# EXECUTIVE SUMMARY

## I. Research Problem

Climate change is the reality of the time. An increase in temperature by 2-4$^0$C is projected by the climatologists for India by 2050s. They expect the number of rainfall days to decrease with significant regional variation and an increase in the intensity and frequency of extreme events, such as droughts, floods, tropical cyclones, precipitation events, hot extremes and heat waves is also being projected. In the North-Eastern region, the number of rainy days is likely to decrease by 1–10 days and the intensity of rainfall in the region is likely to increase by 1–6 mm/day. The projected increase in these events will result into greater instability (seasonal/annual fluctuations) in food production which directly threatens the livelihood of the farmers. The available evidences from crop growth simulation models show a significant drop in the yields of important cereal crops like rice and wheat under the changes in climatic conditions. The impact of climate change on agriculture is expected to suffer serious damage in India as Indian agriculture is mainly rainfed. In a country that gets rain for less than 100 hours in a year (a year has 8,760 hours), this would be disastrous. However, given the fact that the intensity of irrigated gross cropped area to gross sown area is only 45.3 per cent, Indian agriculture continues to be fundamentally dependent on the weather. Rainfed agriculture, mostly practiced by the poor, is more vulnerable to climate change.

The hills of India are well known for its biodiversity but at the same time the hill eco-system are more fragile. The farmers in the hills still depend on the local varieties of cereals and mostly practice organic agriculture. The productivities of different crops are much lesser than the national averages; hence, the hill agriculture becomes more vulnerable to the changes in climatic parameters. In the absence of occupations, in the hills, other than agriculture, the livelihood of the people is expected to be adversely affected by the changes in climatic conditions.

Our present system of knowledge is not enough to develop practical and efficient in estimating the impact of climate change. Hence, there is a need to further strengthen the knowledge base on the emerging challenge of climate change and its impact on crop yield and farm livelihood.

**Specific objectives:**

- To analyze the trends in rainfall and temperature.
- To estimate the impact of climate change on mean yield and variability in yields of major crops and to identify landraces grown by indigenous people to such variability.
- To study the gender specific impact of climate variability on farm livelihood.

## II. Methodology

**Locale of the study**

The study was conducted in North Eastern Himalaya (NEH) of India which is comprised of Sikkim, Darjeeling district of West Bengal (except Siliguri sub-division), Meghalaya, Arunachal Pradesh, Karbi Anglong district of Assam, Nagaland, Manipur, Tripura and Mizoram.

**Sampling Design**

Multistage sampling technique was applied for primary data collection in the present study. One vulnerable district, as identified by Central Research Institute for Dryland Agriculture (CRIDA), from each of the NEH states was selected randomly for primary data collection. In case of Assam, out of the two hill districts *i.e*, Karbi Anglong and North Cachar (N.C. Hills), Karbi Anglong district was selected randomly. Darjeeling (except Siliguri Sub-division) district from West Bengal, was selected as it is the only hill district in the state. West Tripura district of Tripura was identified as the vulnerable district by ICAR. But now the district is bifurcated into two districts *i.e.*, West Tripura and Khowai; hence, West Tripura district was selected randomly.

From each of the districts, two blocks were selected randomly. From each of the selected blocks two clusters of villages consisting of two to four villages were selected randomly. From one block 60 farmers, comprising both the gender, male and female farmers, were selected randomly using Probability Proportional to Size sampling. Hence, from the two selected blocks of a district 120 farmers were interviewed. Thus, a sample of total 1080 farmers was selected from 9 districts of the whole NEH to capture the impact of climatic variability on farm livelihood.

**Data**

Both, primary and secondary data were collected for the present study. Gridded rainfall data ($0.5^0$ X $0.5^0$) for the period of 1975 to 2007 and temperature data ($1^0$ X $1^0$) for the period 1975-2009 were retrieved from IMD dataset. Crop acreage, production and productivity at state level were also collected from Statistical Abstract of respective states, website of Directorate of Economics and Statistics and personal communication with State Agricultural Department. Primary data on socio-economic variables, food, fuel, water (drinking and irrigation), income *etc.* were collected from the farm households, using well-structured schedule, to understand the impact of climatic variability on farm livelihood.

**Analytical Techniques**

The study used standard meteorological analysis of climatic variables and empirical Econometric analysis, tools of social sciences such as case study, focus group discussion (FGD) and survey method *etc.*

## III. Climate Change in North Eastern Himalayas of India

### Rainfall Situation in North Eastern Himalayas

The highest normal weekly rainfall of 168.1 mm was received in 29$^{th}$ Standard Metereological Week (SMW) in Darjeeling during the period of 1975-2007; followed by 165.0 mm (29$^{th}$ SMW) in Sikkim, 129.7 mm (27$^{th}$ SMW) in Mizoram,126.8 mm (27$^{th}$ SMW) in Meghalaya,116.5 mm (28$^{th}$ SMW) in Arunachal Pradesh, 113.0 mm (28$^{th}$ SMW) in Nagaland, 105.8 mm (29$^{th}$ SMW) in Tripura, 84.1 mm (28$^{th}$ SMW) in Karbi Anglong and 65.8 mm (31$^{th}$ SMW) in Manipur.

The highest normal monthly rainfall of 710.6 mm was received in July in Sikkim during the period of 1975-2007, followed by 700.6 mm in Darjeeling, 531.3 mm in

Meghalaya, 501.0 mm in Mizoram, 449.0 mm in Arunachal Pradesh, 431.8 mm in Tripura, 347.8 mm in Karbi Anglong, 293.8 mm in Nagaland and 274.1 mm in Manipur.

The highest normal annual rainfall of 2645.3 mm was registered in Sikkim during the period of 1975-2007; followed by 2540.2 mm in Mizoram, 2457.8 mm in Darjeeling, 2331.1 mm in Meghalaya, 2239.5 mm in Tripura, 2214.3 mm in Arunachal Pradesh, 2204.0 mm in Nagaland, 1747.8 mm in Karbi Anglong and 1541.4 mm in Manipur during 1975-2009.

The pre-monsoon and post-monsoon rainfall have showed positive and significant linear trend in Sikkim during 1990-2007, whereas, the monsoon rainfall has exhibited declining but insignificant trend during the same period. Similar, trends are found in case of Darjeeling also, but the trends are insignificant.

The annual rainfall and the seasonal rainfalls have exhibited positive trends in Meghalaya during 1975-2007. The trend for monsoon rainfall has been positive and significant during 1975-1989.

The monsoon shower has exhibited positive trend during 1975-89 in Arunachal Pradesh which turned out to be negative during 1990-2007 but the trends are insignificant.

The pre-monsoon and monsoon rainfalls have showed negative but non-significant trends during 1975-2007 in Karbi Anglong. The trend for post-monsoon rainfall was positive but not significant in during 1975-2007.

The trends for all the seasons and annual rainfalls are negative in Nagaland during 1975-2007 and the trends are significant for monsoon and annual rainfalls.

The monsoon rainfall (12.25 mm/year) and annual rainfall (18.49 mm/year) has declined in Manipur during 1990-2007 and the trends are statistically significant at 5 per cent level.

The pre-monsoon and monsoon rainfall have declined during the period of 1975-2007 in Tripura. The annual rainfall has also showed negative trend (17.22 mm/year) during the study period but the trend is not statistically significant.

The seasonal and annual rainfall in Mizoram has shown positive trends during 1975-1989, but they turned out to be negative for the period of 1990-2007. The declining trends are significant for pre-monsoon and annual rainfalls.

In a year, more than 50 per cent of the weeks have the probability of being wet in Meghalaya, Arunachal Pradesh, Karbi Anglong, Nagaland, Tripura and Mizoram. All the monsoon weeks have the probability of being wet week in all the hill districts of NEH, except the 21$^{st}$ SMW in Arunachal Pradesh.

Cent per cent and 92.31 per cent of the post-monsoon weeks have the probabilities to be dry in Sikkim and Manipur. In other NEH states, more than 76 per cent of the weeks have the probabilities to be a dry week.

The frequency of conditional probability for a given dry week to be preceded by another dry week is highest during post-monsoon season (more than 84% weeks).

The onset of monsoon has been delayed upto 2$^{nd}$ week of June in most of the states and in case of Mizoram, Sikkim and Tripura it was even in July.

**Temperature Trends in North Eastern Himalayas**

The normal annual minimum temperature is 16.4$^0$C in Sikkim, 16.7$^0$C in Darjeeling, 17.9$^0$C in Karbi Anglong and Tripura, 18.0$^0$C in Manipur and Mizoram, 18.2$^0$C in Meghalaya, 18.6$^0$C in Arunachal Pradesh and 18.7$^0$C in Nagaland.

The normal annual maximum temperature is 29.1$^0$C in Nagaland, 28.5$^0$C in Arunachal Pradesh, 28.2$^0$C in Tripura, 28.1$^0$C in Manipur, 28.0$^0$C in Meghalaya and Mizoram, 27.8$^0$C in Karbi Anglong, 27.1$^0$C in Darjeeling, and 26.8$^0$C in Sikkim.

The trends for minimum temperature for pre-monsoon and monsoon seasons are positive and significant in the study area during 1990-2009, except in Manipur, where the trends are found insignificant. The trend for annual minimum temperature is similar like pre-monsoon and monsoon season.

For post-monsoon season, the trends for minimum temperatures are positive and significant for all the states during 1990-2009, except Manipur and Tripura where the trends are insignificant.

The trends for pre-monsoon and monsoon maximum temperature turned out to be positive during 1990-09 and are statistically significant for Meghalaya, Arunachal Pradesh, Karbi Anglong, Nagaland and Manipur.

The increasing trends in maximum temperature for post-monsoon season are significant in case of Meghalaya, Arunachal Pradesh, Karbi Anglong and Manipur during 1990-2009, whereas, the trend is negative in Nagaland.

The positive trends for annual maximum temperature are statistically significant for the states of Meghalaya (0.06$^0$C/year), Arunachal Pradesh (0.06$^0$C/year), Karbi Anglong (0.07$^0$C/year), Nagaland (0.07$^0$C/year), Manipur (0.07$^0$C/year), Tripura (0.03$^0$C/year) and Mizoram (0.03$^0$C/year) during 1990-09. For the period 1975-09, the trends for annual maximum temperatures were significant for Meghalaya, Arunachal Pradesh, Karbi Anglong, Nagaland and Manipur where the temperatures have risen by 0.02$^0$C/year.

**IV. Climate Change Impacts on Agriculture in North Eastern Himalayas**

The mean yield of rice, maize, wheat, potato and ginger were estimated to be 1444.0 kg/ha, 1571.4 kg/ha, 1742.6 kg/ha, 8163.1 kg/ha and 5146.3 kg/ha, respectively in the NEH region of India. The average milk yield in the NEH states is 47.1 thousand MT per year during the study period.

Time trend and rainfall are risk increasing factors in case of rice yield, whereas, minimum temperature is variance decreasing factor.

Rainfall and maximum temperature have significant (at 1% and 10%, respectively) negative influence on mean yield of maize. Minimum temperature and rainfall are risk decreasing factors, whereas, maximum temperature is risk increasing factor for yield of maize crop.

Time, rainfall and maximum temperature are marginal risk increasing factors for wheat yield in the NEH.

Only annual rainfall has negative but marginal influence on mean yield of potato as well as on variability in yield.

Maximum temperature and rainfall are marginally risk increasing factors for yield of ginger in the region whereas, minimum temperature is strong risk reducing factor.

Time is risk decreasing factor whereas, maximum temperature is strongly risk increasing factor for milk yield in the study region.

## V. Climate Change Impacts on Farms and Farming Community

### Section I: Findings of Household Survey

***Socio-economic status***

The average age of the respondent farmers was in between 35 years (West Kameng) and 52 years (Lunglei) and the families were composed of, on an average, five to seven members in the study area of NEH. Majority of the sample famers were Scheuled Tribe (ST) in East Sikkim, Ri-Bhoi, West Kameng, Senapati and Lunglei district. In Karbi Anglong majority of the respondents were OBC. The literacy rate of sample farmers was highest (94.17%) in Lunglei and lowest in Arunachal Pradesh (53.33%). The average operational land holding ranged between 0.68 ha (Ri-Bhoi) to 3.48 ha (Dimapur). The area under irrigation was highest in Darjeeling district (82.18%); followed by Ri-Bhoi (50.26%), West Tripura (38.67%) and Senapati (29.10%) district and least in Karbi Anglong (6.59%) district, followed by Dimapur (9.95%).

***Perception about climate change***

More than 85 per cent of the farmers in the sample districts perceived that the summer temperature has increased over the years, whereas, the views were mixed in case of winter temperature.

More than 84 per cent of the farmers in the sample districts perceived that monsoon rainfall has declined and majority of them felt that the arrival of monsoon has been delayed in all the districts.

**Impact on area**

About 42.99 per cent in Lunglei, 36.67 per cent in Karbi Anglong, 36.49 per cent in West Tripura, 24.32 per cent in Sikkim, 20.83 per cent in Dimapur, 13.79 per cent in West Kameng, 10.26 per cent in Darjeeling, 9.17 per cent in Senapati and 7.02 per cent in Ri-Bhoi have reduced the area under rice cultivation in case of late rainfall.

Whereas, cent per cent in Lunglei, 78.57 per cent in Darjeeling, 56.52 per cent of the farmers in West Tripura, 53.33 per cent in Karbi Anglong, 50.83 per cent in Dimapur, 40.00 per cent in Ri-Bhoi, 22.97 per cent in Sikkim, 8.33 per cent in Senapati, 5.26 per cent in West Kameng have reduced the area under rice cultivation in case of low rainfall.

In case of maize, only 14.00 per cent and 13.86 per cent of the farmers reduced the area than normal in case of late rainfall and drought/low rainfall, respectively in East Sikkim district. Whereas, in Darjeeling, 25.58 per cent and 81.61 per cent of the farmers have reported that they have reduced the area under maize crop in case of late rainfall and drought, respectively.

**Impact on yield**

The average decline in productivity of rice was estimated to be 48.01 per cent in Mizoram, 46.22 per cent in Darjeeling, 42.41 per cent in Ri-Bhoi, 40.05 per cent in East Sikkim, 39.27 per cent in Karbi Anglong, 38.94 per cent in Dimapur, 36.18 per cent in West Tripura, 23.78 per cent in Senapati in case of droughts/low rainfall situations.

The productivity of maize has declined by 49.18 per cent and 44.56 per cent in Darjeeling and East Sikkim, respectively during the periods of droughts/low rainfall situations.

**Impact on pest and diseases**

Majority of the responding farmers perceived that the pests and disease infestations on rice crop have increased in recent times and resulted into productivity loss. The productivity loss is estimated to be 24.40 per cent in East Sikkim, 16.56 per cent in Dimapur, 16.35 per cent in Karbi Anglong, 14.92 per cent in Darjeeling, 12.71 in West Kameng, 12.05 per cent in Lunglei, 10.54 per cent in Ri-Bhoi, 9.99 per cent in West Tripura and 4.78 per cent in Senapati.

