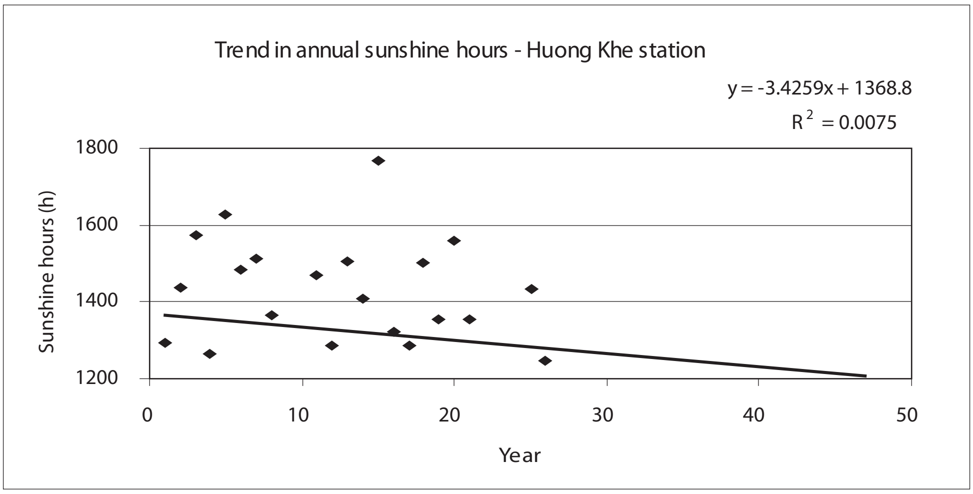


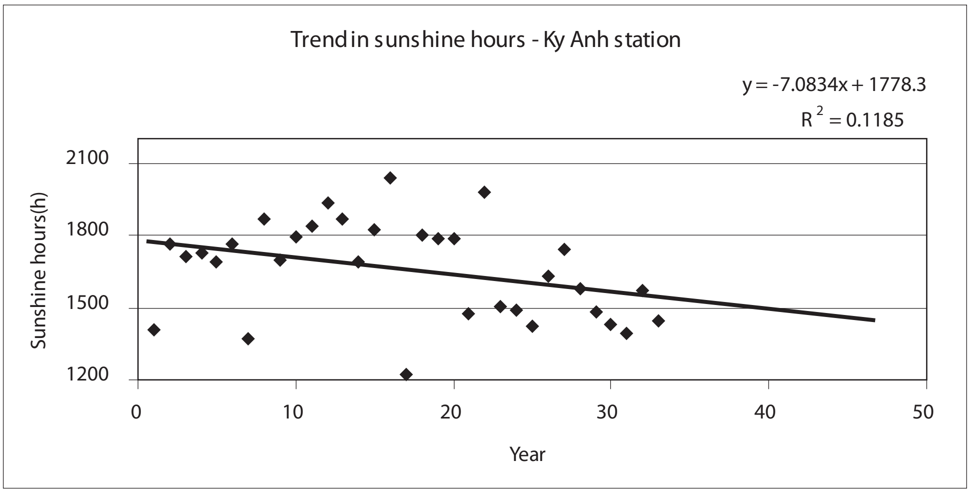
Source: Institute of Meteorology, Hydrology and Environment

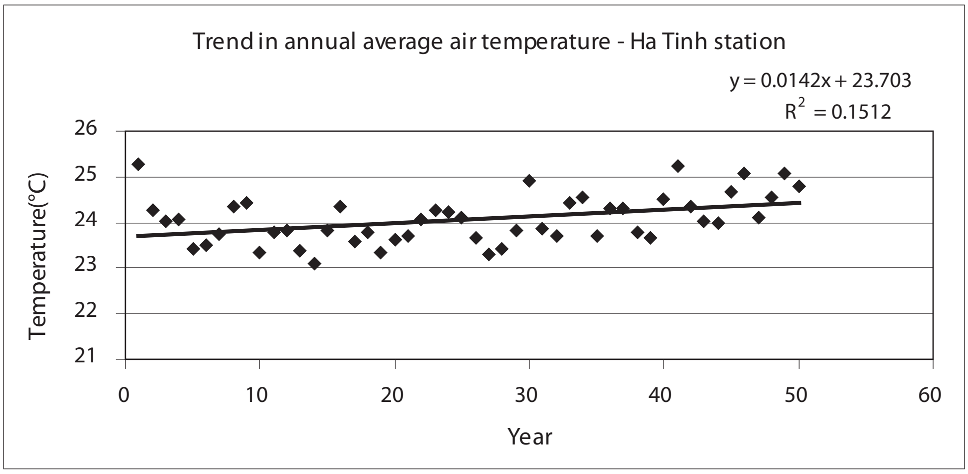
3.4 Conclusions

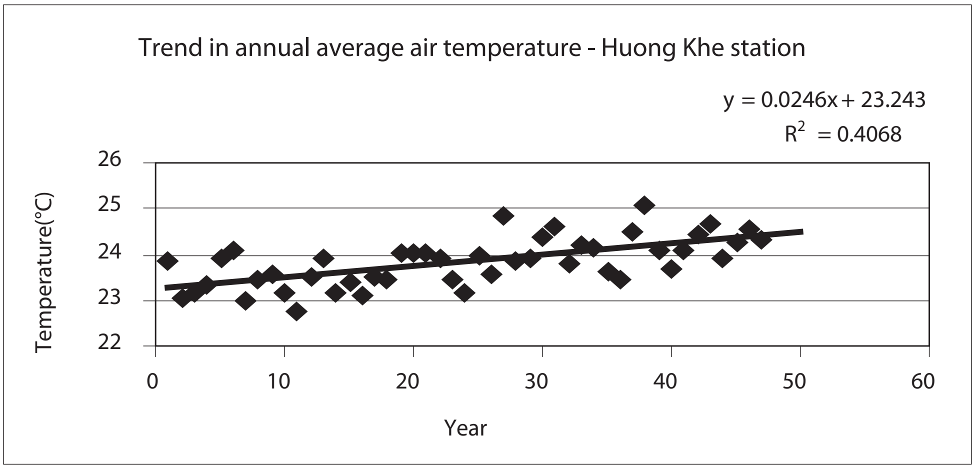
1. The Ha Tinh province is likely to experience more variable weather (including intra-seasonal and inter-annual variability in climate) and associated disasters such as intense heat waves, heavy rainfall extremes, severe floods and droughts, stronger cyclones and associated storm surges, more persistent and stronger ENSO event and a positive trend in sea level rise in the 21st century.
2. As in many places, climatic change and the enhanced variability in climate in Ha Tinh, based on the current scientific understanding, can not be attributed exclusively to anthropogenic factors (it could be due to a combination of natural variability and human activities).
3. The surface air temperature is observed to be significantly higher in recent decade. The average temperature in Ha Tinh over the past 45-50 years has increased by 0.7°C - 1.0°C. The rising trend in temperature in Ha Tinh as well as in North Central region is higher than that in North Delta, South Delta, South Central, Central Highlands and North East, North West.
4. The trend in number of heatwaves and hot days at Ha Tinh is considered to be statistically significant.
5. Most of the other climatic parameters in Ha Tinh do not exhibit any significant change in trend. The annual average increase/decrease speed is at approximately identical level to that of the climatic parameters with changes in trend.
6. The climate change scenarios of Ha Tinh are basically the same as those of North Central region. Most noticeably, the annual mean temperature at the end of the 21st century is likely to increase by 2^{0}C–4^{0}C, rainfall in dry seasons is projected to decrease by 1–12% only, rainfall in rainy seasons is projected to increase by 6–19% and sea level is projected to rise by 74 -100cm.

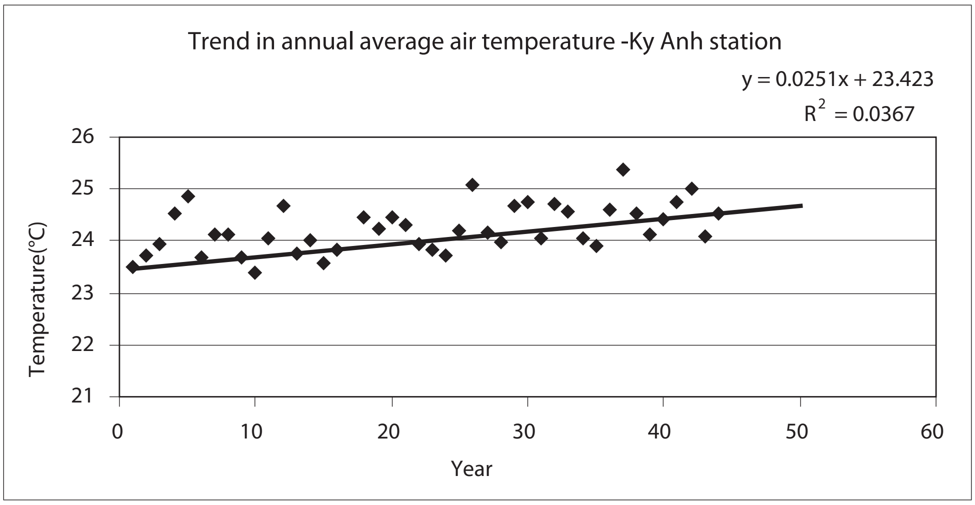

Trend in annual sunshine hours - Ha Tinh station
y = -1.5954x + 1662.9
R^2 = 0.0206
Sunshine hours (h)
2100
1800
1500
1200
0
10
20
30
40
50
Year

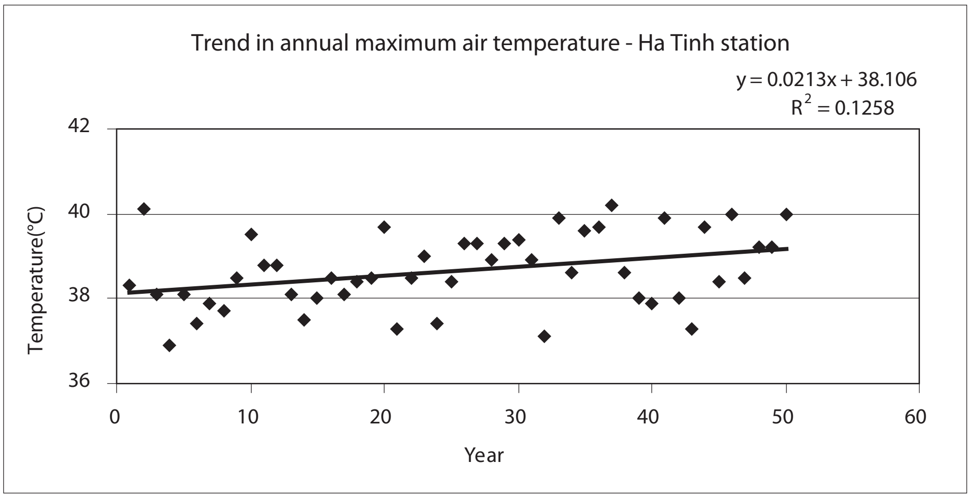

Trend in annual sunshine hours - Huong Khe station
y = -3.4259x + 1368.8
R^2 = 0.0075
Sunshine hours (h)
1800
1600
1400
1200
0
10
20
30
40
50
Year

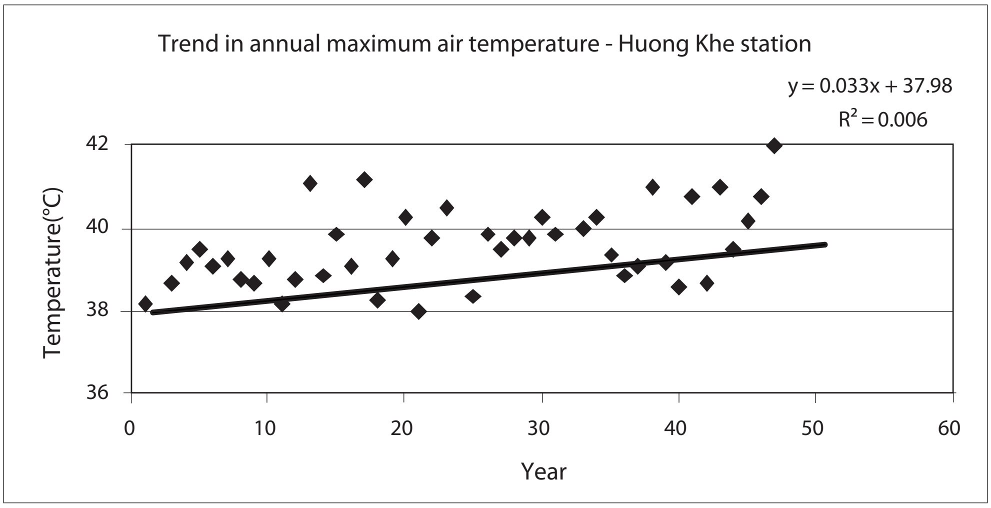

Trend in sunshine hours - Ky Anh station
y = -7.0834x + 1778.3
R^2 = 0.1185
Sunshine hours(h)
2100
1800
1500
1200
0
10
20
30
40
50
Year

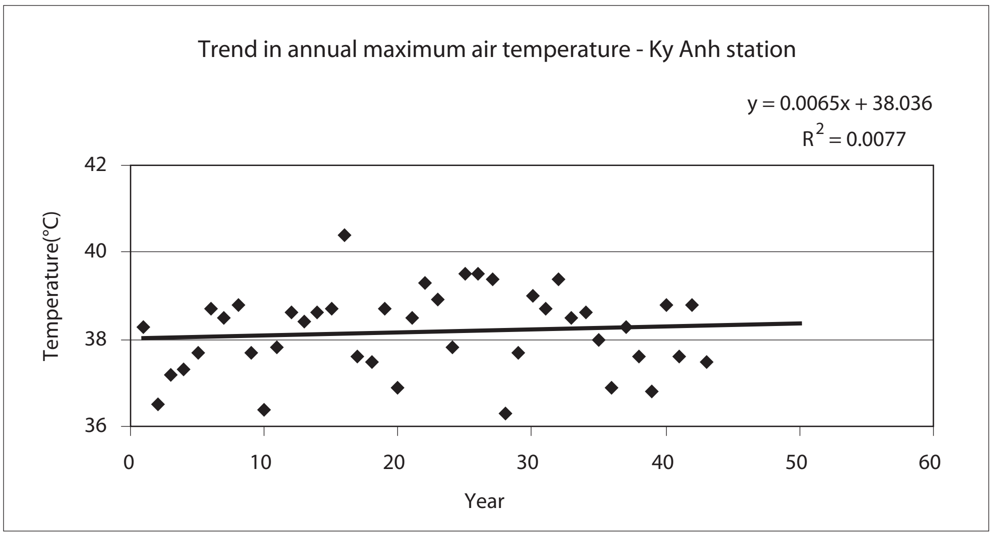

Trend in annual average air temperature - Ha Tinh station
y = 0.0142x + 23.703
R2 = 0.1512
Temperature(°C)
26
25
24
23
22
21
0
10
20
30
40
50
60
Year

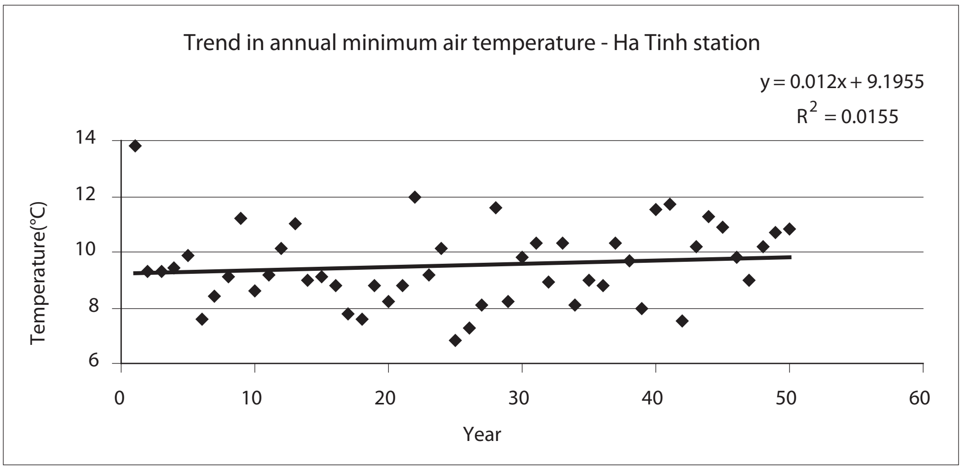

Trend in annual average air temperature - Huong Khe station
y = 0.0246x + 23.243
R2 = 0.4068
Temperature(°C)
26
25
24
23
22
0
10
20
30
40
50
60
Year

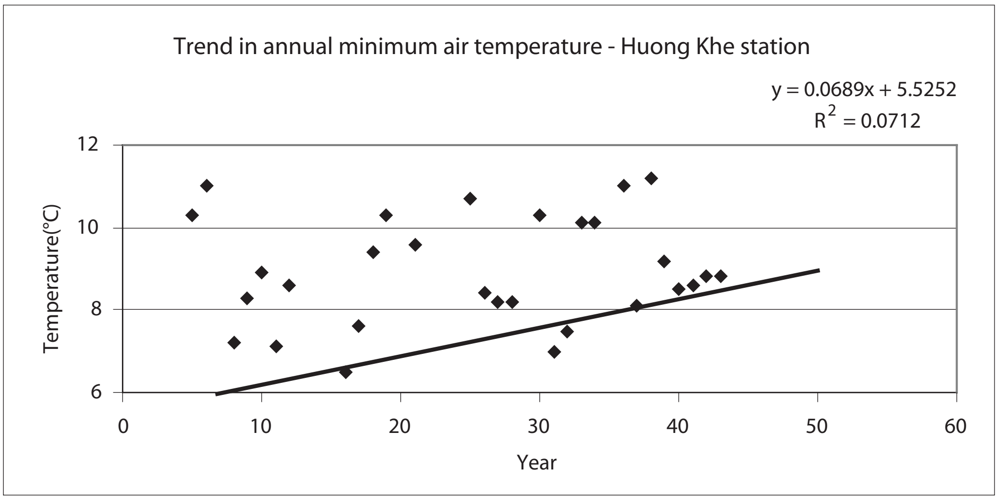

Trend in annual average air temperature -Ky Anh station
y = 0.0251x + 23.423
R2 = 0.0367
Temperature(°C)
26
25
24
23
22
21
0
10
20
30
40
50
60
Year

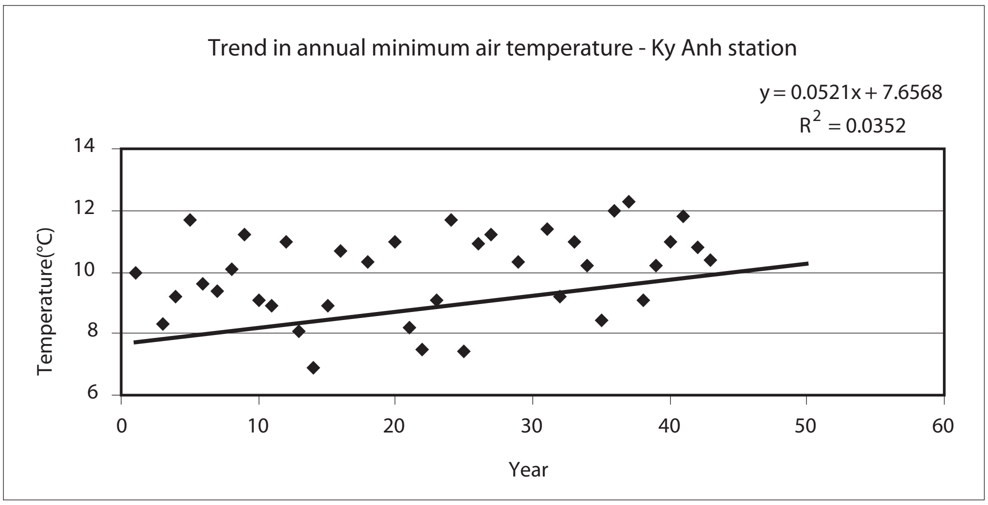

Trend in annual maximum air temperature - Ha Tinh station
y = 0.0213x + 38.106
R2 = 0.1258
Temperature(°C)
42
40
38
36
0
10
20
30
40
50
60
Year

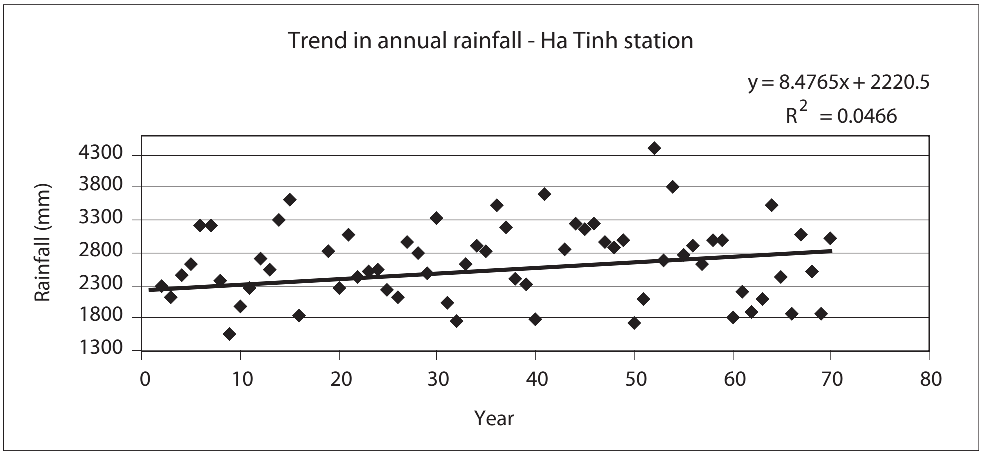

Trend in annual maximum air temperature - Huong Khe station
y = 0.033x + 37.98
R2 = 0.006
Temperature(°C)
42
40
38
36
0
10
20
30
40
50
60
Year

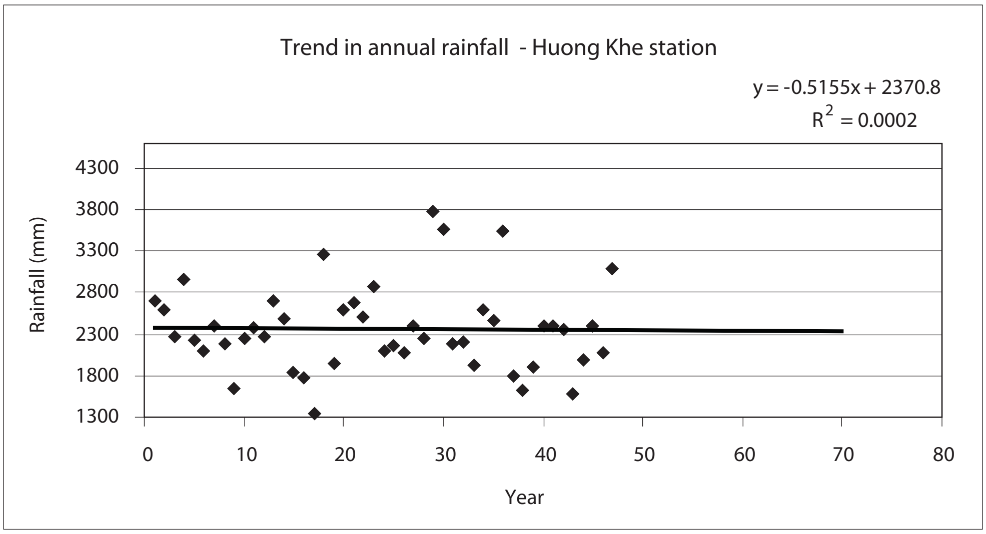

Trend in annual maximum air temperature - Ky Anh station
y = 0.0065x + 38.036
R2 = 0.0077
Temperature(°C)
42
40
38
36
0
10
20
30
40
50
60
Year

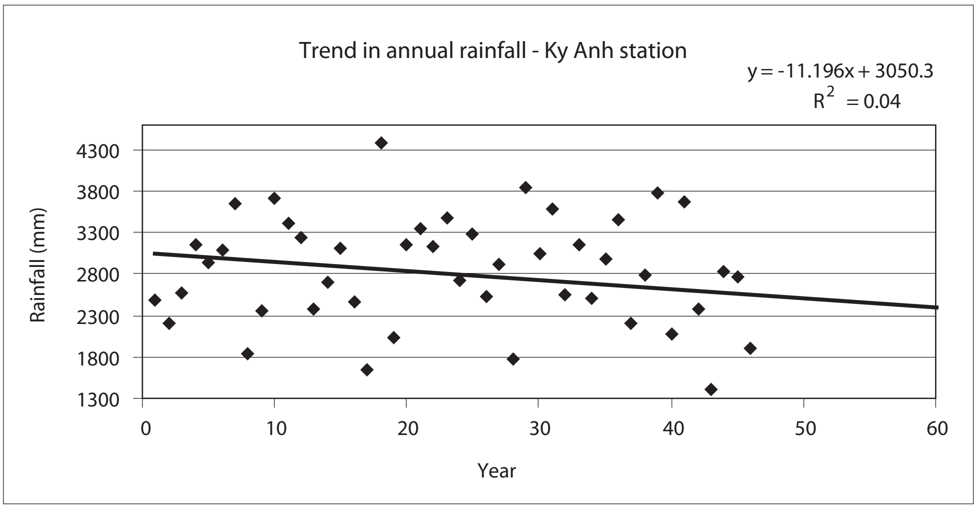

Trend in annual minimum air temperature - Ha Tinh station
y = 0.012x + 9.1955
R2 = 0.0155
Temperature(°C)
Year

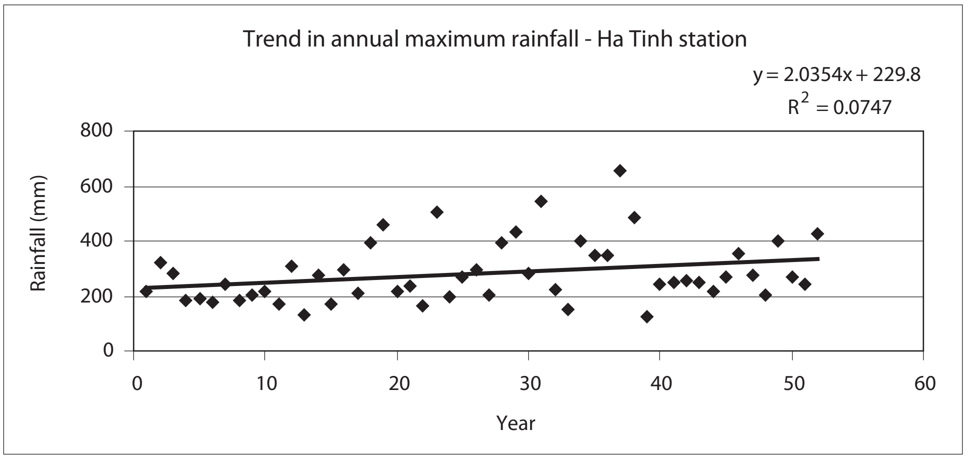

Trend in annual minimum air temperature - Huong Khe station
y = 0.0689x + 5.5252
R2 = 0.0712
Temperature(°C)
Year

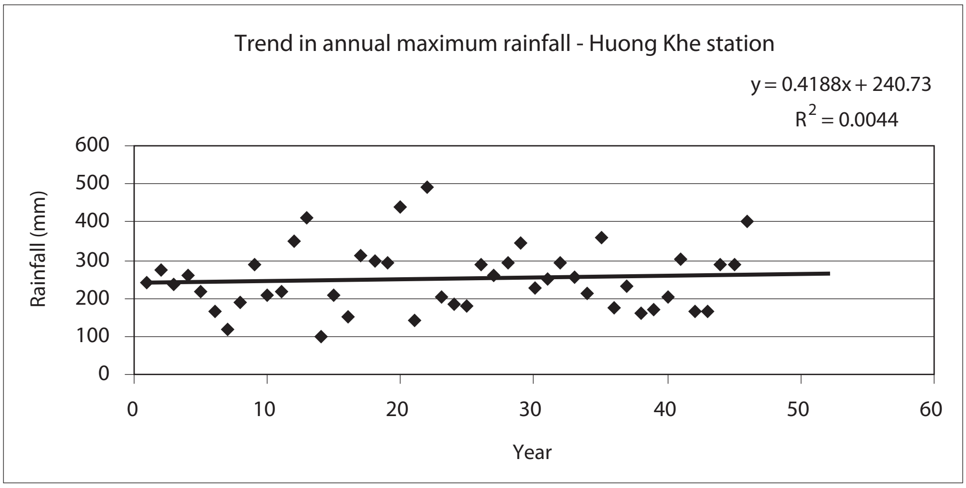

Trend in annual minimum air temperature - Ky Anh station
y = 0.0521x + 7.6568
R2 = 0.0352
Temperature(°C)
Year

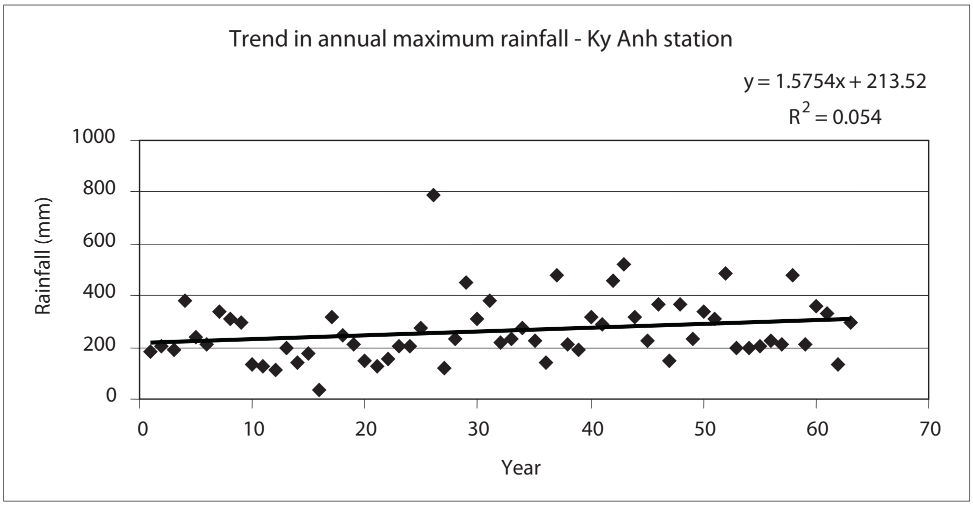

Trend in annual rainfall - Ha Tinh station
y = 8.4765x + 2220.5
R2 = 0.0466
Rainfall (mm)
4300
3800
3300
2800
2300
1800
1300
0
10
20
30
40
50
60
70
80
Year