In case of maize the productivity loss was 24.28 per cent in East Sikkim, 17.19 per cent in Darjeeling and 7.36 in West Kameng district due to pest and disease attack.

**Impact on food**

The period of consumption of produce from own farm reduced during the periods of droughts than the normal periods and many of them reported about insufficiency of money but no gender discrimination was observed in case of food distribution among the family members.

**Water**

Majority of the farmers has reported about shortage in water for irrigation during low rainfall period.

More than 75.00 per cent of the respondents reported that water for drinking facility has dwindled during drought season in the districts of East Sikkim, Darjeeling, Ri-Bhoi, Karbi Anglong and Dimapur district whereas, about 39.56 per cent, 53.27 per cent, 62.50 per cent and 65.00 per cent of the farmers reported about decrease in drinking water facility during the drought season in case of West Kameng, West Tripura, Lunglei and Senapati district, respectively.

Conflicts on water in the village or community in the last 5 years were reported by 53.04 per cent of the farmers in Darjeeling, 37.70 per cent in Dimapur, 22.22 per cent in East Sikkim but only some cases were reported in the other districts under the study.

**Extra burden**

The extra burden during climatic variability was shared by both, male and female members of a household for most of the daily activities, except in the case of fetching drinking water which was mainly performed by the female members of the family, except West Tripura where the extra burden of fetching water was shouldered by the male member of the household.

***Adaptation and mitigation strategy***

About 94.17 per cent of the farmers in Karbi Anglong, 93.33 per cent in Senapati, 83.33 per cent in Dimapur, 79.65 per cent in Ri-Bhoi, 78.41 per cent in Lunglei 73.08 per cent in Darjeeling, 54.55 per cent in West Tripura, 40.83 per cent in West Kameng and 40.17 per cent in East Sikkim has changed time of sowing or transplanting in case of late rainfall.

Working as wage labour, especially under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) was the best alternative source of livelihood for majority of the respondents (57.50%) in case of climatic variability. Some of them also have started business for earning livelihood.

Migration due to climate change was rare in NEH states, except in Dimapur and West Tripura districts where 19.17 per cent and 11.67 per cent of the households reported that their family members have migrated mainly to neighbouring villages and towns and left the wives and minors back at home, repectively.

Use of stress-tolerant cultivars (50.00%), health management of animals (21.67%) and shift to improved cropping system (20.00%) were the measures considered as preferable mitigating options to climate change by the farmers of East Sikkim district.

Health management of animals (26.67%), use of stress-tolerant cultivars (25.83%), shift to improved cropping system (25.83%) and pest and disease management (20.83%) were the measures considered as preferable mitigating options to climate change by the farmers of Darjeeling district.

The mitigation options preferred by the farmers of Ri-Bhoi included use of stress-tolerant cultivars (93.33%), use of short duration crops (75.00%), adopting pest and disease management techniques (69.17%) and shifting to improved cropping systems (54.17%).

Farmers of West Kameng preferred the use of stress-tolerant crop cultivars (60.83%), short duration variety along with other additional crops (51.67%) and shift to improved cropping system (43.33%) as mitigating options during the times of climatic variability.

Use of stress-tolerant cultivars (71.67%) and changes in agricultural water management techniques (31.67%) were the measures considered as preferable mitigating options to climate change by the farmers of Karbi-Anglong.

In Dimapur, use of stress-tolerant cultivars (69.17%), shift to improved cropping system (46.67%), changes in agricultural water management techniques (21.67%), animal health management (22.50%) were preferred.

Use of stress-tolerant cultivars (75.83%), pest and disease management (46.67%) health management of animals and keeping new livestock breeds (10.83%) were the measures considered as preferable mitigating options to climate change by the farmers in the study area.

Farmers of West Tripura expressed their preferences for pest and disease management technique (69.17%), stress-tolerant cultivars (59.17%), short duration varieties (59.17%) *etc.* as measures to reduce the vulnerability to climate variability.

Pest and disease management technique (80.00%), stress-tolerant cultivars (59.17%) and cultivation of short duration varieties (51.67%) were the mitigation measures preferred by the respondents in Lunglei district.

Yield, availability of seeds, taste, tolerance to drought resistance to pest and diseases, market price and demand were the major decisive factors that influenced the farmers' decisions to continue with or change a rice cultivar in the study area of NEH and the decisions were primarily taken by the either, husband and wife jointly or by the husband only.

**Suitable varieties**

*Addey, Tulsi* and *Kale Poge* were the cultivars perceived as suitable in case of drought by the farmers of Sikkim. *Kagge* and *Adde* were the two varieties in Darjeeling which were resistant to water stress situation. The cultivars like *Baphri, Eithati, Laipawa, Lahi, Lakang, Lyngkot Saw and Matiasra etc.* were considered as suitable in case of climate change scenario by the farmers of Ri-Bhoi district. The farmers of West Kameng reported that *Pangra* in rice and *Slang and Michi* in case of Maize*, Sirfur, Misbhalia, Phinang* and *Masuk* incase of wheat crop were suitable to climate change scenario. Goya and IR-8 were considered suitable in water stress situation in both, Karbi Anglong and Dimapur district, in addition, *Kohima Special* and *Ranjit* are recognized as suitable variety in Dimapur. In Senapati district *Tamphaphou, Daranphou, Sonaphou, RCM-5, RCM-9* and *RCM-10, Addey* and *KD* were considered to be suitable to climate change in Senapati. The farmers of West Tripura district perceived *Swarna Mahsuri, Paijam, Malati, Ranjit* and *Shatabdi* to be resistant to water stress. *Aizong, Buhban, Buhpui, Burmabuh, Fangsin, Ido,* IR – 64, *Tampha Tamphapo, Zobuh* were the varieties considered to be resistant to water stress condition in Lunglei district.

**Weather information**

Most of the farmers used their traditional knowledge, watched television, consulted neighbours and read newspapers for accessing weather information.

**Agricultural loan**

The percentage of farmers has taken loan for agricultural purpose in the districts under study was meager, except Darjeeling where about 42.86 per cent have acquired loan for agricultural purposes.

The awareness about livestock and crop insurance was highest among the famers of Darjeeling, followed by Sikkim. In other states only a small percentage of famers have heard about crop or livestock insurance.

MGNREGA (91.67%) and PDS ration (97.50%) were the major support the farmers received in NEH.

**Section II: Learning from Case Studies**

Potato cultivation has suffered due to increasing temperature at Mawlynrei village of Ri-Bhoi district in Meghalaya. The pest and disease infestation has increased. The farmers are now diversifying to other crops to sustain their livelihood.

The increase in temperature at Mukto village in Tawang has been conducive for cultivation of vegetables, fruits like kiwi, apple *etc.* and for oranges at Dirang.

The local varieties have suffered decline in productivity due to increase in temperature in Champhai district of Mizoram.

*Jhum* cultivation has also taken the toll due to shortage in rainfall in North Tripura district. The Reang *jhumias* has stopped cultivating chilli in *jhum* land now-a-days.

In Sikkim the crops have suffered due to shortage of rainfall. The areas under the crops like buck wheat, millet, wheat, mustard and sunflower have declined.

The ginger production has declined during low rainfall period in Shangbangla of Ri-Bhoi. The soft rot disease is also in raise in the village.

Die back disease has heavily impacted the orange orchards in Jampui hills in North Tripura which is a complex disease.

The size of pineapple reduces during the low rainfall period in Meghalaya and Nagaland. The high temperature can damage the suckers and the production decline significantly.

With the increase in temperature the productivity of local varieties of cardamom has declined in Darjeeling and Sikkim and it suited to the improved varieties.

The milk productivity and disease attack on livestock were negatively affected due to climate change at Siphir village in Aizwal district.

In Sikkim and Arunachal Pradesh, the snowfall has declined and restricted to higher altitudes only. The yak rearers moved to higher altitudes during summer season due to increase in temperature. Similar is the case of mithun in Nagaland. The pasture remains greener at high altitude. The yaks suffered higher mortality during the hotter years.

The availability and growth of fish specises have been negatively affected due to declining water level and current of khowai river which because of low rainfall in Khowai district of Tripura. The fish diversity and habitat of fish has also changed over the years.

The mosquito population has increased in the whole study area in recent times which may be due to increase in temperature.

This chapter initially discusses the problem scenario and then present relevant research questions and objectives to answer those questions. This chapter also reviews the relevant literature about the impact of climate change on agriculture and livelihood, and at the end, the nature and scope of the study is presented.

### 1.1. Research Problem

An increase in temperature by 2-4$^0$C is projected for India by 2050s. Climatologists expect the number of rainfall days to decrease with significant regional variation. An increase in the intensity and frequency of extreme events, such as droughts, floods, tropical cyclones, precipitation events, hot extremes and heat waves is also being projected. In the North-Eastern region, the number of rainy days is likely to decrease by 1–10 days and the intensity of rainfall in the region is likely to increase by 1–6 mm/day (INCCA, 2010). The projected increase in these events will result into greater instability (seasonal/annual fluctuations) in food production and threaten the livelihood of the farmers (Mall *et al.*, 2006). The available evidences from crop growth simulation models shows a significant drop in the yields of important cereal crops like rice and wheat under the changes in climatic conditions. The impact of climate change on agriculture is expected to be serious in India as Indian agriculture is mainly rainfed. In a country that gets rain for less than 100 hours in a year (a year has 8,760 hours), this would be disastrous. However, given the fact that the intensity of irrigated gross crop area to gross sown area is only 45.3 per cent (GoI, 2011), Indian agriculture continue to be fundamentally dependent on the weather. Rainfed agriculture, mostly practiced by the poor, is more vulnerable due to climate change (Mongi *et al.*, 2010).

The report submitted by Commission on Sustainable Agriculture and Climate Change (2012) prescribed that the global community must operate within three limits: the quantity of food that can be produced under a given climate; the quantity needed by a growing and changing population; and the effect of climate change on food production. At present the planet operates outside that safe space, which is evident from the huge number of people who are undernourished. If current trends in population growth, diets, crop yields and climate change continue, even then, the world will still be outside this 'safe operating space' by 2050s. Availability of food for the growing population will be a matter of concern under the climate change scenario. The lower farm income due to lower production will reduce the access to food to the poor people. In a country like India that has, multiple stressors; such as economic, political and social conditions, in addition to climatic factors influence food security. The relationship between human migration and climate change started becoming an issue, that worthy of increasing attention in the international realm (Werz and Conley, 2012).

The hills of India are well known for its biodiversity but at the same time the hill eco-system are more fragile. The farmers in the hills still depend on the local varieties of cereals and mostly practice organic agriculture. The productivities of crops are much lesser than the national average; hence, the hill agriculture becomes more vulnerable to the changes in climatic parameters. In the absence of other occupations in the hills, the livelihood of the people is expected to be adversely affected by changes in climatic conditions.

Hill ecosystems provide the most diverse and stringent selection conditions on crops grown in such regions. Together with the environment, the farming communities select and develop landraces that possess multiple stress tolerant traits, and thereby have wider adaptability. Although germplasm collection and characterization programmes exist, the core collections are for those focuses on one or a few stress related traits only. The knowledge that farmers may have regarding adaptability of landraces to climatic vagaries may help plant breeders to improve these landraces to develop climate change resilient varieties.

Our present knowledge is not enough to develop practical and efficient, at least in quantitative terms, to develop practical and efficient measures to address the problem of climate change. There is a need to further strengthen the knowledge base on the emerging challenge of climate change and its impact on crop yield and farm livelihood.

### 1.2. Research Questions:

- What are the trends in major climatic factors (such as rainfall and temperature) in the hills?

- How climate change impacts on the yields of major crops and in turn affects the farm livelihood?

- Whether landraces grown by the indigenous tribal are resilient to climate change or not?

### 1.3. Specific Objectives

- To analyze the trends in rainfall and temperature.
- To estimate the impact of climate change on mean yield and variability in yields of major crops and to identify landraces grown by indigenous people to such variability.
- To study the gender specific impact of climate variability on farm livelihood.

### 1.4. Literature Review

In India, various studies observed an increasing trend in temperature (Hingane *et al.*, 1985, Rupakumar *et al.*, 1994, Pant *et al.*, 1999, Singh and Sontakke, 2002). However, some studies note regional variations in rainfall (Rupakumar *et al.*, 1992; Kripalani *et al.*, 1996; Singh *et al.*, 2001; Mooley and Parthasarathy 1984; Thapliyal and Kulshrestha, 1991). Semi-arid regions of western India are expected to receive higher than normal rainfall as temperatures increases while central India will experience a decrease of 10 to 20 per cent in winter rainfall by the 2050s (Rupakumar *et al.*, 1992). Furthermore, agriculture will also be adversely affected by shifts in the timing of the rainfall.

#### 1.4.1. Impact of Climate Change on Agriculture

Globally, a number of studies tried to capture the impact of climate change on agricultural production and productivity (Kurukulasuriya and Rosenthal, 2003; Carraro and Sgobbi, 2008; Kameyama *et al.*, 2008). Mainly three approaches have been widely used in the earlier studies to measure the sensitivity of agricultural production to climate change; agronomic-economic models, cross sectional models and agro-ecological zone models (Ranganathan, 2009).

According to IPCC, 2007 the crop yield in many countries of Asia has declined, partly due to rising temperatures and extreme weather events. Researchers have found that production of major cereal crops viz., rice, maize and wheat in the past few decades has declined in many parts of Asia due to increasing water stress arising partly from increasing temperature, increasing frequency of El Nino and reduction in the number of rainy days (Wijeratne, 1996; Aggarwal *et al.*, 2000; Jin *et al.*, 2001; Fischer *et al.*, 2002;

Tao *et al.*, 2003; Tao *et al.*, 2004). Peng *et al.* (2004) reported that the yield of rice decreased by 10 per cent for every $1^0$C in growing season minimum temperature.

Studies by Parry *et al.* (1999) and Rosenzweig *et al.* (2001) have suggested the decline in cereal production in Asia by the end of the $21^{st}$century due to climate change. However, sub-regional differences in the response of wheat, maize and rice yields to projected climate change could likely to be significant. Fischer *et al.* (2002) indicated that substantial losses are likely to occur in rainfed wheat area of South and South-East Asia. Faisal and Parveen (2004) predicted the decline in rice by 8 per cent and wheat production by 32 per cent in Bangladesh, by the year 2050. The studies have also shown that a $2^0$C increase in mean air temperature could decrease rain-fed rice yield by 5 to 12 per cent in China (Lin *et al.*, 2004).