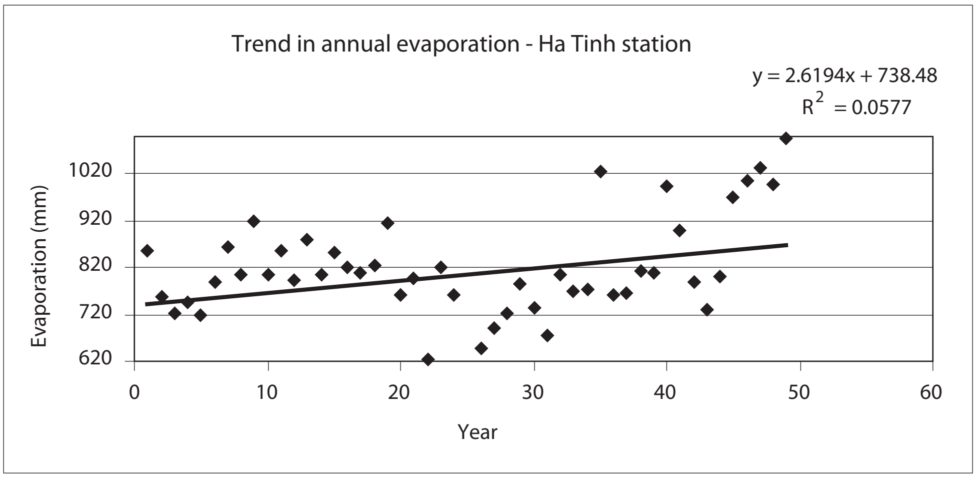

Trend in annual rainfall - Huong Khe station
y = -0.5155x + 2370.8
R2 = 0.0002
Rainfall (mm)
4300
3800
3300
2800
2300
1800
1300
0
10
20
30
40
50
60
70
80
Year

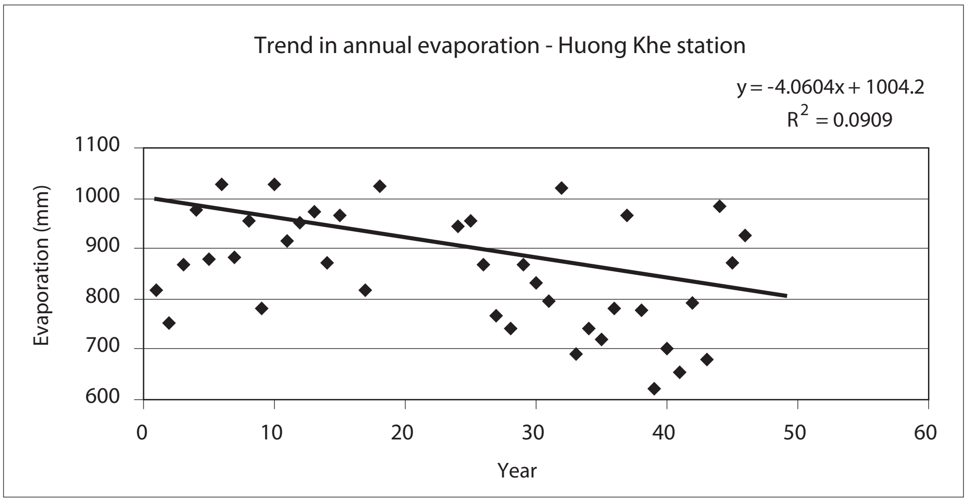

Trend in annual rainfall - Ky Anh station
y = -11.196x + 3050.3
R2 = 0.04
Rainfall (mm)
4300
3800
3300
2800
2300
1800
1300
0
10
20
30
40
50
60
Year

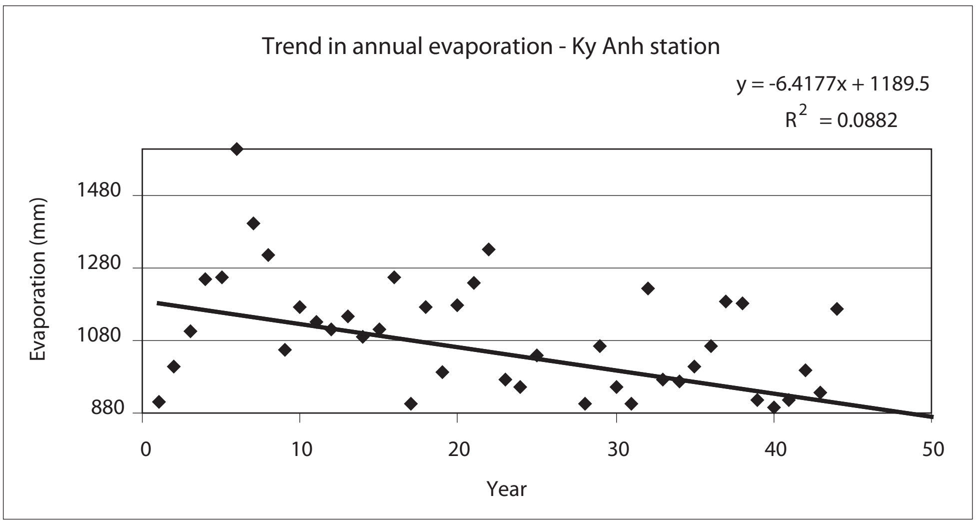

Trend in annual maximum rainfall - Ha Tinh station
y = 2.0354x + 229.8
R2 = 0.0747
Rainfall (mm)
800
600
400
200
0
0
10
20
30
40
50
60
Year

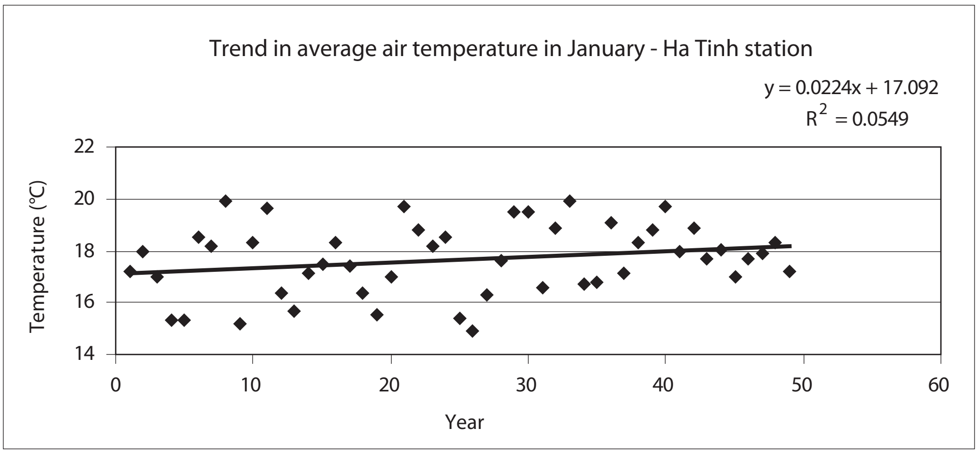

Trend in annual maximum rainfall - Huong Khe station
y = 0.4188x + 240.73
R2 = 0.0044
Rainfall (mm)
600
500
400
300
200
100
0
0
10
20
30
40
50
60
Year

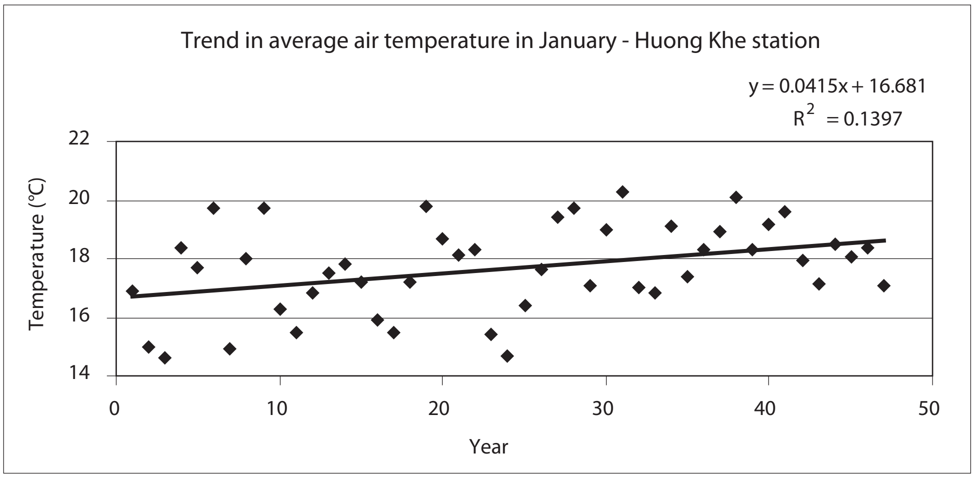

Trend in annual maximum rainfall - Ky Anh station
y = 1.5754x + 213.52
R2 = 0.054
Rainfall (mm)
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
Year

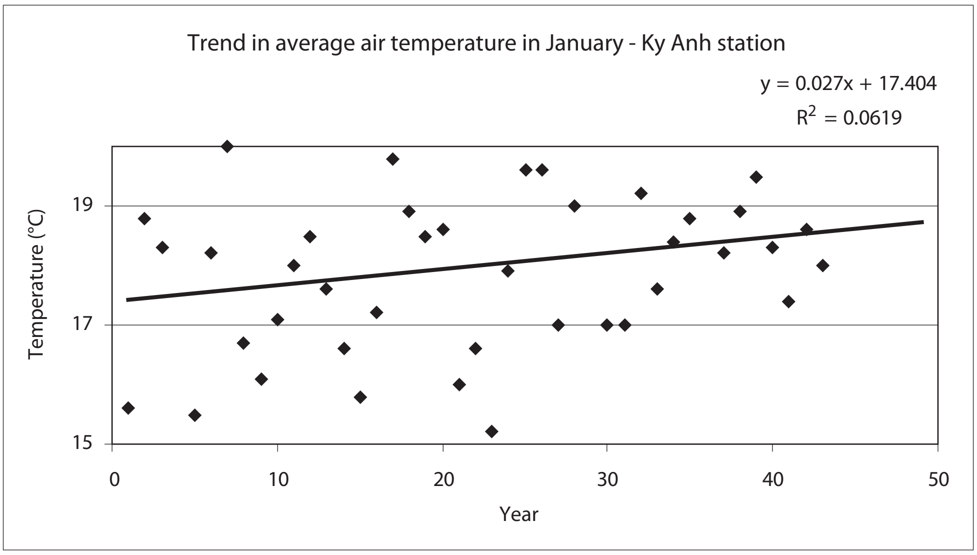

Trend in annual evaporation - Ha Tinh station
y = 2.6194x + 738.48
R2 = 0.0577
Evaporation (mm)
Year

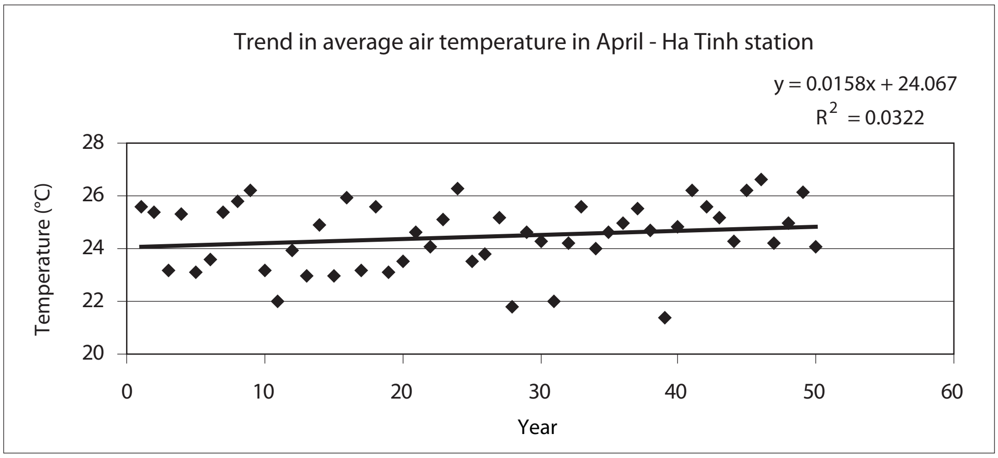

Trend in annual evaporation - Huong Khe station
y = -4.0604x + 1004.2
R2 = 0.0909
Evaporation (mm)
Year

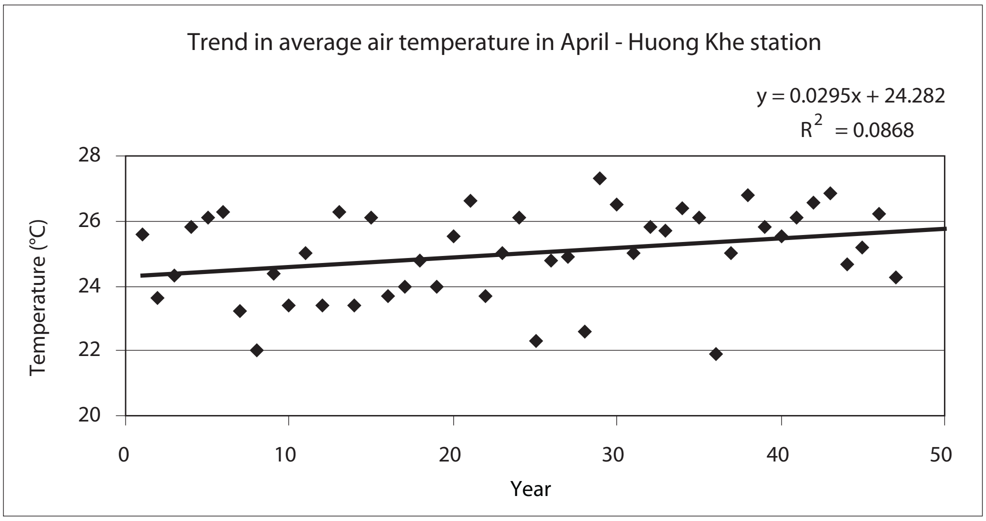

Trend in annual evaporation - Ky Anh station
y = -6.4177x + 1189.5
R2 = 0.0882
Evaporation (mm)
Year

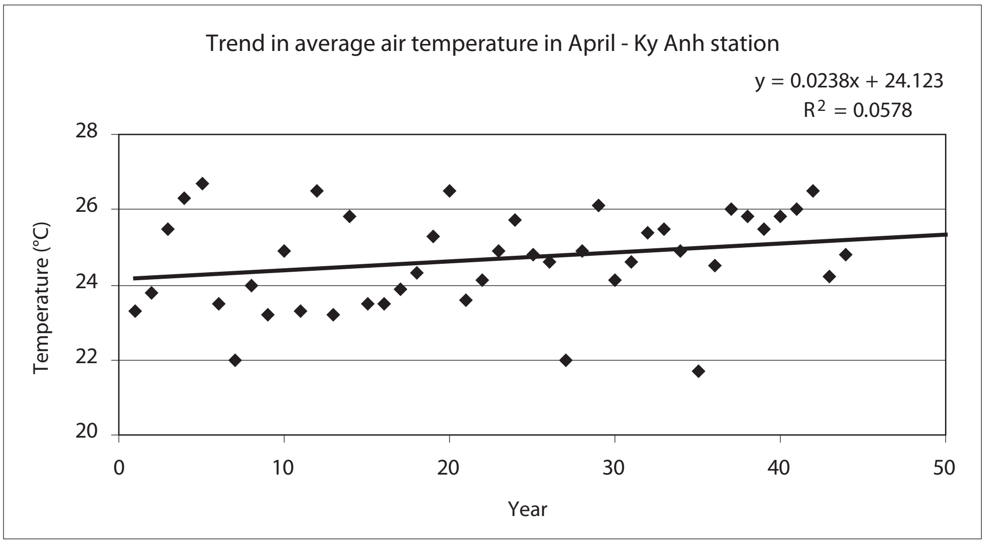

Trend in average air temperature in January - Ha Tinh station
y = 0.0224x + 17.092
R2 = 0.0549
Temperature (°C)
22
20
18
16
14
0
10
20
30
40
50
60
Year

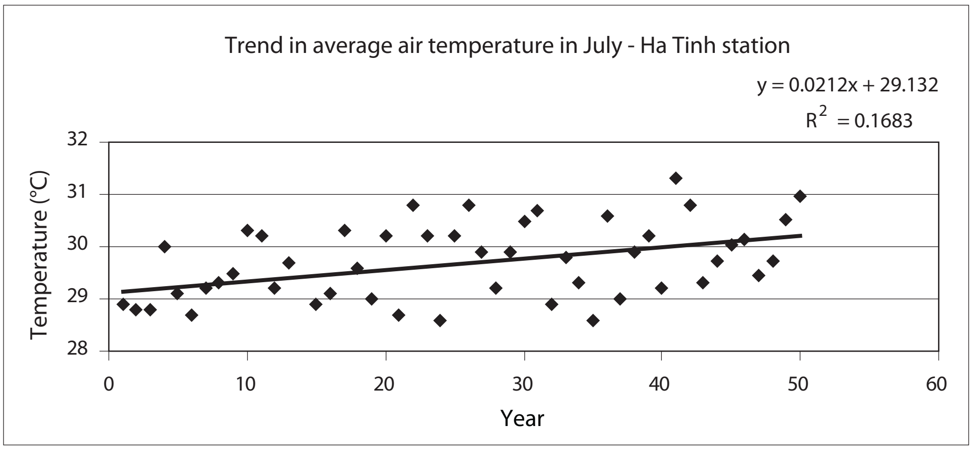

Trend in average air temperature in January - Huong Khe station
y = 0.0415x + 16.681
R2 = 0.1397
Temperature (°C)
22
20
18
16
14
0
10
20
30
40
50
Year

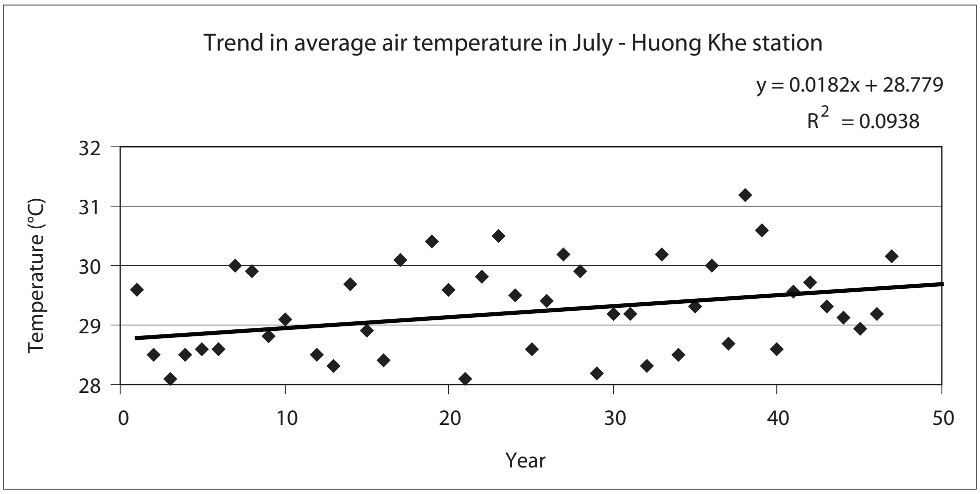

Trend in average air temperature in January - Ky Anh station
y = 0.027x + 17.404
R2 = 0.0619
Temperature (°C)
19
17
15
0
10
20
30
40
50
Year

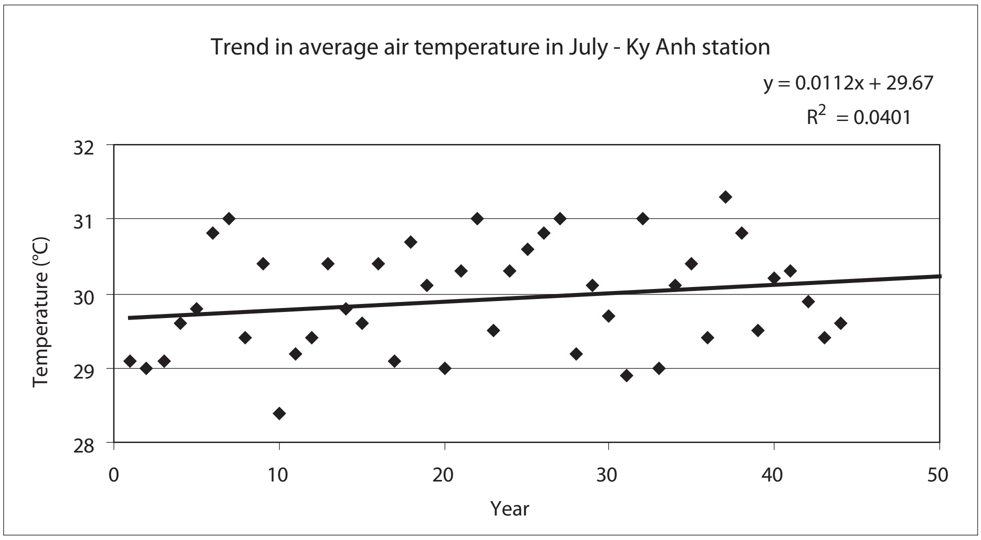

Trend in average air temperature in April - Ha Tinh station
y = 0.0158x + 24.067
R2 = 0.0322
Temperature (°C)
28
26
24
22
20
0
10
20
30
40
50
60
Year

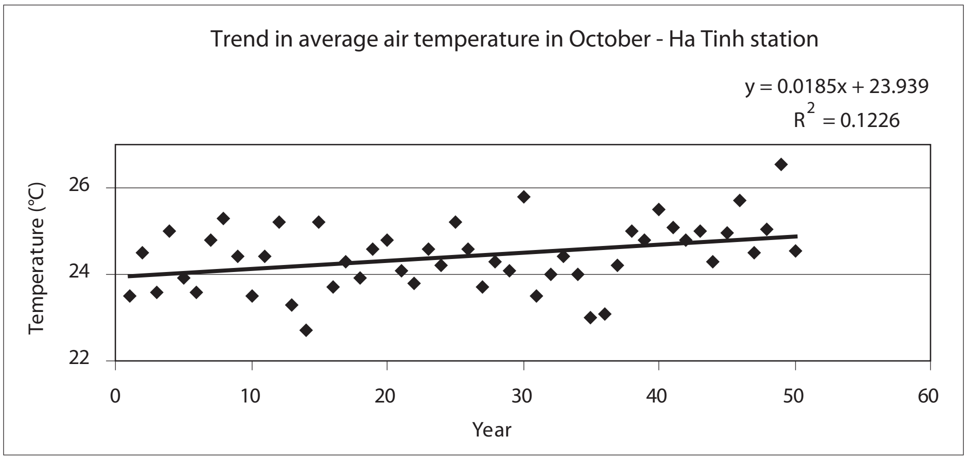

Trend in average air temperature in April - Huong Khe station
y = 0.0295x + 24.282
R2 = 0.0868
Temperature (°C)
28
26
24
22
20
0
10
20
30
40
50
Year

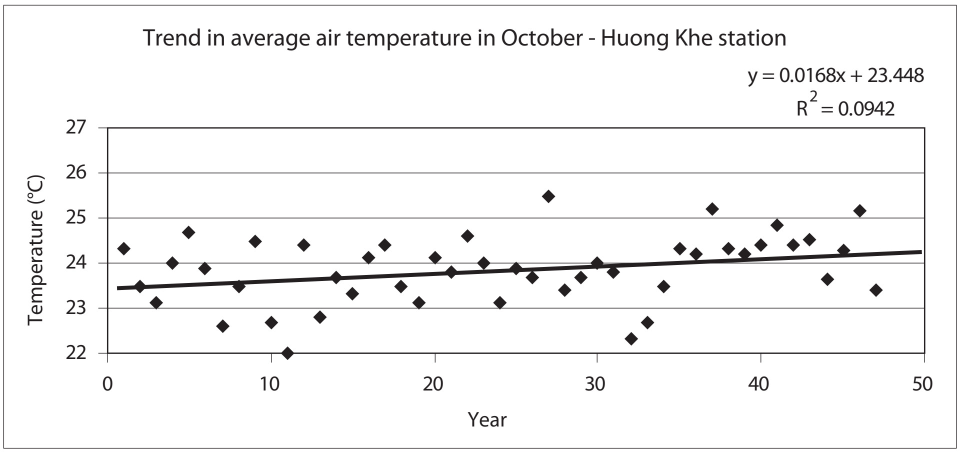

Trend in average air temperature in April - Ky Anh station
y = 0.0238x + 24.123
R2 = 0.0578
Temperature (°C)
28
26
24
22
20
0
10
20
30
40
50
Year

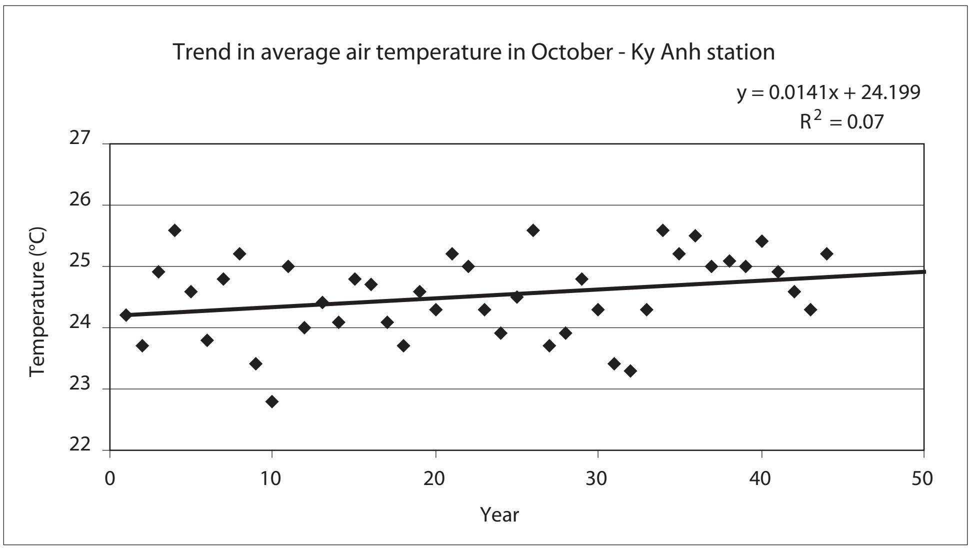

Trend in average air temperature in July - Ha Tinh station
y = 0.0212x + 29.132
R2 = 0.1683
Temperature (°C)
32
31
30
29
28
0
10
20
30
40
50
60
Year

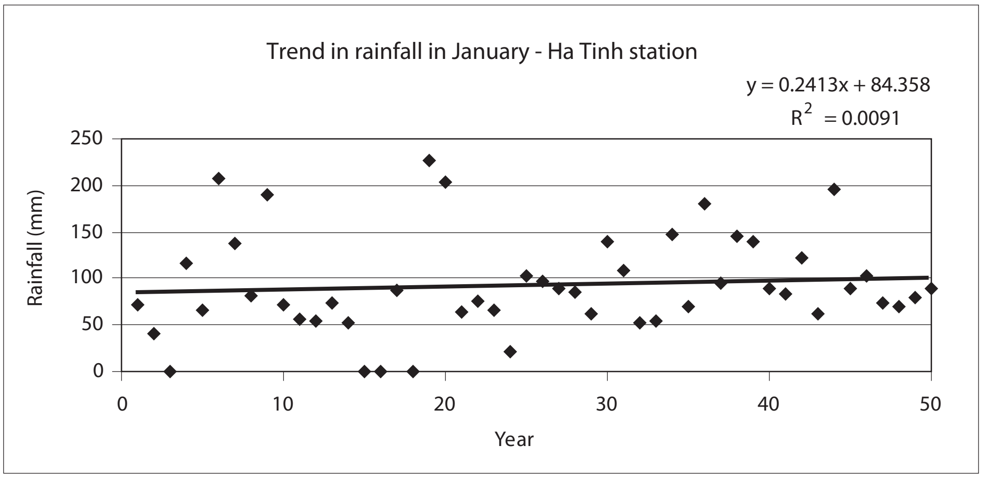

Trend in average air temperature in July - Huong Khe station
y = 0.0182x + 28.779
R2 = 0.0938
Temperature (°C)
32
31
30
29
28
0
10
20
30
40
50
Year

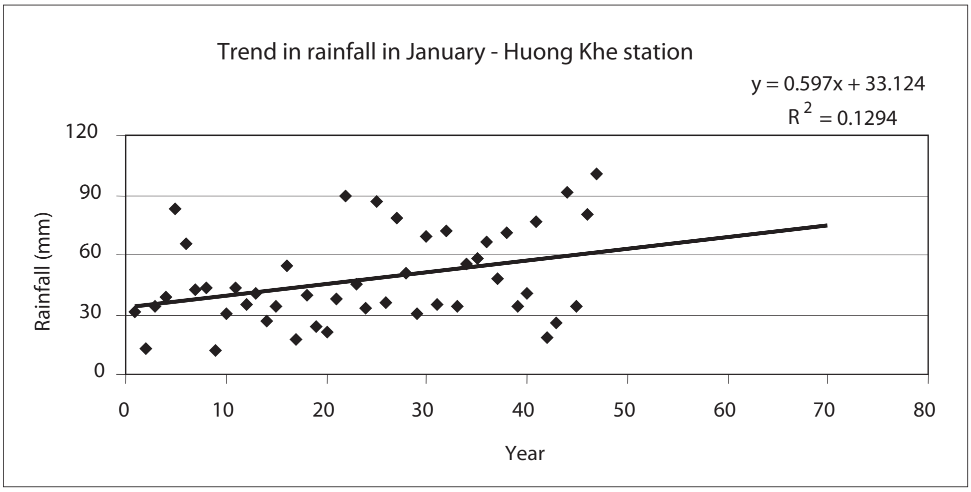

Trend in average air temperature in July - Ky Anh station
y = 0.0112x + 29.67
R2 = 0.0401
Temperature (°C)
32
31
30
29
28
0
10
20
30
40
50
Year