A few Indian studies argue that agricultural production has declined due to climate change (Aggarwal and Kalra, 1994; Dinar *et al.*, 1998; Kumar and Parikh, 2001a, 2001b; Kumar, 2009). If temperature rises by $4^0$C, grain yield would fall by 25- 40 per cent, rice yields by 15-25 per cent and wheat yields by 30-35 per cent (Kumar and Parikh, 1998b). The study conducted by Indian Agricultural Research Institute (ICAR) reported the possibility of losses by 4 to 5 MT of wheat production in future with every $1^o$C rises in temperature during the growing period (but no adaptation benefits), if the irrigation remains at today's level (Kalra *et al.*, 2007). The IPCC report (IPCC, 2007) and study by Dinar *et al.* (1998) indicated that the probability of 10 to 40 per cent losses in crop production in India with an increase in temperature by 2080 – 2100.

Kumar and Parikh (1998) showed that the economic impact would be significant even after accounting for farm-level adaptation. The loss in net revenue at the farm level is estimated to be between 9 and 25 per cent for a 2°C to 3.50°C rise in temperature. Mendelsohn *et al.* (1994) indicated that the global warming would decrease net income by 8 per cent. Sanghi *et al.* (1998) reported that a 2°C rise in mean temperature and a 7 per cent increase in mean precipitation would reduce the net revenue by 12.3 per cent for the entire country.

In cross-sectional approach, known as Ricardian method, farm performances are examined across climate zones (Mendelsohn *et al.*, 1994; 1996; Kumar and Parikh, 1998b). Ricardo observed that land values would reflect land productivity at a site (under competition). In this approach land value is regressed on a set of environmental inputs to measure the marginal contribution of each input to farm income. The approach has been applied to the United States (Mendelsohn *et al.*, 1994; 1996). In the Ricardian analysis, prices of both inputs and outputs are assumed to remain proportionately constant. Climate parameters are precipitation, minimum, maximum and diurnal temperature. Usually climate normals, based on time series averages over a fairly long period of time are considered.

Palanisami *et al.* (2009) employed Ricardian type analysis to study the effect of climate variables on area and yield of paddy, groundnut and sugarcane major crops of Tamil Nadu, State India. The results show that there will be a reduction in both area and yields of major crops by about 3.5 to 12.5 per cent due to the impact of climate change. Consequently, overall production will decrease between 9 to 22 per cent for these crops.

Most of the researchers studied the effect of climate variables on mean yield but fluctuation in crop yields is also important because agricultural production is very sensitive to changes in precipitation and temperature. This aspect has been studied only to a much lesser extent (Bindi *et al.*, 1996; Mearns *et al.*, 1997).

Chen *et al.* (2004) and Isik and Devadoss (2006) have used regression analysis by applying a Just-Pope (1978) production functional form to simultaneously estimate the mean and variability in crop productivity. Chen *et al.* (2004) showed that changes in climate modify crop yield levels and variances in a crop-specific fashion. For sorghum, rainfall and temperature increases are found to increase yield level and variability. On the other hand, precipitation and temperature are individually found to have opposite effects on corn yield levels and variability. Isik and Devadoss (2006) employed Just-Pope production function to analyze the impacts of projected climate change on the yield of wheat, barley, potato and sugar bees in Idaho, USA. The explanatory variables used were total precipitation, temperature and trend. They reported that climate change will have modest effects on the mean crop yields, but will significantly reduce the variance and covariance for most of the crops studied.

Ranganathan (2009) applied econometric modeling for estimating the mean yield and yield variability and also covariance between yields of different crops. The study shows that precipitation and temperature have varying effect on productivity and variability of crops. Climate change, as dictated by HADCM3A2a scenario, will have modest impact on crop productivities across the five zones of Tamil Nadu. Zones where paddy is grown traditionally may witness modest increase in productivity followed by increase in variability while many other crops may have decrease in productivity and there is no uniformity in changes in their variability.

Barnwal and Kotani (2010) examined the effects of temperature and precipitation on the mean and variance of seasonal rice yield in Andhra Pradesh, India. For this purpose, two distinct approaches were employed: (i) panel data analysis using Just and Pope stochastic production function and (ii) quantile regression approach. The first approach suggested that, in general, an increase in temperature as well as inter-annual variance of temperature and rainfall adversely affect the mean crop yield, while the effect of increase in precipitation highly depends on the cropping season. Second, the quantile regression revealed that rice yield's sensitivity to climate change differs significantly across the quantiles of yield distribution. In particular, the adverse effect of climate change is found to be more profound for the crop yields in the lower quantiles.

### 1.4.2. Impact on Livelihood

The FAO study (2002) suggested that climate change will affect the four dimensions of food security, namely food availability (*i.e.*, production and trade), access to food, stability of food supplies and food utilisation. This because low production may affect incomes and high food prices may reduce access to food. Increased price of staple food will adversely affect the nutrition levels, as in one hand demands for food staples (rice, wheat, maize etc. depending on the geographical region and culture) are highly inelastic and the income and price elasticities for food staples in the aggregate are low and in another hand minerals and vitamins are concentrated in non-staple foods; energy is concentrated in staple foods. Hence, the increased price will reduce the intake of vitamins and minerals are currently already too low, resulting in high prevalence rates of micronutrient deficiencies.

The overall impact of climate change on food security will differ across regions and over time and will depend on the overall socio-economic status of the county

(Schmidhuber and Tubiello, 2007). According to IASC (2009) climate change will act as a multiplier of existing threats to food security. By 2050s, the risk of hunger is projected to increase by 10–20 per cent and child malnutrition is anticipated to be 20 per cent higher compared to a no-climate change scenario. Other projections have shown that risk of hunger remain high as under A2 scenario without $CO_2$fertilizationarelikely to increase from 7 to 14 per cent by 2020s, 14 to 40 per cent by 2050s and 14 to 137 per cent by 2080s (Parry *et al.*, 2004; IPCC, 2007).

International Centre for Integrated Mountain Development, Kathmandu, Nepal, surveyed in Karbi Anglong of Assam and East Garo Hills of Meghalaya and reported that communities in these districts expressed concern about the change in precipitation patterns leading to a drying up of water sources for drinking and irrigation. Women's workload is increasing as they have to travel further to fetch water. The lengthening dry season delays sowing and transplantation, particularly of upland rainfed rice. Furthermore, the increased severity of hailstorms caused damage to standing crops in September. Hailstorms also damaged flowers, preventing fruit set, and resulted in early fruit fall among horticultural crops such as citrus, mangoes, lychees, and other fruits. The erratic nature of precipitation had a serious negative impact on harvests. The untimely rain during harvesting season destroyed the crops. Overall, the impact was inducing and perpetuating food insecurity in the region. Moreover, as the productivity of agriculture declines, men in search for wage labour opportunities, adding both to their workloads and to the workloads of their wives (Macchi *et al.*, 2011).

Migration depends on many factors including climate change but it is difficult to isolate climate change induced migration (ADB, 2011). According to The IPCC in its Fourth Assessment Report—Climate-related disruptions of human populations and consequent migrations can be expected over the coming decades. Werz and Conley (2012) opined that in case of "worst case" climate change scenarios of more than 10°F average increase in global temperatures in many part of the world would become uninhabitable that are relatively stable right now.

International Institute for Strategic Studies in London reported that, in "areas with weak or brittle states, climate change will increase the risks of resource shortages, mass migrations and civil conflict" (IISS, 2011). Some studies postulate that climate change already contributes to displacement and migration, although most of this movement remains internal (Warner, 2009).

### 1.5. Nature and Scope of Study

The present study is multidisciplinary in nature and will use the knowledge of specialist on Agro-Meteorology, Economics, Econometrics, Plant Breeding and Rural Sociology but the focus was on socio-economic aspect. The approach for research methodology was flexible and used Focus Group Discussion (FGDs)/ Case Studies and household survey. The study was conducted in the NEH region of the country and the analysis of climatic parameters has limit to rainfall and temperature and their impact on the major crops only. The extent of damage inflicted by climate change on livelihood and social systems was limited to the households involving in farming activities only.

This chapter deals with the description of the study area, sampling design, the nature and sources of data and analytical techniques employed. At the end of this chapter, important terms and concepts used in the study are defined to facilitate a clear understanding. The methodology is presented under the following major heads:

2.1 Locale of the study
2.2 Sampling Design
2.3 Data
2.4 Analytical techniques
2.5 Terms and concepts used

### 2.1 Locale of the study

The study is conducted in North Eastern Himalaya (NEH) of India which comprised of Sikkim, Darjeeling district of West Bengal (except Siliguri sub-division), Meghalaya, Arunachal Pradesh, Karbi Anglong district of Assam, Nagaland, Manipur, Tripura and Mizoram. The brief description of the states and selected districts are given below.

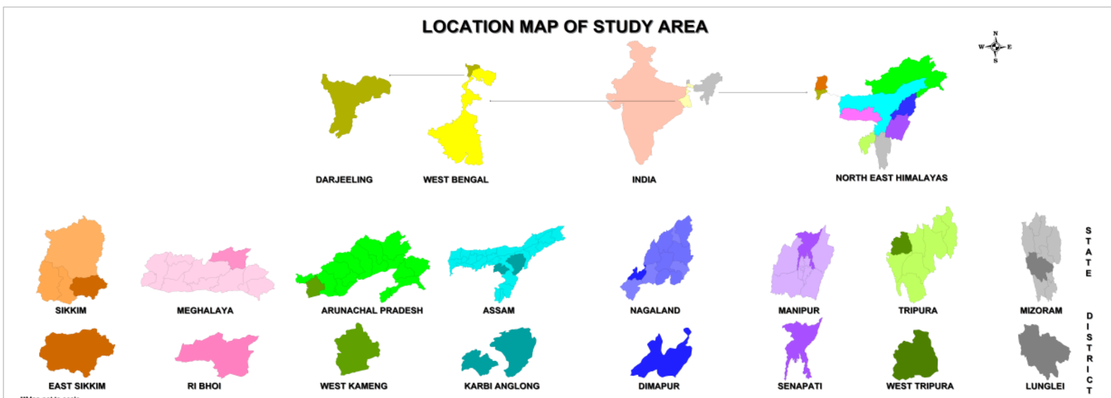



**Fig. 2.1. Locale of the study**

### 2.1.1 Sikkim

Sikkim is located in between 27$^{0}$00’46"N to 28$^{0}$07’48"N latitude and 88$^{0}$00'55"E to 89$^{o}$55'25"E longitude. The state is bounded by the Tibetan Plateaus in the North, the Chumbi Valley of Tibet and the Kingdom of Bhutan in the East, the Kingdom of Nepal in the West and Darjeeling district of West Bengal in the South. East Sikkim, West Sikkim, South Sikkim and North Sikkim are the four districts of the state and Gangtok is the capital of the state located in East Sikkim.

*Population*

The population of Sikkim is around 6.08 lakh and about 75.03 per cent of the population live in 452 villages. The population density is about 86 persons per sq. km. The Schedule Tribe (ST) and Schedule Caste (SC) population constitute 21 per cent and 5 per cent of the population, respectively. The Lepchas, the Bhutias, and the Nepalies are the three major communities inhabit in Sikkim. The literacy rate in Sikkim is at 82.20 per cent and the sex ratio is at 889 female for every 1000 male as in 2011. The percentage of people living under below poverty level (BPL) is with 8.19 per cent in 2011-12.

*Topography and climate*

The state has a geographical area of 7096 sq. km. out of which 47.32 per cent is under forest (FSI, 2013). Nearly two-thirds of the state is covered by high mountains, including the third highest mountain in the world *i.e.*, the Kanchenjunga (8,598 m). Sikkim includes the Lesser Himalaya, Central Himalaya, and the Tethys Himalaya. The average steepness of the land is about 45 degree. North Sikkim and parts of East Sikkim have snow-capped mountains. The elevation of land is sub divided into five categories *viz.,* lower hills (270 to 1500 m above mean sea level (msl)), mid hills (1500 to 2000 m above msl), higher hills (2000 to 3000 m above msl), alpine zone with vegetation (above 3900 m above msl) and snow bound land without vegetation and with perpetual snow cover (up to 8580 m above msl). The main soil types in the state vary from loamy sand to silty clay loam. The two major rivers of the state are the Teesta and Rangit, which originates from Cholamu lake and Rathong glacier, respectively. The state has 84 glaciers and 315 glacial lakes.

The state experiences Tropical (<610 m), Sub-tropical (610-1524 m), Temperate (1524-2743 m), Sub-alpine (2743-3962 m) and Alpine (3962-5182 m) climate at different level of alleviation. The annual rainfall varies from less than 400 mm in the north to more than 3,400 mm in the south-eastern parts, however, the lower part of South and West districts are in the rain shadow area, thereby receiving less than half the rainfall compared to East district.

Most of the inhabited regions of Sikkim, however, face a temperate climate with temperature seldom exceeding 28°C in summer or dropping below 0°C in winter with an average annual temperature around 18°C.

*Agriculture*

In Sikkim, about 56.36 per cent of the workforce depends on agriculture as a source of livelihood. The major cereal crop in Sikkim is maize and it covered an area of 40.17 thousand ha in 2010-11 with productivity around 16.47 MT/ha. The area under rice in the state is around 12.14 thousand ha and the annual production and productivity of the crop is 20.97 thousand MT and 1.72 MT/ha. The major horticultural crops grown in the state are fruits like Sikkim Mandarin orange; vegetables such as beans, garden peas, chayote, leaf mustard, radish, cabbage, cauliflower, tomato and gourds; root and tuber crops like potato, tapioca, sweet potato and yams. Large cardamom, ginger and turmeric are the major spices. Flowers include cymbidium orchids, roses, gladioli, liliums, anthuriums, carnations and gerbera.

**East Sikkim District**

East Sikkim district is located between 27°25'N to 27°11'N latitude and 88°53'E to 88°26'E longitude. The population of East Sikkim district is around 2.81 lakh and 56.81 per cent of the population of the districts lives in rural areas. The sex ratio is 872 females per 1000 males and the literacy rate of the district is 84.67 per cent. The main ethnicities of the district include Nepalese, Bhutias, Tibetan and Lepchas. The district comprise of three sub divisions, namely Gangtok, Pakyong and Rongli.

The district covers an area of 954 sq. km. out of which 619.5 sq. km. is the total forested area. East Sikkim district is dominated by a hilly terrain and the district has an altitude ranging from 300-5000 m above msl. The annual rainfall in the district is around 2500 mm. The major rivers in the district are the Teesta and the Rangit.

The gross cropped area of the district is around 31.9 thousand ha and the net sown area is 18.1 thousand ha, with cropping intensity of 150 per cent. Maize and rice are the major crops of the district with an area covering 9.03 thousand ha and 4.91 thousand ha, respectively in 2012-13. The annual production and productivity of maize in the district is 15.35 thousand MT and 1.7 MT/ha respectively. In the case of rice, the annual production is 8.77 MT and the average productivity of rice in the district is 1.79 MT/ha. Other important crops in the district include vegetables, millet, ginger and cardamom.

### 2.1.2 Darjeeling district

Darjeeling district is located in between $26^{0}27'$N to $27^{0}13'$N latitude and $87^{0}59'$E to $88^{0}53'$E longitude and the district is bounded on the north by Sikkim, on the south by Kishanganj district of Bihar state, on the east by Jalpaiguri district and on the west by Nepal. The district constituted of 12 Blocks and the hilly region of the district comes under the Gorkhaland Territorial Administration (GTA) which covers the three hill sub-divisions of Darjeeling, Kurseong and Kalimpong. The foothill of Darjeeling Himalayas, which comes under the Siliguri sub-division, is known as the Terai.

*Population*

The population of the district is 0.18 lakh of which about 60.58 per cent lives in rural areas as in 2011. The population density in the district is 586 persons per sq. km. The district has literacy rate 79.56 per cent and the sex ratio is at 970 female per 1000 male. Mainly the Nepalies, the Bhutias and the Lepchas are the inhabitant of the district. The SC and ST population constitutes 16.09 per cent and 12.69 per cent, respectively.

*Topography and climate*

The district has a geographical area of 3149 sq. km. and the average elevation is about 2134 m. The arable lands have a gradient of slope of 60 to 70degree. The soil is mainly brown forest soil, sandy loam in texture, porous and shallow in depth. The soil has high organic matter content and is acidic in nature with pH value ranging from 3.5 to 5.0. Phosphorous and potash content in the soil varies from medium low to medium. Teesta, Great Rangit, Mechi and Mahananda are the important rivers of the district.

The agro-climatic condition of areas under Darjeeling Gorkha Hill Council is diverse, varying from sub-tropical on the foothills to the temperate in the higher altitudes. Average rainfall in the area is about 1675 mm per annum concentrated in the months of June to September with an average of 49 rainy days per annum. The mean maximum temperature is $26^{o}$C and the mean minimum temperature is $4^{o}$C.

*Agriculture*

The upper ridges of the district are forest areas; tea plantations and agriculture occupy mid-hill section. The total cultivable land is 160.14 thousand ha out of which 143.86 thousand ha is net sown area. The irrigated area is only 8.94 thousand ha and cropping intensity is 122.48 per cent. Darjeeling is internationally recognized for its Black Tea.

The area under rice was 32.3 thousand ha producing 77.8 thousand tones with an average yield of 2.41 MT/ha in 2010-11. Net sown area is 40.07 per cent of the total reporting area. Maize is another important cereal of the district with annual production of 39.60 MT. spice like large cardamom and ginger; vegetables; fruits like pineapple, banana, plum, pears and peach; flowers like gladiolus and orchid are other important crops cultivated in the district. Poultry, diary, piggery, goatery and apiary are also important sources of livelihood of the people in the area.

**2.1.3 Meghalaya**

Meghalaya lies between the $24^0$57'N to $26^0$10'N latitude and $89^0$46'E to $92^0$52'E longitude. It is bounded on the north by Goalpara, Kamrup, Nagaon and Karbi Anglong districts of Assam state, and on the east by the districts of Cachar and North Cachar (NC) Hills, also of the state of Assam. On the south and west lies Bangladesh. Meghalaya is divided into eleven administrative districts. They are West Jaintia Hills district (Jowai) and East Jaintia Hills district (Khliehriat) in Jaintia hills; East Khasi Hills District (Shillong), West Khasi Hills District (Nongstoin), Ri-Bhoi District (Nongpoh), South West Khasi hills (Mawkyrwat) in Khasi hills; North Garo Hills (Resubelpara), East Garo Hills district (Williamnagar), West Garo Hills district (Tura), South Garo Hills District (Baghmara) and South West Garo Hills District (Ampati) in Garo hills.

*Population*

Meghalaya has a population of 29.64 lakhs with 23.69 lakh population (79.92%) living in 6839 villages and the population density is 132 persons per sq. km. As in 2011, about 86.23 per cent of its population belong to ST community. The sex ratio is at 986 per 1000 males and the literacy rate in the state has improved to 75.48 per cent in 2011 from 62.56 per cent in 2001. About 18.5 per cent of the people live under the BPL. Khasi, Garo and Jaintia are the major tribes of the state.

*Topography and climate*

The state has an area of 22429 sq. km. out of which 77.08 per cent is covered by forest, as in 2013. The Khasi Hills in the central part of Meghalaya, Jaintia Hills in the eastern part of Meghalaya and Garo Hills form the western part of Meghalaya. The height of the central plateau of the Khasi Hills is around 1500 m with the highest point of Shillong peak at 1965 m. Khasi hills is known as the 'Scotland of the East' with the pine trees, rolling hills and numerous waterfalls. The height of the Garo Hills range from 450 m to 600 m and Nokrek (1412 m) in Tura is the highest peak. Simsang, Ringge, Ganol, Manda, Damring and Janjiram are the important rivers of Garo Hills. Kyushi, Umiam Mawphlang and Umngot are the important rivers of Khasi Hills.

The climate of the state varies from sub-alpine, Sub-temperate to Sub-tropical climate. The temperature goes up to $30^0$C at Garo Hills but the maximum temperature of Khasi Hills is about $26^0$C. The minimum temperature falls as low as $2^0$C in the Khasi Hills. The amount of rainfall varies from 2,200 mm to 14000 mm depending on the altitude. The maximum rainfall occurs over the southern slopes of the Khasi hills where Sohra and Mawsynram are located.

*Agriculture*

Meghalaya is basically an agricultural state with about 80 per cent of its population depending entirely on agriculture for their livelihood. The total cultivable area of the state is 5.27 lakh ha and rice is cultivated on 1.09 lakh ha of area with productivity of 2.33 MT/ha. The irrigated area is 65thousand ha with cropping intensity at 118.95 per cent. The state is also known for its horticultural crops like orange (Khasi Mandarin), lemon, pineapple, guava, banana, plum, pear, peach, arecanut and betel vine. Potato, ginger, turmeric, cauliflower, cabbage, radish and carrot are the important vegetables grown in the state.

**Ri-Bhoi district**

Ri-Bhoi is situated between 91°20'E and 92°17'E longitude and 25°40'N to 26°20'N latitude. It is bounded by Kamrup district of Assam in the north, east by Karbi Anglong district of Assam, south by the East Khasi Hills and west by the West Khasi Hills district. The district occupies an area of 2448 sq. km. out of which 36 per cent is under forest cover. The district is located at an altitude of around 1010 m above msl. The district is sub-divided into three blocks *i.e.*, Umling, Umsning and Jirang with headquarters is located at Nongpoh.

The population of the district is 2.59 lakh with the sex ratio at 953 and literacy rate of 75.67 per cent as in 2011. Mainly, the Bhoi sub-tribes of Khasi tribes are inhabitant of the district.

Ri-Bhoi district is a hilly one with intermontane valleys. The western and northern part of the district comprises of the denudational high hills with deep, narrow intermontane valleys. The temperature ranges from 10°C in December to 30°C in the month of July to August. The average annual rainfall of in the district is around 3000 mm and distributed from June to September.

The district has a total net sown area of about 22000 ha and the cropping intensity is 113.05 per cent. The major agricultural crops grown in the district are rice, maize and oilseeds with a total area of 9547 ha, 1583 ha and 426 ha and production of 27592 MT, 4766 MT and 412 MT respectively. The major horticultural crops in the district are vegetables with a total area and production of 1098 ha and 9067 MT respectively. Important fruits include pineapple (3686 ha) and banana (903 ha) with production of 41611 MT and 15569 MT, respectively.

**2.1.4 Arunachal Pradesh**

Arunachal Pradesh, situated between 26°30'N and 29°30'N latitude and 91°30'E and 97°30'E longitude, is the largest state in the NEH region of India. It stretches from snow-capped mountains in the north to the plains of Brahmaputra valley in the south and has a long international border with Bhutan to the west (160 km), China to the north and north-east (1,080 km) and Myanmar to the east (440 km). There are 17 districts in Arunachal Pradesh and its capital, Itanagar is located at an altitude of 530 m above msl.

*Population*

As per Census 2011, the total population of Arunachal Pradesh is 13.84 lakh with 77.33 per cent of them living in rural areas and the population density is only 17 persons per sq. km. About 69 per cent of its population is ST and comprised of 26 major tribes and more than a 100 sub-tribes. Literacy rate is comparatively low at 66.95 per cent and the sex ratio in the state is around 920 females per 1000 males. About 34.67 per cent of the populations are still living under BPL.

*Topography and climate*

Arunachal Pradesh the "*land of the dawn-lit mountains*" has a geographical area of 83,743 sq. km. out of which 80.39 per cent is covered by forests. The altitude of the state varied from 200 m to more than 700 m above msl. Siang, Dibang, Lohit and Tirap are the major rivers of the state.

The climate in the state varies from sub-tropical in the south to alpine in the north. The foot hills experience maximum temperatures higher well over 37°C during summer months. In higher altitudes temperatures go below 0°C. Arunachal Pradesh receives an annual average annual rainfall of about 3000 mm.

*Agriculture*

The total operational land under agriculture in the state is just around 3.9 lakh ha. Rice and maize are the major cereal crops of the state being cultivated on 1.26 lakh ha and 0.47 thousand ha of area with productivity of 1.39 MT/ha and 1.43 MT/ha, respectively. Horticultural crops include apple, kiwi, walnut and citrus. *Jhum* culture (shifting agriculture) is widely practiced by the predominantly large tribal population in the state.

**West Kameng district**

West Kameng district has derived its name from the river Kameng, which is a tributary of the river Brahmaputra that flows through the district. It is situated in between 26°54'N to 28°01'N latitudes and 91°30'E to 92°40' E longitudes and covers a total geographical area of 7422 sq. km. The district is bounded by Tibet in the North, East Kameng district in the East, Assam in the South and Tawang district and Bhutan in the West. The Altitude of the district varies from 216 m to 4571 m above msl. It experiences an alpine to temperate type of climate with three distinct seasons *i.e.*, summer, winter and monsoon. The average annual rainfall in the district is about 1704 mm, and temperature ranges from $25^0$C to -$3^0$C. Agriculture is the main source of income of the inhabitants, and like most of Arunachal Pradesh, *jhum* cultivation is widely practiced by the tribes of the district. Total area under food crops in 2007 was 5445 ha with a total production of 7331 MT. Maize is the major cereal crop of the district with an area covering 2861 ha and productivity of 1.69 MT/ha. Rice and wheat are cultivated over 867 ha and 685 ha, respectively. Other crops include paddy, pulses, wheat, millet, apple, kiwi and walnut.

### 2.1.5 Karbi Anglong district

The Karbi Anglong district is situated between $25^0$33'N to $26^0$35'N latitude and $92^0$10'E to $93^0$50'E longitude in Assam. It is bounded by Golaghat district in the east, Meghalaya and Morigaon district in the west, Nagaon and Golaghat district in the north and North Cachar (N.C.) Hills district and Nagaland in the south. Karbi Anglong district is one of the Autonomous hill district of Assam constituted under the provision of Sixth Schedule to the Constitution of India. The district consists of three Sub-Divisions *viz.*, Bokajan, Hamren and Diphu Sadar.

The total population in the district is about 0.97 lakh, with population density of 93 per sq. km. The literacy rate is 73.52 per cent and there are 956 females per 1000 males. Total number of villages in the district is 2928 and the major ethnic groups are Karbis, Bodos, Kukis, Dimasas, Hmars, Garos, Rengma Nagas, Tiwas, Man (Tai Speaking's). Around 3 lakh people of the district fall under the BPL category.

Karbi Anglong district is part of the Shillong plateau with altitude varying between 100 m to 1400 m. Among them, the highest is the Singhason Peak which is at about 1360 m above the sea level. The district covers an area of 10,434 sq. km. out of which 4922 sq.

km. is under forest cover. The major rivers that flow through the district are the Kopili, Amreng, Borpani, Kolioni and Dhansiri.

During summer, the temperature ranges from $23^0$C to $32^0$C and $6^0$C to $12^0$C during winter season. The average rainfall is about 1205.22 mm per annum.

Agriculture plays an important role in the economy of the district, since around 7.1 lakh people of the rural population directly depends on agriculture for their livelihood. The net sown area is 176.43 ha with a cropping intensity of 129 per cent and the net irrigated area is 5.05 thousand ha in the year 2011-12. The area under rice cultivation is 1.26 mha and the average productivity is 1.88 MT/ha as in 2011-12. Maize is also cultivated in a total area of 10230 ha and production of 8076 MT. The average yield of maize in the district is 0.79 MT/ha.

### 2.1.6. Nagaland

Nagaland lies between 25°60'N to 27°40'N latitude and 93°20'E to 95°15'E longitude. The state shares its borders with the state of Assam to the west, Arunachal Pradesh and part of Assam to the north, Myanmar and Arunachal Pradesh to the east and Manipur to the south. The State is divided into eleven districts, namely Kohima, Phek, Mokokchung, Wokha, Zunhebeto, Twensang, Mon, Dimapur, Kiphire, Longleng, and Peren and the state capital is Kohima (1261 m above msl).

*Population*

The state's population is 1.98 million with population density of 119 persons per sq. km. as in 2011. About 71.07 per cent of the total population lives in 1317 villages. Around 1.4 million people live in the rural areas. About 18.88 per cent of the population lives under BPL. The state has about 931 females per 1000 male and the literacy ratio is 79.55 per cent as in 2011. About 86.48 per cent of the population are ST. The local people were known as *Naka* (in Burmese languages) meaning 'people with pierced ears'. There are 16 main tribes in Nagaland, of which the Konyaks, Angamis, Aos, Lothas, and Sumis are the largest tribes. Tribe and clan traditions and loyalties play an important part in the life of Nagas.

*Topography and climate*

Nagaland is spread over an area of 16579 sq. km. out of which 78.68 per cent is under forest area. The state is mostly mountainous except areas bordering Assam valley. The altitude varies from 194 m to 3048 m. Saramati in Tuensang district is the highest peak in the state. The Naga Hills and Mount Saramati (3841 m) are the major hills. The main rivers that flow through Nagaland are Dhansiri, Doyang, Dikhu, Milak and Tizu. Dhansiri, Doyang, Dikhu and Milak flow westward into the Brahmaputra whereas Tizuriver flows towards east and joins the Chindwin River in Burma. Only 8 per cent of the total area of the state consists of flatlands mainly confined in Dimapur, Jalukie and areas adjoining to Assam. Inceptisols dominate the soils of the state (66.00%); followed by ultisols (23.80%), entisols (7.30%) and alfisols (2.90%) of the total state's geographical area.

Nagaland has a largely monsoon climate with high humidity levels. Annual rainfall averages around 1800–2500 mm, concentrated in the months of May to September. Average summer temperature ranges from 16°C to 31°C. At high elevations during winter, day temperature is limited within 24°C and night temperature ranges from 1°C to 4°C.