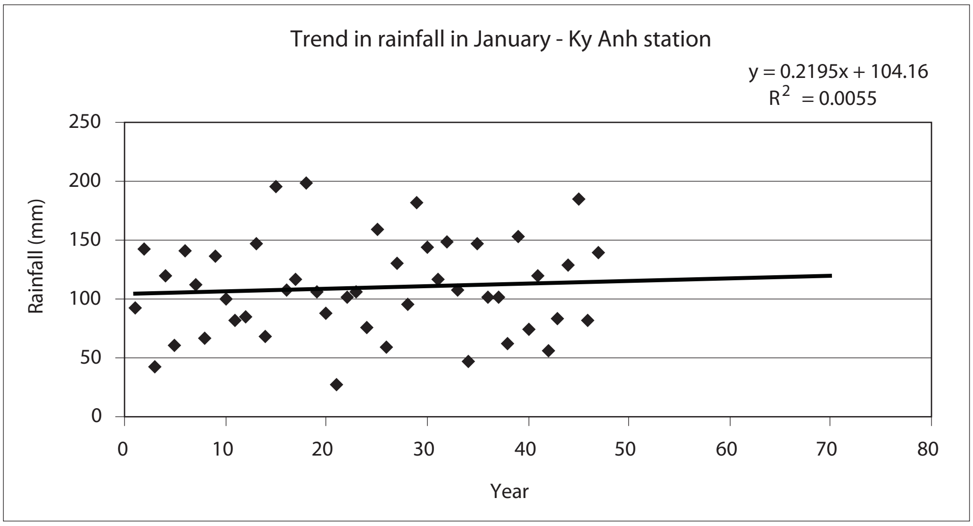

Trend in average air temperature in October - Ha Tinh station
y = 0.0185x + 23.939
R2 = 0.1226
Temperature (°C)
22
24
26
0
10
20
30
40
50
60
Year

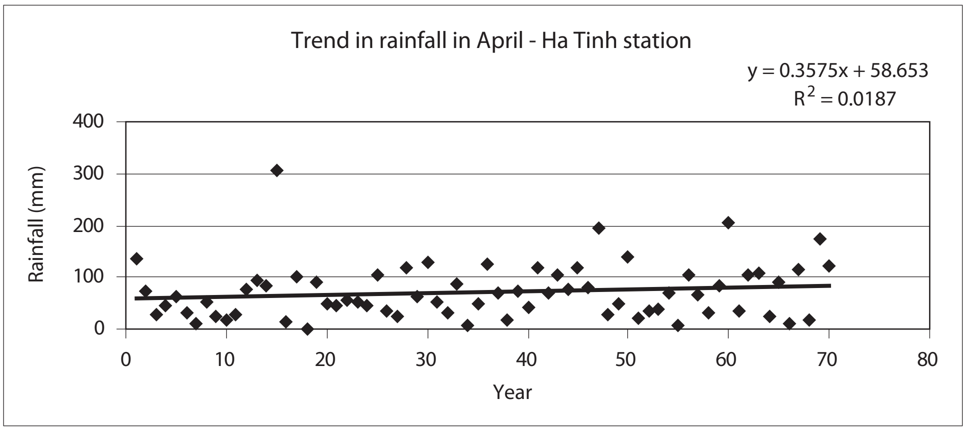

Trend in average air temperature in October - Huong Khe station
y = 0.0168x + 23.448
R2 = 0.0942
Temperature (°C)
22
23
24
25
26
27
0
10
20
30
40
50
Year

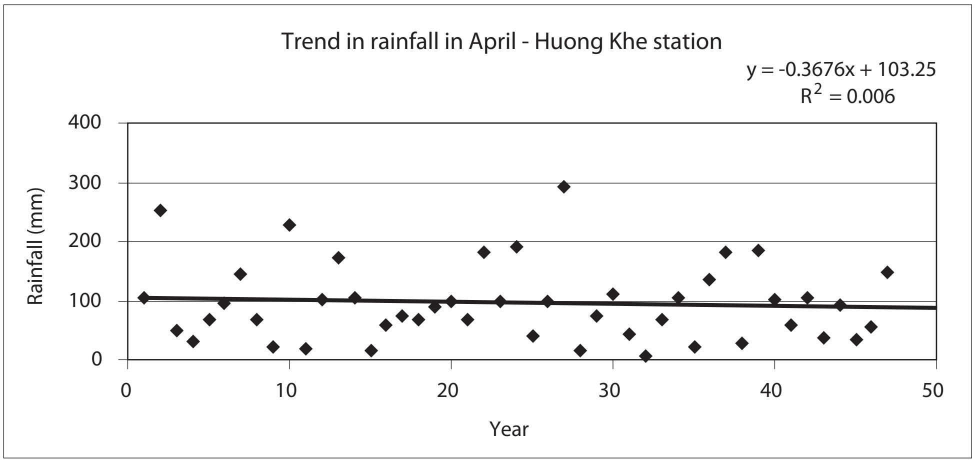

Trend in average air temperature in October - Ky Anh station
y = 0.0141x + 24.199
R2 = 0.07
Temperature (°C)
22
23
24
25
26
27
0
10
20
30
40
50
Year

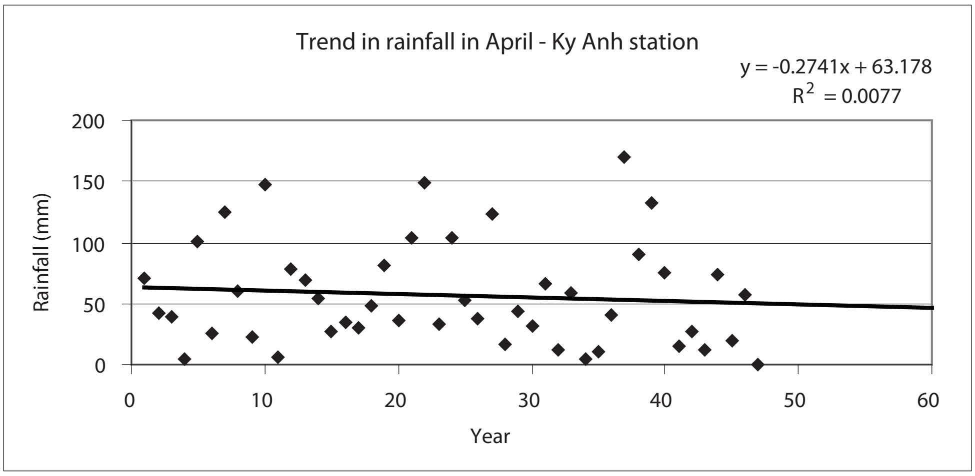

Trend in rainfall in January - Ha Tinh station
y = 0.2413x + 84.358
R2 = 0.0091
Rainfall (mm)
250
200
150
100
50
0
0
10
20
30
40
50
Year

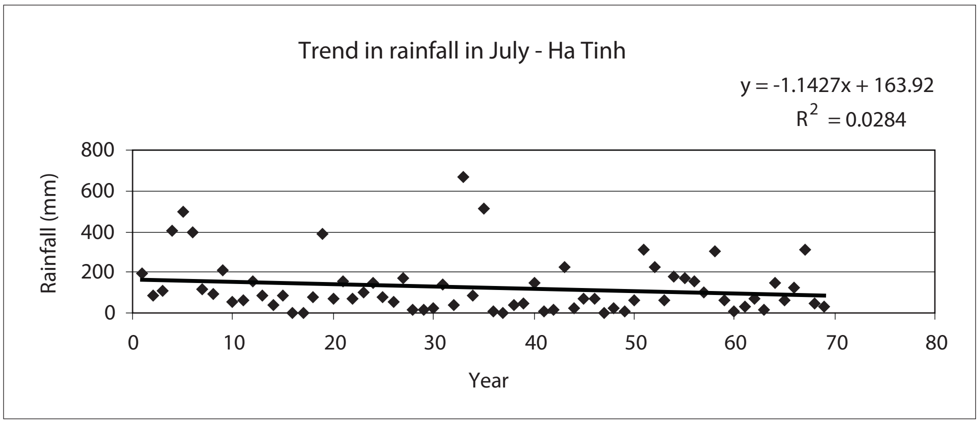

Trend in rainfall in January - Huong Khe station
y = 0.597x + 33.124
R2 = 0.1294
Rainfall (mm)
120
90
60
30
0
0
10
20
30
40
50
60
70
80
Year

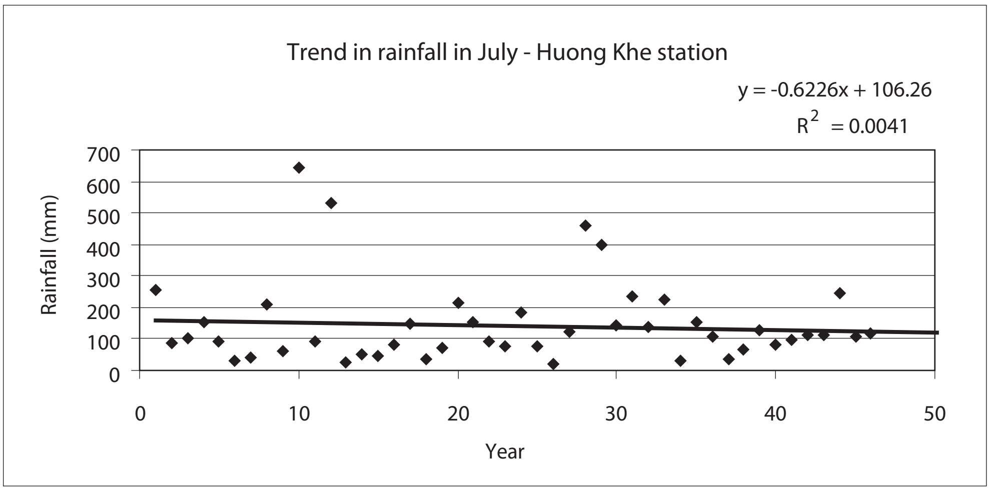

Trend in rainfall in January - Ky Anh station
y = 0.2195x + 104.16
R2 = 0.0055
Rainfall (mm)
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
Year

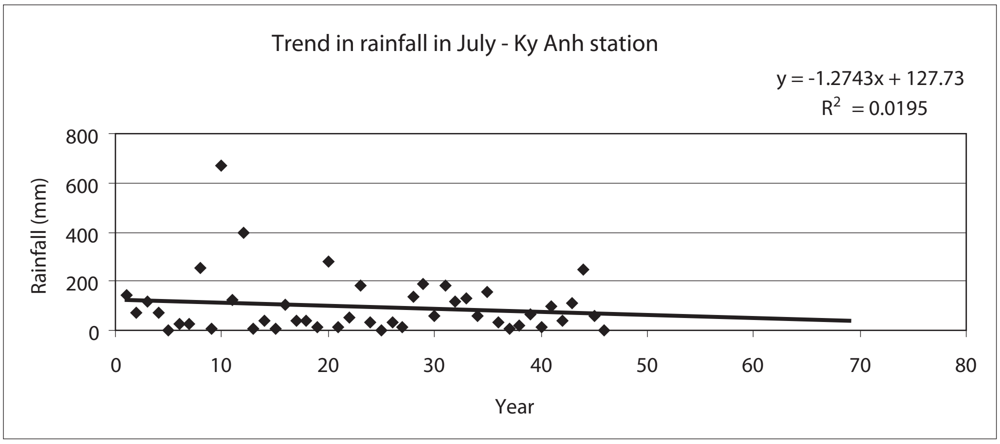

Trend in rainfall in April - Ha Tinh station
y = 0.3575x + 58.653
R2 = 0.0187
Rainfall (mm)
400
300
200
100
0
0
10
20
30
40
50
60
70
80
Year

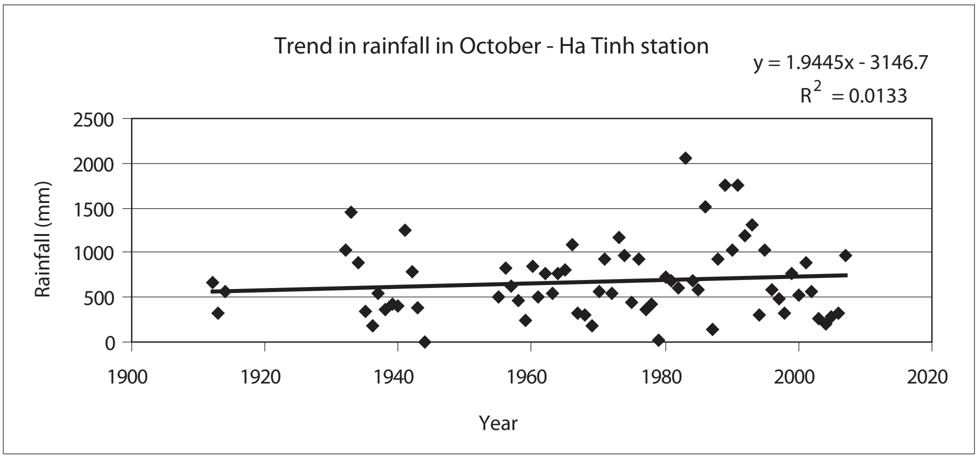

Trend in rainfall in April - Huong Khe station
y = -0.3676x + 103.25
R2 = 0.006
Rainfall (mm)
400
300
200
100
0
0
10
20
30
40
50
Year

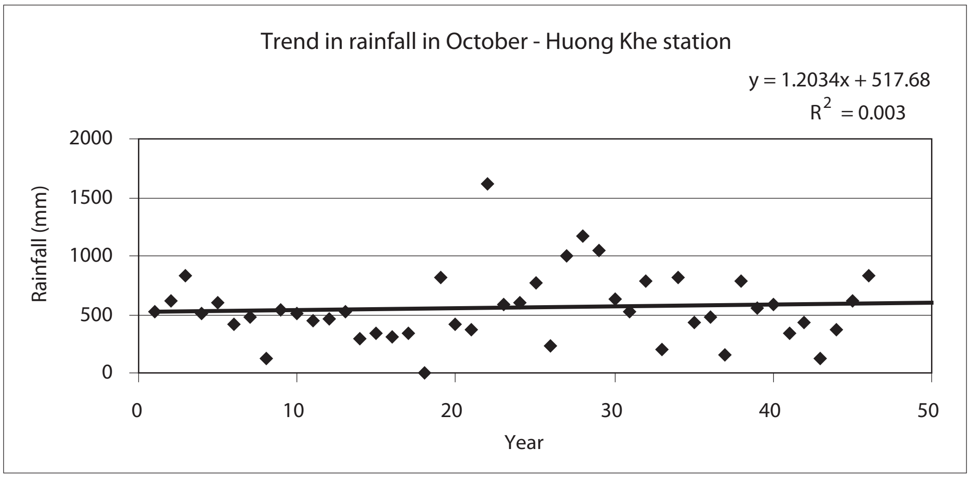

Trend in rainfall in April - Ky Anh station
y = -0.2741x + 63.178
R2 = 0.0077
Rainfall (mm)
200
150
100
50
0
0
10
20
30
40
50
60
Year