*Agriculture*

Agriculture is the most important economic activity in Nagaland, with around 6 lakh of total workforce engaged in agriculture as 2011. The total cultivable area of the state is 5.2 lakh ha, with a total crop area of 4.8 lakh ha and net sown area of 3.8 lakh ha as in 2011-12. Rice is the staple food of the people in Nagaland. It occupies 86 thousand ha, with a production and productivity of 2.1 lakh MT and 2.4 MT/ha, respectively. The two methods of rice cultivation practised in the state are *jhum* and wet land transplanted rice cultivation (WTRC-consisting both low land and terrace rice cultivation). Maize covers an area of 68 thousand ha with a production of 1.3 lakh MT and yield of around 1.96 MT/ha. The other major agricultural crops of the state include millets, grams, mustard, oilseeds, potato, cotton, jute, banana, pineapple, jackfruit; plantation crops such as rubber, coffee, tea, spices such as chilies, ginger and garlic.

**Dimapur district**

Dimapur was declared as a district on 24$^{th}$ January, 2004. The district lies between 25˚54´N latitude and 93˚44´E longitude. It occupies an area of 927 sq. km. and about and the area under forest in the district is around 416 sq. km. It is located on the Western part of Nagaland bordering Assam's Karbi Anglong district. The population of the district is around 3.78 lakh, with about 1.8 lakh residing in rural areas. The sex ratio is 919 females per 1000 males and the literacy rate is 84.79 per cent in the district.

The altitude in the district ranges from 140 to 600 m above msl. The annual rainfall of the district is 1504.7 mm and the temperature in the district ranges from 10$^0$C to 40$^0$C.

Agriculture is the major source of livelihood for the people of Dimapur district. The total cultivable area in the district is around 60 thousand ha and the total cropped area is 7.93 lakh ha as in 2011-12. The net sown area in the district is around 5.62 lakh ha. Rice covers an area of 3.5 lakh ha, with a production and productivity of 8.8 lakh MT and 2.44 MT/ha, respectively. Maize is another important cereal cultivated in the district with an area of 6.69 thousand ha, with a production and productivity of 13.14 thousand MT and 1.96 MT/ha, respectively.

**2.1.7 Manipur**

Manipur is located in between 23°83´N to 25$^0$68´N latitudes and 93°03´E to 94$^0$78´E longitudes. It is surrounded by Nagaland in the north, Mizoram in the south and Assam in the west; it also borders Burma to the east. The state consists of nine administrative districts *viz.*, Bishnupur, Chandel, Churachandpur, Imphal East, Imphal West, Senapati, Tamenglong, Thoubal and Ukhrul. Imphal is the capital city of Manipur.

*Population*

According to Census 2011, the population of the state is 25.70 lakhs, scattered in 33 towns and 2,651 villages. About 67.55 per cent of the total population lives in the rural areas. The population density of the state is 115 per sq. km. The number of female per 1000 male has increased to 992 in 2011 as against 978 in 2001. There are seven SC communities and 33 different tribes of different ethnic groups in the state. Literacy rate in the state is around 72.37 per cent. The number of person falling below the poverty line is around 10.22 lakhs which is 36.89 per cent of the total population of the states as in 2011-12.

*Topography and climate*

About 92 per cent (20507 sq. km.) of the state's total geographical area of 22,327 sq. km. is covered by hills and the remaining area is a small valley covering 1820 sq. km. About 76.10 per cent (16990 sq. km.) of the total geographical area is covered by forest. The altitude of the state varies from 790 to 2020 m above msl.

The climate of Manipur ranges from sub-tropical to temperate. The temperature ranges from sub-zero during January to 36°C during June-July. It receives an average annual rainfall of 1467.5 mm between May and October.

*Agriculture*

About 49.09 per cent of the total workers in Manipur are engaged as cultivators and agricultural labourers. The cultivable land in the state is around 3.65 lakh ha of which 3.39 lakh ha is gross cropped area and net sown area is 2.33 lakh ha as in 2012-13. Rice is the staple food of Manipur and is cultivated primarily as a mono-crop in both hills and plains. Rice is cultivated in hills after cutting the slopes into terrace and also through *jhum* cultivation (slash and burn cultivation). During the period of 2013-14 the annual production and productivity of rice in Manipur was 5.97 lakh MT and 2.68 MT/ha respectively, over an area covering 2.22 lakh ha. In the case of maize, production in 2013-14 was estimated to be 11.91 thousand tonnes. The area under maize was 5.01 thousand ha and average yield was 2.37 MT/ha. The average annual production of fruits and vegetables during the year 2007-08 was 2.74 lakh MT and 0.11 lakh MT, respectively. The major fruits grown in the state are pineapple, orange, lemon, banana, guava and peaches.

**Senapati district**

Senapati district is situated in between 24˚30´N and 25˚45´N latitude and 93˚30´E and 94˚30´E longitude. Senapati district comprises of 6 blocks namely, Mao-Maram, Paomata, Purul, Sadar Hill West, Saitu Gamphazol and Sadar Hill East (Kangpokpi). The hill district covers a total geographical area of 3271 sq. km., which is around 14.65 per cent of the total state geographical area. The district is bounded by Nagaland in the North, Ukhrul district of Manipur in the East, Imphal district in the South and Tamenglong district of Manipur in the West. Although Senapati is the smallest district in area as compared to other hill district of the state, it has the highest population among the hill districts *i.e.*, 1.9 lakh.

The altitude of the district stretches from 720 to 4000 m above msl. It experiences sub-tropical to temperate type of climate with annual rainfall ranging from 671 mm to 1585 mm and has three distinct seasons *i.e.*, summer, winter and monsoon.

The total cropped area is 24.73 thousand ha with a cropping intensity of 141.8 per cent as in 2013-14. Rice and maize are the major cereal crops in the district with total area of around 12.10 thousand ha and 4.7 thousand ha, respectively. In 2013-14 the production of rice and maize in the district was 19.20 thousand MT and 10.55 thousand MT respectively, while the average productivity of rice and maize was 1.58 MT/ha and 2.22 MT/ha, respectively.

**2.1.8 Tripura**

Tripura is situated between $22^0 56'$N to $24^0 32'$N latitude and $91^0.09'$E to $92^0 20'$E longitude. The altitude varies from 213 to 7090 m above msl. It is bounded on the north, west, south and south-east by Bangladesh whereas in the east it has a common boundary with Assam and Mizoram. At present there are eight districts in Tripura namely West Tripura, Khowai, Sipahijala, Gomati, Unakoti, Dhalai, North Tripura and South Tripura.

*Population*

The population of Tripura in 2011 is 36.7 lakh, out of which 27.10 lakh reside in rural areas. Sex ratio in the state stands at 961 (per 1000 males) as in 2011. The literacy rate is found to be 87.75 per cent in the state. The total population of ST in the state is around 11.66 lakh. About 14.05 per cent of the total population of the state is living below the poverty line.

*Topography and climate*

Tripura is a landlocked state in NEH region and one of the smallest hilly states with a total geographical area of about 10486 sq. km., out of which 7866 sq. km. (75.01%) is covered by forest. Forty per cent of total surface of Tripura is classified as plain area, which is situated at the altitude of less than 75 m above msl. The main plain region of the state are found in the southern and western side form a part of the Ganga Brahmaputra plain. The Manu valley is located in the eastern part of the state and Dhalai and Khowai Vallies are located adjacent to the east of the Manu valley. Gomoti is the most important river of Tripura.

Tripura experiences tropical moist or warm humid climate in the plain and sub-tropical to temperate climate in hilly areas. The temperature ranges from $27^0$C and $13^0$C during winter and from $35^0$C and $24^0$C during summer. The total annual rainfall in the state varies between 1500 mm and 2500 mm.

*Agriculture*

The total cultivable area is around 2.59 lakh ha with a cropping intensity of 144.92 per cent. The total cropped area of the state is about 3.71 thousand ha with net sown area of around 2.56 lakh ha. Rice-based cropping system is practiced in Tripura. *Jhum* or shifting cultivation is practiced in the hill region and settled farming in the plains. Small and Marginal farmers constitute about 75 per cent of the total farming community of the state. Rice is grown in three seasons, *i.e., Aush, Aman* and *Boro.* Rice is the major crop in Tripura, with 95.82 per cent of net sown area devoted to the production of rice. The System of Rice Intensification (SRI) method has become popular in the state due to Government intervention. In 2010-11, the total area under rice was 2.64 lakh ha, while the production and productivity was 5.19 lakh MT and 19.61 MT/ha respectively. In the state, maize is cultivated in an area of around 3.10 thousand ha, with a production of 4.10 thousand MT and productivity of 1.32 MT/ha.

**West Tripura district**

West Tripura district lies at 91°09'E to 91°47'E longitude and 23°16'N to 24°14'N latitude. West Tripura covers a total area of 3.5 thousand sq. km. out of total area of 10.49 thousand sq. km. of the state. West Tripura district comprises of 16 blocks namely, Jirania, Khowai, Padmabil, Tulashikhar, Teliamura, Kalyanpur, Mungiakami, Mandwi, Mohanpur, Hezamura, Dukli, Bishalgarh, Jampuijala, Box Nagar, Melaghar and Kathalia. In 2011, the total population of West Tripura is 17.25 lakh, of which 8.79 lakh resides in rural areas. The sex ratio is 964 females per 1000 males and the literacy rate is 88.91 per cent.

The district experiences tropical monsoon climate and temperature ranges between 9°C to 35°C with an average annual rainfall of 2000 mm. Pedologically, the area is characterized by flood plain soils and soils of low lying residual hill valleys.

In 2009-10, the area under rice in West Tripura district was around 96.01 thousand ha. The production and productivity of rice in the district was 2.56 lakh MT and 2.67 MT/ha, respectively. The area under maize was 389 ha and the production and productivity of maize in the district was 350 MT and 900 MT/ha, respectively.

### 2.1.9 Mizoram

Mizoram lies in between $21^0$58'N and $24^0$35'N latitude and $92^0$15'E and $93^0$29'E longitude. The state's north eastern part shares international border with Bangladesh in the west and Myanmar in east and south. Mizoram is divided into eight districts *viz.*, Aizwal, Lunglei, Saiha, Champhai, Mamit, Lawngtlai and Serchip. Mizoram's capital city is Aizawl.

*Population*

The population of the state is about 10.91 lakh and the population density is 52 persons per sq. km. as in 2011. The sex ratio in Mizoram is 975 females per 1000 males and the literacy rate in the state is 91.58 per cent. About 2.22 lakh people live under the BPL category in the state which is about 20.40 per cent as in 2011-12. Mizoram is characterized by a distinct tribal structure with 94.46 per cent of the population belonging to STs. The SC population only comprises about 0.03 per cent of the total State population. The Mizo community is an amalgam of several indigenous tribes who have unique identities and distinctive dialects.

*Topography and Climate*

The area of the state is 21081 sq. km., out of which 90.38 per cent is under forest area. The Mizo Hills, which dominate the state's topography, rise to more than 2050 m near the Myanmar border. The average altitude in the state ranges from 500 m to 800 m with the highest point being Blue Mountain (Phawngpui) at 2157 m above msl. Rivers like Tlawng (Dhaleswari or Katakhal), Tut (Gutur), Tuirial (Sonai) and Tuivawl flow through the northern territory and eventually join river Barak in Cachar and Koldoyne (Chhimtuipui) originates in Myanmar and flows in the south Mizoram.

The state has a climate ranging from moist tropical to moist sub-tropical, with mild summer and winter temperatures. During winter, the temperature varies from $11^0$C to $24^0$C and in summer it varies between $18^0$C to $29^0$C. The average annual rainfall is 2540 mm (range 2160 to 3500 mm) and concentrated during the months of May to September. Normally, winter in Mizoram is a dry season.

*Agriculture*

The total cultivable area and total cropped area in Mizoram was 3.42 lakh ha and 1.33 lakh ha, respectively in 2011-12. The net sown area is around 1.31 lakh ha and the cropping intensity is 107.07 per cent. Paddy is cultivated as *jhum* and wet land rice in both *kharif* and *rabi* season. In 2011-12, the total area under rice is 38.97 thousand ha and the annual production is 75.56 thousand MT with average productivity of 1.93 MT/ha. Maize is another important cereal crop which is cultivated in 6.9 thousand ha. The production of maize in Mizoram is 8.38 MT with a productivity of 1.21 MT/ha in

2011-12. The main horticulture crops are fruits including mandarin orange, banana, passion fruit, grapes, pineapple and papaya.

**Lunglei district**

Lunglei district of Mizoram is situated between 22.03$^0$N to 23.18$^0$N latitude and 92.15$^0$E and 93.10$^0$E longitude. The district is bounded on the north by Mamit and Serchhip districts, on the east by Myanmar, on the south by Lawngtlai and Saiha districts and on the west by Bangladesh. The district is divided into four Rural Development Blocks (RDB); namely Lunglei, Hnahthial, Lungsen and Bunghmun. The district headquarter is located in Lunglei town. Lunglei is also known as Lungleh, which means "bridge of rock". Lunglei has a population of 0.16 lakh as in 2011. Average literacy rate of Lunglei in 2011 is 88.86 per cent and the sex ratio is 947 females per 1000 male.

Lunglei is the biggest district in Mizoram with an area of 4538 sq. km. out of which 9.97 per cent of the total area of Lunglei district is covered by forest. Its hilly terrain is high and prominent in the eastern and northern parts of the district. The average altitude of the district is around 722 m. Lunglei district is characterised by warm climate in general with heavy rainfall (2566 mm/annum) due to its tropical location. May and June are the warmest months with mean daily maximum temperature of 36$^o$C and minimum temperature of 18.5$^0$C, whereas January is the coldest month with the mean daily maximum temperature at 26.6$^0$C and the maximum temperature at 9.9$^0$C.

The farmers of the district mostly practice shifting cultivation. In 2012-13, the district's total net sown area was 17.93 thousand ha whereas the net irrigated area in the district is only out of which only 0.76 thousand ha as in 2012-13. Rice is the major cereal crop cultivated in an area of 4197 ha with an annual production of 5934 MT. Maize is another popular cereal crop with annual production of 1186 MT from an area of 563 ha. Pulses in the district cover an area of 378 ha, with an annual production of 479 MT. The other important crops cultivated in the district include soybean, sesame and sugarcane.