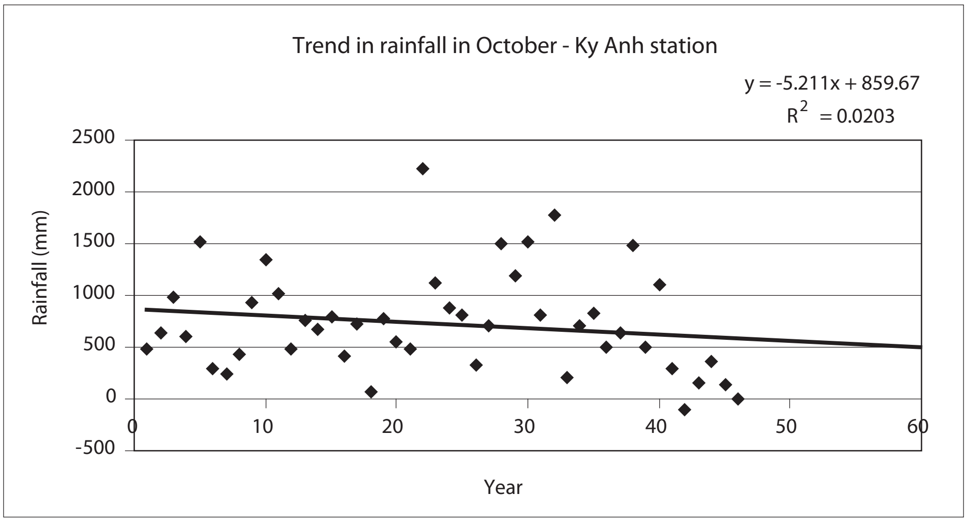

Trend in rainfall in July - Ha Tinh
y = -1.1427x + 163.92
R2 = 0.0284
Rainfall (mm)
800
600
400
200
0
0
10
20
30
40
50
60
70
80
Year


Trend in rainfall in July - Huong Khe station
y = -0.6226x + 106.26
R2 = 0.0041
Rainfall (mm)
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Year


Trend in rainfall in July - Ky Anh station
y = -1.2743x + 127.73
R2 = 0.0195
Rainfall (mm)
800
600
400
200
0
0
10
20
30
40
50
60
70
80
Year


Trend in rainfall in October - Ha Tinh station
y = 1.9445x - 3146.7
R2 = 0.0133
Rainfall (mm)
2500
2000
1500
1000
500
0
1900
1920
1940
1960
1980
2000
2020
Year


Trend in rainfall in October - Huong Khe station
y = 1.2034x + 517.68
R2 = 0.003
Rainfall (mm)
2000
1500
1000
500
0
0
10
20
30
40
50
Year


Trend in rainfall in October - Ky Anh station
y = -5.211x + 859.67
R2 = 0.0203
Rainfall (mm)
2500
2000
1500
1000
500
0
-500
0
10
20
30
40
50
60
Year

Chapter 4

Impacts of climate change in Ha Tinh

4.1 Overview of climate change impacts in Ha Tinh

Stresses from climate and climate-related events and phenomena that could be exacerbated by future climate change are already being felt by most countries through extreme weather and natural disasters in the region. Amidst various apprehensions about the likely impacts of climate change on the people, food security, ecosystems, etc., nations need to prepare on how to adapt themselves to this unprecedented threat. This requires special details on the nature of changes in the weather extremes and natural disasters as well that are likely to be superimposed on the increasing or decreasing trends in key climate variables such as temperature and rainfall. In the following, broad projections of these extremes and disasters likely in Ha Tinh in the future are discussed.

Tropical cyclone

A possible increase in cyclone intensity of 10-20% for a rise in sea surface temperature of 2-4^{0}C relative to the threshold temperature of 28^{0}C is very likely in major ocean basins. Tropical cyclones in the East Sea as well as in Nghe An-Ha Tinh-Quang Binh are, in future, likely to have higher frequency and intensity as compared to the past decades. The length of storm season along this coastal line could also become more variable and perhaps onset of storms could start before the historical storm season (April) and extend beyond the historical storm season (December) or shrink to only some months of the storm season.

Dry and hot westerly winds

Frequency of dry and hot westerly winds is likely to increase with time and length of each spell may become longer. The season of dry and hot westerly winds will, in general, begin earlier and end later, and hence last longer.

The cold front frequency to Ha Tinh is projected to reduce, cold front intensity is projected to decline, the temperature drop in a cold spell would be smaller and cold front season is likely to become shorter.

Temperature

Under the A1FI emission scenario, the rise of surface air temperature during the 2050s and during last decade of this century is projected to be in the range of about 1.4-1.8^{0}C and 3.5-4.2^{0}C respectively. The record maximum temperatures are likely to be higher than normal associated with frequency, length and intensity of heat spell. On the contrary, the record minimum temperatures are not projected to change significantly. Winter season is likely to set in later, and end sooner thus shorten in duration while summer season is likely to get more prolonged.

Rainfall

Total rainfall during the rainy season is projected to increase by 5–8% by the decade 2050 and 13–19% by the end of year 2100, whereas total rainfall during the dry season is projected to decrease by 1 – 5% by the year 2050 and 3 – 12% by the year 2100. Consequently, annually averaged rainfall is projected to increase by about 1% per decade.

The increase in intensity of rainfall and the number of wet days during the rainy season would enlarge the existing rainfall records including maximum daily rainfall, maximum monthly rainfall, and maximum annual rainfall and therefore, the potential of flood is also likely to increase. More intense rainfall spells are also projected in a warmer atmosphere, increasing the probability of extreme rainfall events and hence flash floods.

The decrease in rainfall intensity and length of duration during the dry season is likely to lead to increase in frequency as well as period and intensity of droughts.

Evaporation

Evaporation would be enhanced with rise in surface temperature, and is likely to contribute to higher drought index especially in the dry season when the rainfall is projected to decrease.

Sea level rise

Sea level rise is projected to be about 30cm by the year 2050 and 65cm by the year 2100. It translates into the sea level rise of 6-7cm every decade and 0.6-0.7cm every year.

4.2 Climate change impacts on water resources

The flow in all the four basins, namely, La river, Cua Sot river, Cua Nhuong river and Cua Khau river is likely to undergo changes in the similar manner as the big rivers in Viet Nam. This is anticipated in national announcement of Viet Nam: the annual current biases to the negative (4%-6% down to minus 14% - minus 20%), exhausted flow also biases to the negative (minus 2 % - minus 10% down to minus 14% - minus 24%); whereas flood flow biases to the positive (12%-15% up to 5%-7%).

It is projected that the flow change in rivers of Ha Tinh Province during the 21st century will be similar to the flow scenario for the rivers of Hue: the annual flow is likely to rise by 3%-4% in the first half century and by 6%-7% in the last half century; the flow in the flood-season rises by 6%-7% in the first half century and by 10%-12% in the last half century; but the flow in the dry season could fall by 5%-7% and 12%-13% in the first and last half century respectively.

Projected flow changes are likely to bring about the increase in salinity of one of the millionth in Cua Sot river, Cua Nhuong river, Cua Khau river, the salinity intrusion of more than thousands of kilometers in depth on the estuaries in the months of the dry season, especially during May, June and July.

Fresh water source is becoming scarce, the water quality in many coastal districts is deteriorating due to several factors but the most important ones are longer duration of droughts and more salinity intrusion. The situation is likely to exacerbate with the ongoing climate change.

Heavy rains associated with enhanced warming is projected to speed up land slides, end the aggradation process on lakes such as Ke Go lake, Rac river lake, and decrease in the capacity of lakes rather drastically in comparison with normal climate condition.

4.3 Climate change impacts on agriculture

Impacts of climate changes on plant distribution

A number of agro-climate factors related to plants are projected to change toward the direction of increasing tropical features and decreasing non-tropical features. These include the period or duration of high maximum temperature (> 25^{0}C) lasts about 10–20 days in the first decade (year 2050) to about 20- 30 days in the last decade (year 2100); likewise the period or duration of low minimum temperature (< 20^{0}C) decreases by about 10-15 days in the first decade (year 2050) and 15-20 days in the last decade (year 2100), total annual temperature increases by 100-300^{0}C in the first decade (year 2050) and about 500–900^{0}C in the last decade (year 2100). The highest temperature projections does not exhibit any considerable increase but the lowest temperature projections exhibit an increase by 2 or 3^{0}C in the next decade. Therefore, typical tropical plants such as rubber trees, coffee trees can grow favorably while crops of winter seasons and growth of cryophilic plants are projected to reduce.

Impacts of climate change on water sources for agricultural production

The decline in rainfall in the dry season in line with the increase of evaporation will increase the frequency and intensity of droughts and, as a result, the irrigation needs and production costs for winter - spring crop are projected to increase as well as the earlier beginning of main crop are projected. Furthermore, the increase in total rainfall and rain intensity during the middle and end of crop season could cause flood events to increase and will necessitate high demand of water drainage especially during the rice harvest time.

In coastal plain districts, increase in salinity intrusion which causes difficulties in drought prevention and leads to the rise of irrigation cost with time. Moreover, the rise in sea level is also likely to increase the risk of floods in rice growing area and for all crops, especially during the peak storm season (the end of autumn and the beginning of winter).

Available fresh water resources will be a scarce commodity for irrigation purposes in agriculture sector due to enhanced demand with increases in population, likely changes in hydrological cycle as a consequence of climate change and salinity intrusion in coastal areas.

Impacts of natural disasters in agricultural production

The increase in frequency and/or intensity of storms and tropical low pressure systems, in intensity of dry and hot westerly wind, more heavy rains and floods are likely to have negative impacts on agricultural production.

However, other natural disasters such as severe and damaging cold waves are also likely to occur more frequently due to enhanced variability in the climate.

Besides, insect pests are projected to increase and cause losses for agricultural production because the temperature rise and higher humidity due to more intense rains.

Impacts on crop productivity

The agricultural production losses due to rise in surface air temperature beyond the critical threshold would be significant. Irrespective of the aerial fertilization effect of atmospheric CO_2 enrichment which includes enhanced plant growth, increased plant water use efficiency, greater food production for both people and livestocks, plus a host of other biological benefits, the thermal stress due to rise in temperature and adequate and timely availability of rainfall due to projected changes would likely negate these positive attributes and the outcome would be a decline in crop productivity. In general, as the climate extremes become more severe, crop production will continue to fall. Excessive heat stress and high rain intensity will speed up landslides, and soil erosion processes which make soil arid, rapidly degraded and decrease crop productivity and livestock productivity as well.

4.4 Climate change impacts on fishery

In Ha Tinh, impacts of climate change on the fishery industry comes from 3 following consequences:

- The rise of sea level and the increase of salinity intrusion;
- The rise of sea surface temperature leading to the modification in thermocline;
- The increase of heavy rain episodes and high rain intensity.

Impacts of the rise of sea level and the increase of salinity intrusion

Salt water penetrates into the land and destroys suitable habitats of some freshwater aquatic products on main estuaries: Cua Sot river, Cua Nhuong river and Cua Khau river.

The rise in sea level causes bialneological, hydration, aquatic conditions to change possibly and leads to changes in structure and constituents of aquatic products. The sea level rise also affects aquaculture.

Impacts of the sea temperature rise

The sea surface and sub-surface temperature increases beyond a threshold limit can cause clear distortion in temperature stratification in vertical thermal structure in the marine boundary layer and will adversely affect living process of creatures and their productivity.

When the sea surface and sub-surface temperature rises considerably, some aquatic species would move further to the North or move down which would change aquatic structure in deeper waters. More seriously, subtropical fish of high economic value will decrease.

The sea surface and sub-surface temperature rise speeds up photochemical process and decomposition of organic substances that influence food source of marine creatures. The higher the temperature becomes, the more energy creatures will consume for respiration process as well as other activities.

The sea surface and sub-surface temperature rise would also contribute to degradation and even destruction of coral reefs and lead to unprecedented changes in physiological and biochemical processes in the relation of corals and algaes.

Impacts of the increase in rain frequency and intensity

Heavy rains would lead to the temporary decrease of salinity and may cause the mass deaths of brackish and coastal creatures especially bivalve mollusks. The increase in heavy rain episodes would also result in the flood water rise, and result in losses of freshwater aquaculture.

Impacts of the increase in storm frequency and intensity

For a province with long coast like Ha Tinh, fishing is an important part in the community livelihood. The rise in intensity and/or frequency of storms would cause additional difficulties and may cause great losses for coastal fisherman, especially for fishermen in estuaries where they earn their living by fishing on the sea.

4.5 Climate change impacts on forestry

Climate change impacts on forestry are likely through following consequences:

- Rise of the sea level and storm surges
- Higher radiation intensity, higher than critical threshold temperature and dryer and hotter westerly wind resulting in the decrease of humidity and the rise of evaporation.

Specific impacts of climate change are identified as under:

- The rise in sea level will shrinks mangroves' area mainly along aegiceras banks on the mouth of estuaries and sour cypress forests along rivers.
- High temperature and considerable decline in low temperature frequency creates good condition for the favourable growth of tropical industrial trees and avoidance of damaging cold in the first winter spell during growth process. Xerophilous forests also grow dramatically faster in hotter condition.

- Higher temperature, and higher radiation intensity enhances greening process but humidity decrease can restrain biomass growth index of forest trees. Furthermore, higher frequency and intensity of hot and dry westerly wind, higher temperature and evaporation will increase the risk of forest fire in the first and middle months of summer.

4.6 Climate change impacts on biodiversity

Factors affecting biodiversity

Climate change affects the ecosystem through following climate factors:

- The increase in storm frequency and intensity
- The decrease in cold front frequency
- The increase in frequency and intensity of hot and dry westerly winds
- The rise in air and sea temperatures
- The increase in total rainfall during the rainy season and the decrease in rainfall during the dry season.
- The rise of sea level

Impacts of climate change on ecosystems

Many typical organisms of the ecosystem in Northern Truong Son such as Sao La in Vu Quang mountain, wild animals, domestic animals and plants sensitive to climate condition such as stags in Huong Son mountain, Phuc Trach grapefruits, bu oranges will be unable to cope up with frequent occurences of extremes due to climate change e.g., the rise of dry and hot weather conditions, more severe dry season and more intense rainy season.

In the coastal and island areas, coral reefs in the oceans would be under the risk of bleaching due the effects of the sea surface temperature rise as in the year 1998. In that year, up to 30 countries reported massive coral losses which is estimated to make profits of about 30 USD billions of goods and services per year in the world.

On internal rivers and lakes, the increase in rainfall and stream flow change in the rainy season have completely changed the living conditions of aquatic creatures such as their food habits, breeding season. The situation is likely to exacerbate further in future.

Climate change would adversely affect the growth process of coastal mangroves through potential changes in the North-East monsoon, tropical cyclones, rise in sea level, and excessive erosion in many coast sections including the sections with predominant mangroves; flood tide is likely to carry excessive sand further into the shore and bury a part of the existing mangroves.

4.7 Climate change impacts on other economic sectors

Impacts of climate change on other economic industries mainly include impacts to industry, transportation, civil construction works and energy demand for citizens.

Industries

All mineral extraction works and industrial production in the beach plain would suffer more and more from increase in storm frequency, flood level and the rise in sea level. Works which are about to be repaired or constructed shall need to pay special attention to safety margin and parameters in design and construction relevant to likely changes in climate conditions during the life time of the infrastructures.

Transportation

Coastal traffic works which have been constructed shall need to monitor carefully and take into account the projected change in sea level rise. Traffic works in mountains, especially North-South railway shall have the risk of increased flooding, flash flood and associated landslides in the South West hill.

Civil works

Schools, hospitals and offices of districts, especially beach plain districts will be affected more and more by severe climate conditions and natural disasters: storms, severe heatwaves, heavy rain and floods.

Energy demand

There is an evidence to suggest that the energy sector will also be vulnerable due in large part to the climate-related risks associated with water availability, extreme weather events, and changes in seasonal temperatures. These particular impacts will have implications for energy supplies which depend on water at some stages of its production. From the demand side, increased temperatures will cause an increase in demand for electricity in the summer and a decrease in demand for heating in the winter. Energy infrastructure, such as transmission lines are particularly vulnerable to extreme weather events such as flooding, landslides, wave heights, and tropical storms.

4.8 Vulnerability to climate change

For several decades, Ha Tinh as well as North Central provinces have suffered from severe weather conditions during both winter and summer seasons, in dry season as well as in rainy season. However, during recent years, the weather has changed abnormally, for example, the dry and hot season has extended to the beginning or middle of September (1983, 1992, 2003), winter was more frequently affected by tropical cyclones, tropical low pressure systems, and the highest temperature recorded was over 42^0C (1992); other extremes include record high rainfall (1989), the highest number of servere heat wave conditions (1999).

Vulnerability to ongoing climate change in the Province would be represented in all ecosystems.

Even small changes in mean temperature and rainfall and its variability can also seriously affect biodiversity of dry land and wet land (agro-ecosystems), affect functions, constituents and development of forests (forest ecosystem), lead to decline in great number of freshwater creatures (freshwater ecosystem), make species living on island (island ecosystem) become extinct easily, and degrade coral reefs (marine ecosystem).

Vulnerability to climate change is also observed and would likely exacerbate in all socio-economic activities of regions especially coastal regions in the future.

Heavy rains, and flash floods are likely to occur in mountainous regions, which can damage crops, assets and life of people, erode and outwash veneer of soil, degrade soil and enhance desertification potential of the region.

Storms, tropical low pressure systems with strong wind, heavy rains, the rise in sea level associated with flood tide and storm surges are likely to damage houses, infrastructre, boats and rafts, and aquaculture units. The most serious damage are likely due to landslides, coastal erosion which carry over estate, gardens, accommodations of people in the coastal regions like what happened in Cua Nhuong.

4.9 Conclusions

1. Climate change will have adverse impacts in Ha Tinh through typical weather extremes such as the increase in intensity and frequency of storms, heat waves, more intense heavy rains and especially the rise in sea level.
2. Impacts of climate change in Ha Tinh will be notable in all sectors including water availability, agricultural productivity, aquatic productivity, forestry, industrial development, transportation resources out of which the most noticable is likely to be the negative impacts on agricultural, forestry and aquatic production as it would adversely affect the livelihood of the communities.
3. Climate change would also adversely impact biodiversity of the region including mountainous ecosystem, island ecosystem, coastal ecosystem, inland water ecosystem and mangroves.
4. Ha Tinh's vulnerability to climate change is likely to be felt across all ecosystems: agro-ecosystem, forest ecosystem, freshwater ecosystem, and regional ecosystems especially marine ecosystem.
5. Climate change will also have adverse impacts on the safety of industrial, traffic, civil works in terms of the design and construction.
6. The gap in electricity demand and production in the province is likely to widen due to climate change.

Chapter 5

Mitigation and Adaptation Policies and Measures on Climate change in Ha Tinh

5.1 Introduction to terms

Mitigation

Mitigation is bringing in changes or supplements to reduce the total amount of emission or the emission volume per unit of product. In terms of climate change, mitigation means to implement policies on green house gases reduction and increasing sinks absorbing green house gases.

Mitigation of global warming involves taking actions to reduce greenhouse gas emissions and to enhance sinks aimed at reducing the extent of global warming. Mitigation is effective at avoiding warming, but not at rapidly reversing it. Scientific consensus on global warming, together with the precautionary principle and the fear of abrupt climate change is leading to increased effort to develop new technologies and sciences and carefully manage others in an attempt to mitigate global warming. Ways of mitigating climate change include reducing demand for emissions-intensive goods and services, increasing efficiency gains, increasing use and development of low-carbon technologies, and reducing non-fossil fuel emissions.

Adaptation

Adaptation includes initatives and solutions for mitigating damages to natural systems and people in order to prevent real effects or potential effects of climate change. There are many adaptationing methods, including individual and community adaptation, voluntary and planning adjustment. For example, consolidating river and sea dykes, planting trees for preventing hot weather, etc.

Adaptation to global warming consists of initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. The fundamental principles to be considered when designing adaptation policy.

- The effects of climate change vary by region.
- The effects of climate change may vary across demographic groups.
- Climate change poses both risks and opportunities.
- The effects of climate change must be considered in the context of multiple stressors and factors, which may be as important to the design of adaptive responses as the sensitivity of the change.
- Adaptation comes at a cost.
- Adaptive responses vary in effectiveness, as demonstrated by current efforts to cope with climate variability.
- The systemic nature of climate impacts complicates the development of adaptation policy.
- Maladaptation can result in negative effects that are as serious as the climate-induced effects that are being avoided.
- Many opportunities for adaptation make sense whether or not the effects of climate change are realized.

Examples of adaptation include defending against rising sea levels through better flood defenses, and changing patterns of land use like avoiding more vulnerable areas for housing or other infrastructure construction purposes.

A significant effect of global climate change is the altering of regional and local rainfall patterns, with certain effects on agriculture. Extended drought can cause the failure of small and marginal farms with resultant economic, political and social disruption.

Agriculture of any kind is strongly influenced by the availability of water. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most crops and particularly so to corn, soybeans, and rice. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress. As a result, there will be a need to develop crop varieties with greater drought tolerance.

The demand for water for irrigation is projected to rise in a warmer climate, bringing increased competition between agriculture—already the largest consumer of water resources in semi-arid regions and urban as well as industrial users. Falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive, particularly when with drier conditions more water will be required per acre.

One strategy involves adapting urban areas to increasingly severe storms by increasing rainwater storage (domestic water butts, unpaved gardens etc.) and increasing the capacity of stormwater systems (and also separating stormwater from blackwater, so that overflows in peak periods do not contaminate rivers).

5.2 Climate change mitigation policies and measures

The feasible policies and methods for mitigating climate change in Ha Tinh, basically, are policies and measures for mitigating climate change in Viet Nam as well.

In a coastal province in the North Central, within the framework of National Program to response to climate change and sea level rise, the mitigating policies and methods are mainly clasified into two sectors: energy, forestry and agriculture.

5.2.1 Climate change mitigation policies and measures in energy sectors

- Assessing the general situation of power network in province, discovering inappropriate points in power network design and the old state of network of which wires and means of electrical transmission in some regions need to be replaced.
- Exploiting different investment resources, gradually replace or repair the local power network which has substantial losses in electrical transmission and distribution.
- Setting up common regulations on organizing and operating of the public lighting network in some regions and unions which have considerable need of lighting facilities.
- Setting up regulations on using electricity in organizations and enterprises of the State.
- Guiding and encouraging households to utilize appropriately electrical devices, especially the rating of using lamps and rational power of lighting at different urban and rural regions, etc.
- Regularly looking for models of economic cookers with the highest efficiency and encouraging people to widely use them, especially in the rural area.
- Step by step, putting the effecient lighting devices into practice, removing lighting equipments which consume a large amount of energy, such as incandescent bulbs.
- Evaluating the potentiality of hydroelectric energy, such as wind power, solar power at each different district or location which are in need of using a lot of energy, including resorts, small urbans, etc.
- Carrying out the survey to discover, designing and establishing medium and small hydroelectric plants at districts of flat regions.
- Encouraging fishermen and the households who do bussiness in tourism to recover the use of sailing boats in some activities of manufacturing and services.
- Carrying out the survey, forwarding to design and build some power stations with low capacity (For example, the wind station with capacity of 150W, the diameter of wing is 1.5 meters, the battery made by the Insitute of Energy).
- Evaluating the potentiality and encouraging households and collectives to use the solar power for different purposes, from low price to high price for dry and heat generating units, etc.
- Encouraging households, collectives to use sources of organic exhausts from animals (animals' excrements, people's excrements, wastes from the units producing seafoods and creatures) to plants (raws, stems and leaves of maizes, different kinds of vegetables and beans, etc) to make the cooker or generate the biogas.
- Carrying out survey on the amplitude of tide and evaluate the potentiality of tidal power at some regions of Ha Tinh coast.

5.2.2 Climate change mitigation policies and measures in forestry and agriculture

- Evaluating forest planning activities in the area, proposing long-term orientations and plans for development and protection of forests which are suitable with Viet Nam strategy for forest protection.
- Implementing the project of planting new 5 millions of hectares of forests in Viet Nam and plans for using 60% of the forestry lands by 2020.
- Solving shortcomings in protecting forests, especially the watershed forests and protective forests in the coastal areas.
- Carrying out planning activities to design and build protective forests and flooded forests in each coastal area, such as Nghi Xuan, Thach Ha, Cam Xuyen and Ky Anh.
- According to the Project 661, duplicating the model of Phuc Trach village - the Young set up their own business in mountainous districts, such as Huong Son, Huong Khe, Duc Tho, Vu Quang.

- Implementing program of developing rubber forests and wood forests following the province's plan: 12.000ha of rubbers, 42.000ha of eucalyptus, glues and cajuputs.
- Recovering thousands of hectares of bare soils and hills to plant fruit trees, medicinal trees and other tropical trees.
- Making efforts to mobilize and plant trees seperately in different households, public places, schools, hospitals, infirmaries, offices, etc.
- Planting trees appropriately and developing greeneries in Ha Tinh city, Hong Linh town and other towns in the province.
- Improving activities of preventing forest fires, predicting the risks of forest fires and issue warning in time for likely cases of forest fires, especially in the hot weather.
- Gradually, experimenting and improving irrgation and drainage activities through appropriate techniques of drainage in paddy fields, after the period of growing in some branches and before-ripening of rice crops.

5.3 Climate change adaptation policies and measures

Basically, policies and methods for adaptation to climate change in Ha Tinh are policies and methods for adaptation to climate change in a coastal province in the North Central, within the framework of National Target Program to response to climate change and sea level rise.

5.3.1 Climate change adaptation policies and measures in water resources

- Building dams and water reservoirs for storing water, flood control and regulating water supply and use in dry weather.
- Upgrading and expanding the irrigation and drainage system.
- Upgrading current river and sea dikes, gradually expanding and building sea dikes in coastal areas.
- Organizing the residential areas for preventing damage due to rising sea water in the whole area and inshore areas.
- Building and completing the mechanism of controlling and collecting water resources at river basins, especially advanced procedures for regulating water reservoirs.
- Organizing agricultural production in the wild lands, especially hills and mountains in the midlands, improving techniques of agricultural and aquatic product cultivation.
- Protecting and developing the watershed forests in some districts, such as Huong Son, Huong Khe, Vu Quang, Cam Xuyen, Ky Anh.
- Increasing efficiency in water use, regulating currents in dry weather by water reservoirs.
- Improving the public awareness on using safely and appropriately the surface water and ground water.
- Conducting research on long term forecasts and water use plans.

5.3.2 Climate change adaptation policies and measures in agriculture

- Rechecking and regulating plans of crop schedules, irrigation and drainage activities to be suitable with climate change situations.
- Building dams and water reservoirs, controlling floods and regulating water in dry weather.
- Upgrading canals for draining water away with irrigation and drainage systems, install pump stations to serve agricultural purposes.
- Practising irrigation and drainage more effectively.
- Setting up suitable structures for crops adapting to the situation, cultivating new seeds which are able to grow in severe weather, such as floods, droughts, etc.
- Conservating and protecting local species, establishing the bank of cereal seeds.
- Applying cultivation activities which are suitable with climate change situation.
- Improving awareness and popularizing knowledge of climate change and climate change adaptation to farmers.
- Developing and upgrading the production model of garden-pond-cage.
- Creating jobs for people to increase the income in the rainy season and free time.

5.3.3 Climate change adaptation policies and measures in forestry

- Promoting activities of reforestation, namely, planting trees in the watershed regions, the bare soil and hill areas, protecting unregulated stream water flows by developing forests.
- Protecting current mangrove forests and replanting some of those forests; controlling flooded forests, mangrove forests, ranges of eucalyptus forests, etc.

- Protecting protective forests, developing the producing forests and exploiting natural forests appropriately.
- Preventing forest fires in dry weather, educating and encouraging people to end the evil of burning forest, controlling and punishing severely that evil.
- Establishing the bank of natural forest trees' seeds in order to protect valuable and rare species.
- Improving the manufacturing technique of woods and restricting the usage of wood materials.
- Selecting and developing forest trees' seeds which are suitable under warmer climate and can grow in severe weather conditions.

5.3.4 Adaptation to climate change in sectors of industry, engery and transportation

- Upgrading and repairing transportation infrastructure in region prone to submergence due to sea level rise and flood risks.
- Identifying regions, locations which are subject to soil erosion and the steep terrains and hilly areas which run the risks of flood sweeps.
- Early warning for local people to evacuate from dangerous areas.
- Maintaining streets and roads frequently.
- Considering different factors of climate change in planning of seaport energy, stores coastal areas or low-lying lands.
- Implementing strict regulations of waterborne transportation, warning ships and boats in cases of floods and dry weather.
- Comprehensively managing water resources based on the regulations to meet the needs of relevant sectors: electricity production, irrigation and drainage, aquaculture, etc.
- Controlling energy needs based on the regulation of ensuring higher power efficiency, appropriate power consumption and stable power security.
- Invest in researching and predicting hydrological regulations and currents in order to ensure the safe operation of water reservoirs.