**2.2 Sampling Design**

| Sl. No. | Region | Number of States | Number of hill districts | No of sample respondents for survey |
|---|---|---|---|---|
| 1 | North Eastern | 7 | 1×7=7 | 7 × 120 = 840 |
| 2 | Eastern | 2 | 1×2=2 | 2×120 = 240 |
| | Total | 9 | 9 | 1080 |

*Selection of States and Districts*

Multistage sampling technique was applied for the present study. The NEH is spread from West Bengal (Darjeeling district of West Bengal, except Siliguri sub-division) and Sikkim in East to North Eastern states *viz.,* Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and hills of Assam. ICAR under the National Initiative on Climate Resilient Agriculture (NICRA) project has identified 100 districts in India which are vulnerable to climate change. Out of 100 districts, 17 districts were from North Eastern states. One vulnerable district from each of the states was selected randomly for primary data collection. In case of Assam, out of the two hill districts *i.e*, Karbi Anglong and N.C. Hills (other districts are plain districts, so they are excluded in the sampling procedure), Karbi Anglong district was selected randomly. Darjeeling (except Siliguri Sub-division) district from West Bengal, was selected as it is the only hill district in the state. West Tripura district of Tripura was identified as the vulnerable district by ICAR. But now the district is bifurcated into two districts *i.e.*, West Tripura and Khowai, hence West Tripura district was selected randomly. The identified vulnerable districts in North Eastern states are given below.

| **State** | **Vulnerability Situation** | **Vulnerable Districts (NICRA)** | **Selected district** | **Selected Blocks** |
|---|---|---|---|---|
| Arunachal Pradesh | Water stress | Tirap, West Siang | West Kameng | Dirang<br>Nafra |
| | Cold stress | West Kameng | | |
| Manipur | Drought | Senapati, Imphal East | Senapati | Kangpoki<br>Hangbum |
| Meghalaya | Drought | Ri-Bhoi, West Garo Hills | Ri-Bhoi | Umsning<br>Umling |
| Mizoram | Water Stress | Lunglei | Lunglei | Lunglei<br>Hnahthial |
| Nagaland | Drought | Phek, Dimapur, Mokokchung | Dimapur | Dhansiripar<br>Medziphema |
| Sikkim | Soil erosion and Water Stress | East Sikkim | East Sikkim | Nandok<br>Assam Lingzey |
| Tripura | Cyclones | West Tripura | West Tripura | Mohanpur<br>Jirania |
| Assam | Not Vulnerable | N.C. Hills, Karbi Anglong | Karbi Anglong | Lumbajong<br>Langsomepi |
| West Bengal | Not Vulnerable | Darjeeling (except Siliguri Subdivision) | Darjeeling | Kalimpong Block I<br>Darjeeling Sadar |

*Household survey*

From each of the districts, two blocks were selected randomly. From each of the selected blocks two clusters of villages consisting of two to four villages were selected randomly. From one block 60 farmers, comprising both male and female farmers, were selected randomly using Probability Proportional to Size sampling. Hence, from two blocks of a district 120 farmers were interviewed. Thus, a sample of total 1080 farmers was selected from 9 districts of the whole NEH to capture the impact of climatic variability on farm livelihood.

*Focus Group Discussion/ Case Study/ Interview of Key Informants*

To supplement the information gathered from household survey, case studies were conducted through Focus Group Discussions (FGDs) and interview of key informants.

**2.3 Data**

Both primary and secondary data were collected for the present study. Data on climatic variables *viz.,* rainfall ($0.5 \times 0.5^0$) and temperature ($1 \times 1^0$) were retrieved from India Meteorological Department (IMD) gridded data. The temperature and rainfall data pertained to the period of 1975-2009 and 1975-2007, respectively. Crop acreage, production and productivity at state level were also collected from the State Agricultural Departments and the publications of Directorate of Economics and Statistics. Primary data on socio-economic variables, food, fuel, water (drinking and irrigation), income *etc.*

were collected from the farm households to understand the impact of climatic variability on farm livelihood.

### 2.4 Analytical Techniques

The study used empirical Econometric analysis, tools of social sciences such as gender analysis, focus group discussion and survey method *etc.*, and analysis of climatic variables.

**Analysis of climatic variability**

To find out the trend in climatic variables such as rainfall, temperature IMD data were collected and analyzed. The analysis of rainfall was based on the criteria set by Ashokraj (1979). The criteria adopted for identifying the onset of monsoon is discussed below.

i. The first day`s rain in the 7 days spell is not less than average daily evaporation (e in mm).
ii. The total rain during the 7 days spell is not less than (5e + 10) mm.
iii. At least four out of these seven days do not have less than 2.5 mm of rain each day.

Voluminous work has been carried out in the past by various investigators on rainfall analysis. The criterion set by Raman (1979) for rainfall of 1 mm for defining a rainy day is not suitable for agricultural purpose. So, the criteria fixed by IMD for defining the rainy day, *i.e.* the day with at least 2.5 mm rain is called a rainy day, is used by various researchers working with rainfall analysis (Ashokraj, 1979; Khambete *et al.*, 1998; Rath *et al.*, 1996; Tiwari *et al.*, 2007; Ray *et al.*, 2012a, 2012b, 2012c).

*Markov Chain Probability Model*

Markov chain probability model is extensively used to find out the long term frequency behavior of wet and dry weather spell (Victor and Sastry, 1979). Markov chain probability has also been used for computation of probability of occurrence of daily precipitation (Stern, 1982). A number of researchers have been used Markov chain probability model earlier for dry and wet spell analysis in terms of shortest period like weekly weather temperature and have demonstrated it practical utility in agricultural planning (Agarwal *et al.*, 1984; Pandarinath, 1991; Dash and Senapati, 1992; Dalabehera and Sahoo, 1993).

The methodology followed for the analysis is based on Markov chain probability model as described by Pandarinath (1991) who used weekly data to establish drought frequencies during week periods. The procedure has been suggested by WMO (1982) in which 30 mm or more rainfall in 10 days period is taken as the criteria for deciding the spell as wet. Pandarinath (1991) and Das and Senapati (1992) have assumed 20 mm or more rainfall in a week as the wet week.

In the present study, it is assumed that the week is wet if it receives 20 mm or more rainfall, otherwise dry. The initial probability of a week being dry is defined by

$$p(d) = \frac{F(d)}{N} \quad \dots (1)$$

where,
p (d) is the probability of the week being dry
F (d) frequency of dry week, and
N is total number of years of data being used
Thus the initial probability of the week being wet is given by

$$p(w) = \frac{F(w)}{N}$$ … (2)

where,

p (w) is the probability of the week being dry

F (w) is frequency of dry week, and

N is total number of years of data being used

The transitional probability of a week being dry preceded by another dry week is given by

$$p(dd) = \frac{F(dd)}{N}$$ … (3)

where,

p (dd) is the probability of the week being dry preceded by another dry week

F (dd) is frequency of dry week preceded by another dry week, and

N is total number of years of data being used

The consecutive dry and wet week probabilities are computed as under

$$p(2D) = p(dw1) \times p(ddw2)$$ … (4)

$$p(3D) = p(dw1) \times p(ddw2) \times p(ddw3)$$ … (5)

where,

p (2D) is the probability of two consecutive dry weeks; p (dw1) is probability of the first week being dry; and p (ddw2) is the probability of $2^{nd}$ consecutive dry week given the preceding week being dry; p (3D) is the probability of 3 consecutive dry weeks; p (ddw3) is the probability of $3^{rd}$ week being dry given the preceding week being dry.

In a similar manner, transitional probability of a week being wet preceded by another wet week, p (ww); probability of dry week preceded by wet week p (d/w); probability of wet week preceded by dry week p (w/d); probability of 2 consecutive wet weeks p (2w); and probability of three consecutive wet weeks p (3w) were computed.

*Onset of Monsoon*

South West Monsoon (SWM) gives most of the annual rainfall in India during four months *viz.*, June to September. About 80 per cent of the national average rainfall is from the SWM and the rest 20 per cent from the NE phase of monsoon. IMD has defined a rainy day as a day with equal to or more than 2.5 mm rainfall. Based on this criteria, in this study onset is defined as the first rainy day (>2.5mm) of the first 5 rainy day sequence from $1^{st}$ June without being followed by a consecutive 7-days with each day receiving less than 2.5 mm of rainfall in the following 30 days from the onset. As NE receives plenty of monsoon showers, therefore setting the onset date initiation from the $1^{st}$ June (beginning of SWM) will specifically capture the rainfall in this season only. Researchers like Moron and Robertson (2009) set 10 days for second criteria in Indian condition but in case of NE which receives heavy rainfall during monsoon season, 7 days criteria will serve best.

**Impact on Crop Yield and Variability**

Just-Pope model

Just-pope model stochastic production is given by Just and Pope (1978) and the function is

$$y = f(X; \beta) + \omega h(X; \delta)^{0.5}$$ …. (6)

Where,

*y* is the productivity (production per hectare) of *kharif* rice

$X$ is a vector of explanatory variables

ω is the stochastic term with mean zero and variance 1

β and δ are the production function parameters to be estimated using historical data

The error term) ωh (X; δ)$^{0.5}$in equation (i) shows that Just-Pope model has hetroskedastic error terms. From equation (i), the expected productivity of crop is given by $E(y) = f(X; \beta)$ and crop variability is given by $V(y) = h(X; \beta)$. Hence, by $E(y) = f(X; \beta)$ and $V(y) = h(X; \beta)$ are called mean and variance functions, respectively. The derivatives of the variance function $h(X; \beta)$ w.r.t. the input variables, *viz.*, precipitation and temperature can be used to identify whether a climate variable increases or decreases crop variability. So if, $= \delta h/\delta x > 0$, it indicates that the corresponding input variable x is risk increasing, if $h_x < 0$ it implies risk decreasing. Thus byemploying Just-Pope production function, not only the mean yield but also yield variabilityand effect of an input variable on risk can also be simultaneously estimated.

**Estimation of the function**

Estimation of the above production function can be considered as estimation with heteroskedastic errors as in the following equation.

$$y = f(X; \beta) + u \qquad \text{.... (7)}$$

Where,

u= ωh (X; δ)$^{0.5}$with $E(U) = 0$ and $Var(u) = hf(X; \beta)$

Maximum likelihood estimation (MLE) technique has been applied to estimate the mean and variance functions of the Just-Pope production function and the model was estimated using GRETL 1.10.1.

The variables used in the Just and Pope model and their functional forms are as below:

| Variables | Functional form | |
|---|---|---|
| | Mean function | Variance function |
| Dependent : *Kharif* yield (1975-2007) | | |
| Explanatory | | |
| Trend (T)<br>Average monsoon rainfall (AR) in mm<br>Monsoon maximum temperature (MaxT) in $^0$C<br>Monsoon minimum temperature (MinT) in $^0$C | Cobb - Douglas w.r.t. T, AR, MaxT, MinT.<br>Linear in squared MaxT, squared MinT, squared AR, MaxT X MinT, MaxT X AR, MinT X AR. | Cobb-Douglas w.r.t. T, AR, MaxT, MinT |

In addition, household survey and FGDs was also conducted to assess the impact of climatic variability on cereals, vegetables and livestock etc.

**Impact on Farm Livelihood**

To assess the social impact of climate change FGD as well as household survey was carried out in the study area. Investigations were carried out to find out how the extreme climatic variability (ECV) affects the water, food and fuel availability, farm income and migration if any. What happens to households in relation to food availability during ECVs was studied. Whether the home grown food fall shorts during ECVs and households are forced to purchase food, if yes, then whether they have sufficient resources to purchase food from market were investigated. It is interesting to know whether the gender bias prevails in case of food consumption during the ECVs. The impact of climate change on availability of drinking water for both human as well as animals was considered. Availability of irrigation water for crops during ECV was also being taken into account. The source and availability of fuel in the study area were studied. How fuel availability gets affected and who among the family members (male or female) shares the extra work load in terms of time spent and labor to fetch woods from jungle during the ECVs were investigated. Information on migration (where they migrate, who are left behind in home *etc.*), if happens, was recorded.

This chapter aims at understanding the long term changes in primary climatic factors, *viz.,* rainfall, maximum temperature and minimum temperature. The results of the analysis of climatic factors are presented in following heads:

3.1 Rainfall Situation in North Eastern Himalayas of India

3.1.1 Descriptive statistics for rainfall

3.1.2 Trend in seasonal and annual rainfall

3.1.3 Probability of rainfall

3.1.4 Onset of monsoon

3.2 Temperature Situation in North Eastern Himalayas of India

3.2.1 Descriptive statistics for minimum and maximum temperatures

3.2.2 Trends in minimum and maximum temperatures

## 3.1 Rainfall Situation in North Eastern Himalayas of India

### 3.1.1 Descriptive statistics for rainfall

*Rainfall in Sikkim*

The weekly and monthly rainfall situations in Sikkim are presented in Table 3.1.1.1 and Table 3.1.1.2.

Table 3.1.1.1 Weekly rainfall (mm) in Sikkim during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 2.9 | 0.0 | 55.6 | 347.9 | 27 | 161.9 | 14.2 | 334.5 | 52.4 |
| 2 | 2.1 | 0.0 | 17.8 | 216.0 | 28 | 164.4 | 24.5 | 344.1 | 46.2 |
| 3 | 3.8 | 0.0 | 62.3 | 304.7 | 29 | 165.0 | 22.6 | 424.8 | 49.8 |
| 4 | 2.3 | 0.0 | 28.2 | 249.6 | 30 | 142.4 | 7.9 | 333.0 | 60.8 |
| 5 | 3.7 | 0.0 | 26.2 | 182.1 | 31 | 120.8 | 30.7 | 591.3 | 90.0 |
| 6 | 7.3 | 0.0 | 42.7 | 163.2 | 32 | 126.1 | 9.2 | 325.5 | 61.8 |
| 7 | 7.5 | 0.0 | 78.8 | 214.6 | 33 | 103.7 | 3.1 | 328.3 | 73.4 |
| 8 | 5.0 | 0.0 | 20.2 | 131.5 | 34 | 126.7 | 6.2 | 445.2 | 68.3 |
| 9 | 9.6 | 0.0 | 78.0 | 182.2 | 35 | 109.0 | 13.8 | 310.4 | 70.0 |
| 10 | 4.7 | 0.0 | 48.6 | 214.5 | 36 | 131.8 | 9.2 | 438.0 | 77.1 |
| 11 | 8.8 | 0.0 | 61.4 | 166.5 | 37 | 127.5 | 0.4 | 331.6 | 66.8 |
| 12 | 13.6 | 0.0 | 98.2 | 153.9 | 38 | 75.9 | 1.5 | 248.2 | 91.2 |
| 13 | 18.0 | 0.0 | 109.1 | 150.3 | 39 | 87.4 | 2.4 | 349.9 | 94.4 |
| 14 | 12.1 | 0.0 | 94.3 | 167.9 | 40 | 36.2 | 0.0 | 207.4 | 140.7 |
| 15 | 18.7 | 0.0 | 105.4 | 133.1 | 41 | 26.0 | 0.0 | 147.7 | 130.7 |
| 16 | 21.9 | 0.0 | 116.0 | 109.5 | 42 | 24.9 | 0.0 | 292.0 | 224.9 |
| 17 | 36.6 | 0.0 | 109.2 | 80.6 | 43 | 11.7 | 0.0 | 85.3 | 175.5 |
| 18 | 33.0 | 3.2 | 108.2 | 72.0 | 44 | 2.8 | 0.0 | 36.7 | 258.5 |
| 19 | 37.6 | 4.7 | 112.8 | 75.7 | 45 | 5.8 | 0.0 | 133.7 | 406.8 |
| 20 | 40.8 | 0.0 | 107.0 | 67.0 | 46 | 2.8 | 0.0 | 44.3 | 305.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | 66.3 | 0.8 | 341.9 | 98.0 | 47 | 1.5 | 0.0 | 25.2 | 306.3 |
| 22 | 63.1 | 1.3 | 255.5 | 80.9 | 48 | 4.6 | 0.0 | 126.3 | 477.4 |
| 23 | 68.2 | 5.1 | 165.8 | 71.6 | 49 | 0.6 | 0.0 | 6.4 | 262.9 |
| 24 | 109.5 | 12.9 | 283.6 | 52.9 | 50 | 1.4 | 0.0 | 28.2 | 358.3 |
| 25 | 128.9 | 26.9 | 439.5 | 64.2 | 51 | 0.1 | 0.0 | 2.7 | 460.7 |
| 26 | 154.3 | 37.9 | 485.4 | 56.0 | 52 | 3.9 | 0.0 | 30.5 | 205.8 |

The highest normal weekly rainfall was received in 29th Standard Meteorology Week (SMW) (165.0 mm), followed by 28th SMW (164.4 mm) and 27th SMW (161.9 mm) in Sikkim during 1975-2007. The lowest normal rainfall was registered in 51st SMW (0.1 mm). The highest maximum weekly rainfall of 591.3 mm was received in 31st SMW in 1995. The variation in weekly rainfall was maximum in 48th SMW (477.4%), followed by 51st SMW (460.7%) and 45th SMW (406.8%).