5.3.5 Climate change adaptation policies and measures in healthcare

- Improving socio-economic conditions and people's standard of livings, especially poor people and those in evacuation regions; promptly carrying out the hunger elimination and proverty reduction program at local level.
- Improving people's awareness, educating people about the knowledge of domestic sanitation and culture through the Clean Water and Environmental Sanitation program at the national and local level.
- Developing and carrying out programs and action plans on improving medical care in regions which risk the epidemic diseases, aimed at giving timely solutions for dealing and controlling these diseases.
- Determining the green and clean residential areas in densely populated areas.
- Determining the target for constructing houses at each region, considering the risk of climate change and natural disasters.
- Improving public's awareness and individual awareness on climate change so that each member in social community can create their own adaptation solutions.
- Quaranteening the border areas in order to prevent the spread of epidemic diseases to other places.

5.3.6 Climate change adaptation policies and measures in tourism

- Completing detail plans for major tourism spots, enhancing investment in tourism infrastructure which is suitable with adaption policies to climate change.
- Continuing issuance of management regulations for major tourism spots, environmental standards, etc. of those which are suitable with adaptation policies to climate change.
- Issuing policies of encouraging investment to explore the tourism potentiality and serve for development of sustainable ecological tourism.
- Conducting research on ecological tourism development under the situation of implementing solutions adapted to climate change.
- Training, educating tour guides, holding seminars, exchanging experiences on developing tourism which is friendly with environment and adapts to climate change.

5.3.7 Climate change adaptation policies and measures in biodiversity

- Continue researching and investigating on the basis of evaluating the biodiversity values in different ecosystems: forests, sand dunes and seas. Researching potential solutions in order to recover ecosystems, especially coastal ecosystems such as flooded forests, corals, and sand dunes.

- Concentrating on establishment of conservation zones of oganisms and biodiveristy of province.
- Implementing the strategy of controlling forest fires, for protecting the forests, taking priority of local forest trees to endure the severe weather conditions.
- Employing plans and methods to prevent and kill harmful foreign organisms, such as medium-sized edible snails, etc.

5.3.8 Adaptation options to climate change in districts

- Checking and regulating crop plans and seasonal schedules to be suitable with climate change situation in the district.
- Paying attention to the irrigation and drainage techniques, ensuring the stable efficiency of crop plants in more severe weather conditions.
- Applying more advanced techniques of catching seafoods in other provinces, paying attention to improve technique of cultivating seafoods.
- Developing long-term plan to ensure food security to cope with the losses due to increase in storms and floods and other natural disasters.
- Looking after, protecting and developing the flooded forests and ranges of protective forest at coastal areas.
- Developing activities of planting trees in households and on the abandoned land.
- Building projects, using solar energy which consumes less living mass materials in civil activities and utilizing wind power for tourism, catching up seafoods, contributing to reduce power energy consumption.
- Regulating or changing some plans of standard projects, designing projects of transportation protection, architecture, seafood manufacturing industry, education and medical care centres, etc; dealing with rising sea water and flooded areas.
- Increasing public's awareness on climate change, knowledge of adaptation to climate change in order to make flexible changes in the cause of public environmental protection.
- Organizing epidemic prevention activities effectively, especially with rising tropical diseases.

5.4 Conclusions

1. It is possible to build and implement many policies and measures to adapt to climate change in Ha Tinh, within the framework of National Target Program to Response to Climate change in Viet Nam.
2. The mitigation policies and methods for climate change would contribute to reduce the total amount of emissions in short term and long term. They include policies and methods in energy sector, such as energy saving, increase in energy use efficiency; development of renewable energy. Besides, there are policies and measures in forestry and agriculture, mainly forest development, appropriate and sustainable exploitation of forests and prevention of forest fires.
3. Climate change adaptation policies and measures must be able to prevent potential effects of climate change in almost all socio-economic sectors: water resource, agriculture, forestry, industry, energy, transportation, medical care from delta provinces to mountainous provinces, especially the coastal areas.
4. Basically, policies and methods for mitigating and adapting to climate change are suitable with policies of exploiting appropriately natural resources, environmental proctection and other socio-economic, sustainable development programs of our country.

Box 5.1 Climate Change Adaptation Measures in Thuan An town, Thua Thien Hue province

Works solution

Building and reinforcing dikes and embankments

In order to reduce effects of natural clamity and climate change phenonmena, the local authority and people have made great efforts to strengthen and build new works in the area, including:

- The purpose of building Thao Long dam in Dien Truong village is first to separate the salts in lagoons out of paddy fields and against Hương river, secondly to letting water out in flood reason. With the central expense, this dam was built in 2000, and completed at the beginning of September, 2006.
- In 2003, Dien Truong dyke was built, connecting the highway number 49A with Quy Lai dyke to separate salts in shrimp lakes in Tan My and Dien Truong out of the whole agricultural areas in Phu Thanh and Dien Truong. Up till now, only 400 meters of dyke has been built.
- At the beginning of 21st century, H-shape dike was built in Thuan An gate to prevent salts and floods. At present, one part of this project is sunk, and the rest contributes to make the Hai Tien bay for anchorage of ships, helping fishermen to avoid the risks from storms and preventing floods from Huong river. This part includes 500 meters that belong to Hai Tien town, called Hai Tien rock way. Some people are now living in this part.
- Next to Thuan An seaport is Hoa Duan channel, which belongs to Minh Hai and Hai Thanh village. In flood season during 1999, this channel was broken, that led to the soil erosion in dam and caused severe damages for 64 households. These households had to move to settle down in Rong village. After that, Hoa Duan channel was reconstructed. Now, it is one part of Highway 49B going through Minh Hai and Hai Thanh village. At present, Minh Hai and Hai Thanh villagers have settled in this area and built a seaside resort with poplar forests replanted after 5 years of constructing Hoa Duan dam.

Storm warning station

- The storm warning station at Thuan An gate was built in 2000. Thuan An border post has continued to inform fishermen about the storms by signal fires and also transmitted through radio signals. The lighthouse is 300 meters from the gale warning station, which is 12-13 meter in height, belonging to Hai Duong communes (near Thuan An). It was built in 2001. When it had not been built, people used the 5-6 meter flagpole in Tan Lap village to hang the warning flash to inform the communities about approaching storms and help to orient fishermen. These two projects are under the control of Thuan An border post.
- When natural disasters occur, almost all ships and boats hide themselves in local shelters:
  - An Hai anchorage for ships, boats, ferries
  - Tan Binh, Tan Lap anchorage for ferry boats of Tan Binh and Tan Lap
  - Hai Tien anchorage gives priority to ships with more than 22 CV
  - Thuan An fishing port for anchorage of high power means of transport
  - An Hai Bay for small boats

Non-work solutions

Utilizing knowledges on local weather and climate

Indigenous knowledge is experiences which have been summed up in daily activities and production activities and have been preserved from one generation to next ones. Thuan An people have applied the indigenous knowledge on weather prediction and repetition frequency of extreme phenomena to strengthen the adaptive ability in whole process of coping with natural disasters.

Most of all indigenous knowledge is in forms of singings, and traditional folks.

Enhancing the adaptation capability

In daily and production activities, Thuan An people have created themselves different methods to adapt and cope with natural disasters.

Houses in low-lying lands, or located near the lagoons, riverbanks, sea sides are often built with high and stable foundations. The makeshift houses in catching area of aquatic products are constructed with cheap materials, for easy shifting to higher areas. Almost all families have motorized junks and rubber rings as protection in case of floods.

Almost all people in the area know how to swim. Children who are over 10 ages can swim well.

Organizing activities for preventing natural disasters

Thuan An town has a Steering committee for preventing floods. Its head is President of the town. The Steering committee also has representatives from all relevant agencies and four local steering committees managed by commune's executives or head of villages.

Those who participate in flood prevention activities are members of different associations, unions and armed forces.

People's committee of Thuan An is the focal body in all activities of controlling natural disasters.

PROJECT MANAGEMENT UNIT OF YOUNG PROGRAM IN PHUC TRACH COMMUNE

The effectiveness of the Project 661 has influenced to the construction of Young Village. Phuc Trach Young Village was constructed in the land of Huong Trach and Phuc Trach communes of Huong Khe district of Ha Tinh province. In 2001, the Prime Minister approved for Young Communist League to construct the pilot young village model for Nghe An, Ha Tinh, Quang Binh and Quang Nam provinces which site along Ho Chi Minh Road aim to exploit potential land for socio-economic development when the construction of this road has been completed.

FIVE MILLIONS HECTARES REFORESTATION PROGRAMME

Conclusions and Recommendations

1. Conclusions

1. Ha Tinh is a coastal province in the North Central with severe natural conditions. The socio-economic conditions mainly comprises of agriculture which depend much on nature.
2. Ha Tinh has tropical monsoon climate, is cold in winter and rainy at the first half of season, less rain in the later half. In summer, weather is hot at the beginning and the middle of the season due to effects of dry and hot westerly winds.
3. Ha Tinh suffers strongly from natural disasters, such as tropical cyclones, hot weather, droughts, floods, etc. Especially, the dry and hot westerly winds in the middle of summer season interrupts the rain season when the temperature gets abnormally high and the evaporation is at its peak. This results in serious droughts and subsequently it faces repeated spells of heavy rains and tropical storms.
4. In Ha Tinh, all climate elements have exhibited some changes during the period of available records, including natural cyclicity, and forced changes due to global climate change. Natural cyclicity leads to intra and inter annual variability around average numeric value of many years. Forced (anthropogenic) changes have been slow, but significant with clearly discernable trends.
5. Over the later half of the last century, anthropogenic changes have made essential contribution to significant climate change in Ha Tinh, especially during the 1986-1990 period. Many records about westerly winds and extreme temperatures were set in which the most noticeable one was the number of days with hot westerly winds went up to 93 days in 1993 and the highest temperature recorded up to 42.6^{0}C in 1992 ranking the first in our country. The records were also set in with the daily rainfall in excess of over 790.1mm, just only lower than some regions in Hue City, etc. However, according to the criteria of statistical probability in climate, not all the climate elements have exhibited identically uniform increasing or decreasing trends.
6. Two climatic elements that tend to have increased remarkably in Ha Tinh are the number of heatwaves and numbers of hot days, average temperature in the year and months. The hot days have increased by 3 days in each decade, and annual average temperature have increased by 0.14-0.25^{0}C each decade. The result is that for the period of past 45 to 50 years, average temperature in Ha Tinh have increased by 0.7 to 1.0^{0}C, the highest in Viet Nam.
7. As for the scenarios of climate in future, average surface temperature is projected to continue to increase by 1-2^{0}C at the end of decade 2041-2050 and 2-4^{0}C at the end of decade 2091-2100. Annual rainfall is projected to increase by 3.5% at the end of decade 2041-2050 and between 5 and 11% at the end of decade 2091-2100. As is the generalised scenario for entire Viet Nam, sea level will rise by 30-33cm at the end of the decade 2041-2050 and from 74 to 100cm at the end of decade 2091-2100.
8. Global climate change has resulted in changes in almost all climatic elements in Ha Tinh and the climate has become more extreme. Temperature range is higher, frequency of dry and hot westerly wind is more, season of westerly wind comes earlier and ends later, whereas the cold season is shorter, frequency of low temperature has decreased. The records for extremes in both maximum temperature and minimum temperature have increased. Storms have intensified in terms of frequency and rain intensity is more irregular. Rainfall in rainy season and intensity of rain have risen. Meanwhile, rainfall in dry weather has decreased, frequency and intensity of floods have increased, and the frequency and intensity of droughts are also on the increase.
9. Climate change has led to many visible impacts and potential effects to every socio-economic sector in each region from delta to mountains in Ha Tinh province, especially:
   - Water resources have deminished, flood currents increased, exhaust currents decreased, and salinity penetration has widened. The surface water resources have become rarer and underground water is more difficult to be explored and exploited.
   - There have been changes in distribution of cultivated crops and seasons of crops, namely in a wider expansion of tropical plants and restriction to subtropical plants and cold season plants. The demands for irrigation and drainages has led agricultural expenses to escalate. Soils in mountainous areas and delta are degenerated quickly due to erosion and quick discoloration. This has led to a net decline in yields and total productivity of crops. The animal husbandry has also coped with stresses because poultries and

cattles have to live in an environment, which is less adaptive, and epidemic diseases have increased.

- In terms of agriculture, biomass indicators have risen. The areas of flooded forests and protective forests were not restricted, which leads to the increase of forest fire cases.
- There were many visible changes in aquatic life and liquefication, causing changes in distribution and customs of aquatic life, damaging the coral reefs along the coastal waters.
- Transportation, construction projects and other civil projects are facing risks, due to rising sea water which has led to massive erosion along coastal regions, floods and erosion due to mud slides and land slides in mountainous areas.
- The losses of life and properties have risen because of more severe natural disasters in mountainous areas, and deltas. The number of epidemic diseases has also increased, especially tropical diseases, such as malaria and petechial fever, etc.

10. Climate change mitigation policies include some policies and measures in energy sector:
    - Increasing the efficiency in energy use and energy saving
    - Development and application of renewable energy sources
    - Exploiting appropriately the fuel sources of living mass, including some policies and measures in forestry and agriculture sectors
    - Recovering and developing flooded and protective forests along coast lines
    - Exploiting the forest resources sustainably and preventing forest fires, and
    - Improved irrigation management and drainage system, together with appropriate savings of water resource.
11. Adaptation policies and measures to climate change include some policies and methods which are mainly in following subjects:
    - Utilizing water resources scientifically, appropriately and efficiently
    - Improving techniques of agricultural cultivation to circumvent the impacts of climate change
    - Supervising and controlling medical emergencies, preventing and treating vector borne diseases and some policies and methods for districts: Implementation of integrated coastal zone management; Developing agricultural and forestry based economy in mountainous areas.
12. Policies and measures for mitigating and adapting to climate change in Ha Tinh comply with recommendations of international organizations on climate change and adapting to the real background of Viet Nam and, in particular, Ha Tinh.

    It is important to emphasize that policies and measures for coping with climate change in Ha Tinh are totally compatable with socio-economic development policies of our country.

2. Recommendations

1. Impacts of climate change are threat to every social sector of any regions, but the most serious challenge is for locals where natural conditions are severe, with many natural disasters, and the standard of livings, together with production level are still low, such as some coastal provinces in North Central. Therefore, in order to prepare favorable conditions to overcome those challenges, from now we have to prepare long term plans to monitor climate change, to evaluate its impacts and to build appropriate solutions and policies to adapt to climate change in the whole province and in each region of the province.
2. Among the activites to deal with climate change, the most important mission is to build action plan to adapt to climate change. In order to make this program realistic, it is necessary to integrate adaptation policies and measures into socio-economic development plans in general, including hunger and poverty reduction.
3. Climate change is an urgent issue which consists of many new and complicated scientific aspects. Therefore, we should have programs to train people on adaptation pathways to climate change and gradually help them to enhance their capacity and capability on coping mechanism. It also needs to improve monitoring and analytical skills related to climate change, including observing and keeping track of climate change, evaluating impacts of climate change and building solutions to cope with.
4. We need to acquire and apply experiences from many developing countries to implement mission of coping with climate change, which originates from public interest, and is based on public interest and combining scientific knowledge with popular experiences of the public.

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