Table 3.1.1.2. Monthly rainfall (mm) in Sikkim during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 12.5 | 0.0 | 64.0 | 126.4 | Jul | 710.6 | 407.9 | 1597.0 | 32.8 |
| Feb | 28.0 | 0.0 | 158.6 | 122.3 | Aug | 503.6 | 48.8 | 1473.8 | 51.6 |
| Mar | 45.3 | 0.0 | 231.3 | 115.7 | Sep | 449.4 | 151.6 | 814.7 | 42.5 |
| Apr | 101.0 | 3.4 | 250.0 | 71.0 | Oct | 98.9 | 0.2 | 305.4 | 80.7 |
| May | 208.2 | 58.4 | 451.4 | 47.7 | Nov | 13.6 | 0.0 | 133.7 | 190.0 |
| Jun | 464.8 | 228.5 | 865.3 | 34.8 | Dec | 9.3 | 0.0 | 109.6 | 216.9 |

Table 3.1.1.3. Seasonal and annual rainfall (mm) in Sikkim during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min | Max | |
| Pre-monsoon | 395.0 (14.93) | 101.6 | 787.5 | 44.6 |
| Monsoon | 2128.4 (80.46) | 1183.7 | 4193.1 | 25.3 |
| Post-monsoon | 121.8 (4.60) | 2.1 | 346.9 | 73.4 |
| Annual | 2645.3 | 1805.6 | 4820.3 | 22.3 |

Note: Figures in parenthesis indicate per cent to total

The highest normal monthly rainfall of 710.6 mm was received in the month of July in Sikkim, followed by August (503.6 mm), June (464.8 mm) and September (449.4 mm). The lowest normal rainfall was received in December (9.3 mm). Sikkim has registered highest maximum rainfall of 1597.0 mm in the month of July in 1998. The variation in rainfall was maximum in December (216.9%), followed by November (190.0%) and January (126.4%) whereas minimum in the month of July (32.8%). The seasonal and annual rainfall situation in Sikkim is presented in Table 3.1.1.3.

Sikkim has received normal annual rainfall of 2645.3 mm during 1975-2007 with maximum annual rainfall of 4820.3 mm in the year 1998 and minimum annual rainfall of 1805.6 mm in the year 1996. Maximum of the rainfall was concentrated during the monsoon season (80.46%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (73.4 %) and minimum in monsoon season (25.3%).

*Rainfall in Darjeeling*

The weekly and monthly rainfall situations in Darjeeling are presented in Table 3.1.1.4 and Table 3.1.1.5.

Table 3.1.1.4. Weekly rainfall (mm) in Darjeeling during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 1.0 | 0.0 | 17.3 | 310.4 | 27 | 167.0 | 10.8 | 359.1 | 50.8 |
| 2 | 1.9 | 0.0 | 13.6 | 204.1 | 28 | 162.6 | 13.1 | 370.0 | 56.2 |
| 3 | 4.1 | 0.0 | 35.3 | 234.9 | 29 | 168.1 | 24.9 | 359.8 | 51.0 |
| 4 | 2.1 | 0.0 | 19.2 | 228.0 | 30 | 131.8 | 10.1 | 357.5 | 73.4 |
| 5 | 2.2 | 0.0 | 15.9 | 182.9 | 31 | 112.8 | 22.4 | 591.0 | 90.5 |
| 6 | 3.5 | 0.0 | 19.6 | 169.8 | 32 | 100.9 | 3.2 | 257.7 | 68.3 |
| 7 | 3.2 | 0.0 | 26.5 | 179.7 | 33 | 99.7 | 11.7 | 272.5 | 72.6 |
| 8 | 3.8 | 0.0 | 38.0 | 201.5 | 34 | 121.5 | 6.8 | 378.0 | 64.4 |
| 9 | 4.4 | 0.0 | 39.5 | 206.5 | 35 | 90.2 | 9.1 | 259.3 | 70.3 |
| 10 | 1.8 | 0.0 | 13.1 | 179.5 | 36 | 115.3 | 4.5 | 444.7 | 82.2 |
| 11 | 4.0 | 0.0 | 29.7 | 155.5 | 37 | 105.3 | 11.3 | 410.5 | 72.4 |
| 12 | 5.8 | 0.0 | 37.5 | 154.3 | 38 | 82.9 | 4.2 | 386.3 | 113.6 |
| 13 | 10.8 | 0.0 | 40.9 | 123.9 | 39 | 87.0 | 0.4 | 243.6 | 80.3 |
| 14 | 5.4 | 0.0 | 40.2 | 163.2 | 40 | 57.1 | 0.0 | 305.0 | 138.2 |
| 15 | 12.2 | 0.0 | 40.5 | 111.7 | 41 | 29.4 | 0.0 | 149.6 | 102.4 |
| 16 | 17.5 | 0.0 | 52.7 | 82.5 | 42 | 20.0 | 0.0 | 253.8 | 236.5 |
| 17 | 29.1 | 0.0 | 81.6 | 74.2 | 43 | 9.1 | 0.0 | 72.8 | 191.3 |
| 18 | 32.8 | 2.4 | 85.6 | 64.2 | 44 | 2.3 | 0.0 | 13.5 | 178.1 |
| 19 | 39.2 | 3.3 | 86.2 | 56.3 | 45 | 3.9 | 0.0 | 80.4 | 365.8 |
| 20 | 44.4 | 3.5 | 130.8 | 61.7 | 46 | 2.4 | 0.0 | 19.6 | 218.9 |
| 21 | 65.1 | 0.5 | 167.5 | 63.5 | 47 | 0.9 | 0.0 | 13.3 | 273.7 |
| 22 | 68.0 | 0.7 | 232.8 | 73.4 | 48 | 3.2 | 0.0 | 87.3 | 468.8 |
| 23 | 82.5 | 4.2 | 206.3 | 62.4 | 49 | 0.3 | 0.0 | 4.2 | 271.5 |
| 24 | 96.5 | 5.2 | 240.8 | 77.5 | 50 | 1.7 | 0.0 | 24.0 | 288.7 |
| 25 | 114.8 | 36.5 | 265.7 | 53.5 | 51 | 0.3 | 0.0 | 5.8 | 383.8 |
| 26 | 121.8 | 11.0 | 299.3 | 64.0 | 52 | 3.9 | 0.0 | 32.1 | 189.3 |

The 29$^{th}$ SMW has registered highest normal weekly rainfall of 168.1 mm, followed by 27$^{th}$ SMW (167.0 mm) and 28$^{th}$ SMW (162.6 mm) in Darjeeling district of West Bengal during 1975-2007. The lowest normal weekly rainfall was received in 1$^{st}$ SMW (1.0 mm). The highest maximum weekly rainfall of 591.0 mm was received in 31$^{st}$ SMW of 1995.The CV was maximum in 48$^{th}$ SMW (468.8%), followed by 51$^{st}$ SMW (383.8%) and 45$^{th}$ SMW (365.8%). The lowest weekly variation was registered in 27$^{th}$ SMW (50.8%) and followed by 29$^{th}$ SMW (51.0%).

| Table 3.1.1.5. Monthly rainfall (mm) in Darjeeling during 1975-2007 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
| | | Min | Max | | | | Min | Max | |
| Jan | 9.9 | 0.0 | 41.3 | 114.4 | Jul | 700.6 | 292.7 | 1435.8 | 29.9 |
| Feb | 14.0 | 0.2 | 67.1 | 108.5 | Aug | 457.2 | 135.7 | 1005.1 | 43.0 |
| Mar | 22.2 | 0.0 | 71.2 | 82.9 | Sep | 407.6 | 161.0 | 994.5 | 48.6 |
| Apr | 76.1 | 0.4 | 172.4 | 56.3 | Oct | 116.2 | 1.0 | 344.7 | 77.7 |
| May | 217.0 | 101.0 | 429.7 | 38.9 | Nov | 9.6 | 0.0 | 80.9 | 162.1 |
| Jun | 418.8 | 191.1 | 732.1 | 32.4 | Dec | 8.6 | 0.0 | 70.8 | 166.6 |

The month of July has registered highest normal monthly rainfall of 700.6 mm in Darjeeling during 1975-2007, followed by August (457.2 mm) and June (418.8 mm) whereas, the month of December has received the lowest normal rainfall of 8.6 mm. It was found that rainfall of as high as 1435.8 mm has occurred in the month of July in 1995. The CVs were higher in the months of December (166.6%), November (162.1%), January (114.1%) and February (108.5%). Within monsoon period, the variation in rainfall was maximum in the month of September (48.6%). The seasonal and annual rainfall situation in Darjeeling is presented in Table 3.1.1.6.

| Table 3.1.1.6. Seasonal and annual rainfall (mm) in Darjeeling during 1975-2007 | | | | |
|---|---|---|---|---|
| Season | Normal (%) | Extremes | | CV (%) |
| | | Min (mm) | Max (mm) | |
| Pre-monsoon | 339.1 (13.80) | 198.1 | 482.0 | 24.1 |
| Monsoon | 1984.2 (80.73) | 1166.1 | 3061.5 | 21.3 |
| Post-monsoon | 134.5 (5.47) | 5.7 | 426.3 | 73.9 |
| Annual | 2457.8 | 1576.9 | 3484.4 | 18.7 |

Note: Figures in parenthesis indicate per cent to total

The highest normal seasonal rainfall occurred during the monsoon season (80.73%), followed by pre-monsoon and post monsoon season. The normal annual rainfall is calculated to be 2457.8 mm. The highest maximum rainfall of 3484.4 mm was received in the year of 1998. The variation in rainfall was maximum in post-monsoon season (73.9%), followed by pre-monsoon (24.1%) and monsoon season (21.3%).

*Rainfall in Meghalaya*

The weekly and monthly rainfall situations in Meghalaya are presented in Table 3.1.1.7 and Table 3.1.1.8. The highest normal weekly rainfall was received in 27$^{th}$ SMW (126.8 mm), followed by 28$^{th}$ SMW (126.0 mm) and 29$^{th}$ SMW (124.5 mm) in Meghalaya during 1975-2007. The lowest normal rainfall was registered in 49$^{th}$ SMW (0.7 mm). The highest maximum weekly rainfall of 576.9 mm was received in 34$^{th}$ SMW in 2005. The variation in weekly rainfall was maximum in 48$^{th}$ SMW (393.9%), followed by 47$^{th}$ SMW (347.3%) and 49$^{th}$ SMW (318.9%).

The highest normal monthly rainfall of 531.3 mm was received in the month of July, followed by June (438.1 mm), August (354.8 mm) and September (290.5 mm). The lowest normal rainfall was received in January (11.0 mm). Meghalaya has registered highest maximum rainfall of 1108.3 mm in the month of August in 2005. The variation in rainfall was maximum in November (125.2%), followed by December (124.3%) and January (115.2%) whereas, minimum in the month of August (35.4%).

Table 3.1.1.7. Weekly rainfall (mm) in Meghalaya during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 1.3 | 0.0 | 15.8 | 257.3 | 27 | 126.8 | 20.9 | 359.1 | 67.1 |
| 2 | 3.5 | 0.0 | 60.2 | 310.3 | 28 | 126.0 | 10.5 | 441.7 | 82.9 |
| 3 | 3.6 | 0.0 | 25.2 | 161.0 | 29 | 124.5 | 15.0 | 378.1 | 75.5 |
| 4 | 1.8 | 0.0 | 9.8 | 131.1 | 30 | 112.1 | 11.4 | 404.3 | 77.5 |
| 5 | 3.5 | 0.0 | 14.7 | 120.8 | 31 | 82.7 | 27.4 | 234.9 | 58.2 |
| 6 | 4.8 | 0.0 | 29.7 | 156.6 | 32 | 68.0 | 11.6 | 276.4 | 77.5 |
| 7 | 4.7 | 0.0 | 33.1 | 157.4 | 33 | 76.8 | 31.6 | 235.6 | 60.6 |
| 8 | 6.8 | 0.0 | 42.4 | 132.1 | 34 | 97.9 | 25.2 | 576.9 | 99.0 |
| 9 | 5.4 | 0.0 | 21.9 | 118.5 | 35 | 74.0 | 27.8 | 312.3 | 78.9 |
| 10 | 4.6 | 0.0 | 42.3 | 186.3 | 36 | 82.3 | 10.8 | 462.7 | 99.8 |
| 11 | 8.1 | 0.0 | 43.5 | 118.1 | 37 | 73.3 | 9.4 | 211.8 | 68.1 |
| 12 | 16.0 | 0.0 | 120.8 | 150.3 | 38 | 57.3 | 5.5 | 192.2 | 79.4 |
| 13 | 23.3 | 0.0 | 89.7 | 111.3 | 39 | 61.2 | 4.9 | 184.2 | 63.7 |
| 14 | 23.1 | 0.0 | 86.2 | 107.3 | 40 | 56.5 | 2.6 | 173.3 | 85.1 |
| 15 | 26.6 | 0.0 | 80.2 | 83.6 | 41 | 54.4 | 3.8 | 316.3 | 127.0 |
| 16 | 35.8 | 0.0 | 87.9 | 72.5 | 42 | 38.3 | 0.0 | 210.3 | 123.3 |
| 17 | 49.0 | 0.0 | 96.6 | 50.5 | 43 | 13.0 | 0.0 | 142.4 | 208.2 |
| 18 | 52.5 | 4.7 | 110.2 | 55.8 | 44 | 14.3 | 0.0 | 236.6 | 315.0 |
| 19 | 55.2 | 17.2 | 114.6 | 41.9 | 45 | 7.7 | 0.0 | 63.3 | 196.4 |
| 20 | 54.7 | 7.1 | 222.5 | 70.6 | 46 | 8.5 | 0.0 | 85.5 | 226.3 |
| 21 | 66.9 | 9.5 | 364.5 | 95.6 | 47 | 4.1 | 0.0 | 81.8 | 347.3 |
| 22 | 81.1 | 10.0 | 182.4 | 59.9 | 48 | 7.2 | 0.0 | 161.5 | 393.9 |
| 23 | 84.8 | 13.7 | 291.9 | 67.3 | 49 | 0.7 | 0.0 | 10.4 | 318.9 |
| 24 | 113.3 | 18.1 | 299.5 | 60.5 | 50 | 4.2 | 0.0 | 57.2 | 268.0 |
| 25 | 121.8 | 19.7 | 665.1 | 91.7 | 51 | 1.2 | 0.0 | 14.1 | 232.2 |
| 26 | 102.2 | 5.8 | 294.3 | 71.8 | 52 | 3.5 | 0.0 | 32.7 | 214.5 |

Table 3.1.1.8. Monthly rainfall (mm) in Meghalaya during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 11.0 | 0.0 | 64.7 | 115.2 | Jul | 531.3 | 206.6 | 1041.6 | 39.6 |
| Feb | 22.0 | 0.0 | 65.2 | 70.2 | Aug | 354.8 | 173.0 | 1108.3 | 49.7 |
| Mar | 49.6 | 3.7 | 184.4 | 78.7 | Sep | 290.5 | 131.0 | 639.9 | 39.8 |
| Apr | 149.3 | 0.0 | 332.8 | 51.2 | Oct | 173.5 | 15.4 | 484.5 | 64.6 |
| May | 271.6 | 117.5 | 606.5 | 36.5 | Nov | 27.9 | 0.0 | 151.3 | 125.2 |
| Jun | 438.1 | 93.3 | 969.7 | 39.3 | Dec | 11.5 | 0.0 | 57.9 | 124.3 |

The seasonal and annual rainfall situation in Meghalaya is presented in Table 3.1.1.9. Meghalaya has received normal annual rainfall of 2331.1 mm during 1975-2007 with maximum annual rainfall of 4522.5 mm in the year 2005 and minimum annual rainfall of 1555.1 mm in the year 2006. Maximum of the rainfall was concentrated during the monsoon season (69.3%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (51.1%) and minimum in monsoon season (29.8%).

Table 3.1.1.9. Seasonal and annual rainfall (mm) in Meghalaya during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min (mm) | Max (mm) | |
| Pre-monsoon | 503.5 (21.6) | 266.5 | 863.8 | 27.5 |
| Monsoon | 1614.8 (69.3) | 957.8 | 3330.9 | 29.8 |
| Post-monsoon | 212.9 (9.1) | 73.9 | 493.8 | 51.1 |
| Annual | 2331.1 | 1555.1 | 4522.5 | 25.0 |

Note: Figures in parenthesis indicate per cent to total

*Rainfall in Arunachal Pradesh*

The weekly and monthly rainfall situations in Arunachal Pradesh are presented in Table 3.1.1.10 and Table 3.1.1.11.

Table 3.1.1.10. Weekly rainfall (mm) situation in Arunachal Pradesh during 1975-2007

| Week | Normal | Range | | CV (%) | Week | Normal | Range | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 1.5 | 0.0 | 11.1 | 186.3 | 27 | 108.9 | 42.0 | 249.6 | 41.9 |
| 2 | 4.4 | 0.0 | 52.9 | 223.9 | 28 | 116.5 | 22.6 | 225.8 | 47.6 |
| 3 | 4.3 | 0.0 | 23.3 | 127.3 | 29 | 100.9 | 35.5 | 218.4 | 44.3 |
| 4 | 3.8 | 0.0 | 23.9 | 128.2 | 30 | 88.1 | 13.0 | 218.4 | 59.8 |
| 5 | 6.8 | 0.0 | 25.7 | 116.0 | 31 | 71.3 | 24.2 | 169.5 | 47.2 |
| 6 | 7.8 | 0.0 | 31.5 | 115.7 | 32 | 72.4 | 2.0 | 153.8 | 61.1 |
| 7 | 9.6 | 0.0 | 77.4 | 157.9 | 33 | 86.3 | 12.0 | 168.3 | 50.4 |
| 8 | 9.5 | 0.0 | 42.6 | 105.0 | 34 | 93.6 | 18.2 | 244.0 | 44.1 |
| 9 | 10.7 | 0.0 | 46.2 | 103.9 | 35 | 73.7 | 4.1 | 228.8 | 55.3 |
| 10 | 8.9 | 0.0 | 62.3 | 171.3 | 36 | 72.6 | 18.6 | 183.7 | 52.9 |
| 11 | 10.6 | 0.0 | 37.8 | 103.6 | 37 | 77.8 | 0.5 | 261.8 | 73.1 |
| 12 | 18.2 | 0.0 | 59.7 | 101.6 | 38 | 59.3 | 4.3 | 148.6 | 53.1 |
| 13 | 21.3 | 0.1 | 63.5 | 86.2 | 39 | 56.2 | 0.7 | 132.8 | 65.0 |
| 14 | 29.9 | 0.0 | 98.6 | 87.9 | 40 | 41.8 | 4.7 | 138.7 | 77.4 |
| 15 | 36.0 | 0.2 | 113.1 | 79.5 | 41 | 37.7 | 0.2 | 161.5 | 108.7 |
| 16 | 44.0 | 0.2 | 115.4 | 73.6 | 42 | 32.8 | 0.0 | 181.6 | 114.3 |
| 17 | 50.7 | 0.0 | 121.4 | 57.9 | 43 | 15.6 | 0.0 | 98.9 | 167.8 |
| 18 | 54.8 | 1.1 | 122.9 | 53.6 | 44 | 12.9 | 0.0 | 231.1 | 341.7 |
| 19 | 48.6 | 10.9 | 180.1 | 69.8 | 45 | 6.2 | 0.0 | 44.4 | 162.7 |
| 20 | 65.2 | 15.2 | 215.1 | 78.7 | 46 | 5.6 | 0.0 | 39.8 | 154.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | 61.2 | 2.4 | 204.8 | 74.8 | 47 | 5.2 | 0.0 | 53.5 | 215.8 |
| 22 | 11.9 | 1.0 | 45.2 | 79.8 | 48 | 5.4 | 0.0 | 60.9 | 248.8 |
| 23 | 80.9 | 10.9 | 276.1 | 64.6 | 49 | 2.1 | 0.0 | 27.3 | 246.7 |
| 24 | 92.9 | 6.1 | 287.1 | 56.9 | 50 | 5.5 | 0.0 | 56.1 | 225.4 |
| 25 | 100.3 | 23.6 | 173.5 | 44.7 | 51 | 1.8 | 0.0 | 12.3 | 181.9 |
| 26 | 95.7 | 35.8 | 176.8 | 41.1 | 52 | 3.5 | 0.0 | 25.5 | 190.4 |

The highest weekly normal rainfall was received in 28th SMW (116.5 mm), followed by 27th SMW (108.9 mm) and 29th SMW (100.9 mm) in Sikkim during 1975-2009. The lowest normal rainfall was registered in 1st SMW (1.5 mm). The highest maximum weekly rainfall of 287.1 mm was received in 24th SMW in 1976. The variation in weekly rainfall was maximum in 48th SMW (248.8%), followed by 49th SMW (246.7%) and 50th SMW (225.4%).

Table 3.1.1.11. Monthly rainfall (mm) situation in Arunachal Pradesh during 1975-2007

| Month | Normal | Range | | CV (%) | Month | Normal | Range | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 16.6 | 1.3 | 64.9 | 79.6 | Jul | 449.0 | 257.1 | 666.4 | 23.4 |
| Feb | 36.8 | 0.2 | 95.8 | 60.2 | Aug | 359.0 | 225.9 | 607.0 | 26.7 |
| Mar | 59.6 | 10.2 | 131.7 | 62.0 | Sep | 282.1 | 152.1 | 520.3 | 31.9 |
| Apr | 175.1 | 3.1 | 397.6 | 49.5 | Oct | 137.9 | 40.9 | 317.2 | 50.3 |
| May | 275.8 | 109.6 | 514.9 | 34.2 | Nov | 22.3 | 0.0 | 81.1 | 102.0 |
| Jun | 385.0 | 189.6 | 603.7 | 25.6 | Dec | 15.0 | 0.0 | 59.5 | 102.3 |

The highest normal monthly rainfall of 449.0 mm was received in the month of July in Arunachal Pradesh, followed by June (385.0 mm), August (359.0 mm) and September (282.1 mm). The lowest normal rainfall was received in December (15.0 mm). Arunachal Pradesh has registered highest maximum monthly rainfall of 666.4 mm in the month of July in 1979. The variation in rainfall was maximum in December (102.3%), followed by November (102.0%) and January (79.6%) whereas, minimum in the month of July (23.4%).

Table 3.1.1.12.Seasonal and annual rainfall (mm) situation in Arunachal Pradesh during 1975-2007

| Season | Normal (%) | Range | | CV (%) |
|---|---|---|---|---|
| | | Min (mm) | Max (mm) | |
| Pre-monsoon | 564.0 (25.46) | 229.6 | 1016.0 | 26.7 |
| Monsoon | 1475.1 (66.62) | 1115.7 | 1802.7 | 11.8 |
| Post-monsoon | 175.3 (7.92) | 71.0 | 322.1 | 35.6 |
| Annual | 2214.3 | 1733.0 | 2848.3 | 11.5 |

Note: Figures in parenthesis indicate per cent to total

The seasonal and annual rainfall situation in Arunachal Pradesh is presented in Table 3.1.1.12. Sikkim has received normal annual rainfall of 2214.3 mm during 1975-2007 with maximum annual rainfall of 2848.3 mm in the year 1977 and minimum annual rainfall of 1733.0 mm in the year 1996. Maximum of the rainfall was concentrated during the monsoon season (66.62%), followed by pre-monsoon (25.46%) and post-monsoon (7.92%) season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (35.6 %) and minimum in monsoon season (11.8%).

*Rainfall in Karbi Anglong*

The weekly and monthly rainfall situations in Karbi Anglong are presented in Table 3.1.1.13 and Table 3.1.1.14.

Table 3.1.1.13. Weekly rainfall (mm) in Karbi Anglong during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 2.0 | 0.0 | 34.9 | 317.7 | 27 | 81.4 | 19.0 | 257.7 | 66.8 |
| 2 | 3.2 | 0.0 | 41.6 | 244.7 | 28 | 84.1 | 23.3 | 189.4 | 53.9 |
| 3 | 2.7 | 0.0 | 30.9 | 209.7 | 29 | 76.7 | 26.6 | 212.0 | 58.1 |
| 4 | 1.6 | 0.0 | 9.0 | 147.6 | 30 | 71.3 | 14.7 | 175.8 | 49.2 |
| 5 | 5.0 | 0.0 | 26.1 | 126.3 | 31 | 77.5 | 20.6 | 274.6 | 61.5 |
| 6 | 6.0 | 0.0 | 35.8 | 154.5 | 32 | 59.7 | 10.5 | 119.5 | 47.6 |
| 7 | 5.6 | 0.0 | 35.2 | 156.2 | 33 | 57.6 | 15.9 | 151.4 | 54.6 |
| 8 | 9.1 | 0.0 | 36.2 | 117.1 | 34 | 63.7 | 16.3 | 123.1 | 46.0 |
| 9 | 6.9 | 0.0 | 32.8 | 116.2 | 35 | 63.9 | 16.1 | 190.2 | 55.0 |
| 10 | 6.5 | 0.0 | 45.8 | 167.7 | 36 | 56.8 | 16.9 | 162.8 | 57.8 |
| 11 | 9.3 | 0.0 | 40.5 | 97.5 | 37 | 54.7 | 8.4 | 115.6 | 53.3 |
| 12 | 16.3 | 0.0 | 73.3 | 123.6 | 38 | 45.3 | 6.7 | 100.6 | 58.6 |
| 13 | 21.6 | 1.6 | 132.1 | 122.7 | 39 | 51.2 | 3.4 | 223.4 | 86.5 |
| 14 | 20.7 | 0.0 | 85.0 | 98.7 | 40 | 43.5 | 0.8 | 147.5 | 76.0 |
| 15 | 26.3 | 0.0 | 68.7 | 75.5 | 41 | 46.6 | 2.7 | 197.6 | 106.9 |
| 16 | 30.9 | 0.5 | 89.2 | 79.3 | 42 | 33.0 | 0.0 | 170.9 | 117.8 |
| 17 | 39.8 | 0.3 | 102.0 | 59.6 | 43 | 11.1 | 0.0 | 50.4 | 117.5 |
| 18 | 40.4 | 6.0 | 92.9 | 59.1 | 44 | 14.6 | 0.0 | 197.2 | 263.7 |
| 19 | 37.3 | 3.9 | 71.3 | 50.6 | 45 | 8.1 | 0.0 | 51.0 | 153.4 |
| 20 | 43.7 | 2.5 | 195.1 | 77.2 | 46 | 7.9 | 0.0 | 87.7 | 234.6 |
| 21 | 47.7 | 3.1 | 264.9 | 100.5 | 47 | 3.9 | 0.0 | 62.2 | 276.8 |
| 22 | 49.0 | 11.3 | 123.0 | 64.2 | 48 | 6.5 | 0.0 | 123.8 | 336.5 |
| 23 | 63.4 | 10.6 | 158.1 | 64.5 | 49 | 0.9 | 0.0 | 17.8 | 356.9 |
| 24 | 76.0 | 23.5 | 161.5 | 50.3 | 50 | 3.8 | 0.0 | 37.7 | 245.7 |
| 25 | 75.3 | 11.1 | 173.4 | 53.1 | 51 | 2.1 | 0.0 | 27.1 | 270.8 |
| 26 | 71.2 | 21.9 | 187.9 | 53.8 | 52 | 3.9 | 0.0 | 40.1 | 234.4 |

The highest normal weekly rainfall was received in 28$^{th}$ SMW (84.1 mm), followed by 27$^{th}$ (81.4 mm) and 31$^{st}$ SMW (77.5 mm) in Karbi Anglong during 1975-2007. The lowest normal rainfall was registered in 1$^{st}$ SMW (2.0 mm). The highest maximum weekly rainfall of 274.6 mm was received in 31$^{st}$ SMW in 1981. The variation in weekly rainfall was maximum in 49$^{th}$ SMW (356.9%), followed by 48$^{th}$ week (336.5%) and 1$^{st}$ SMW (317.7%).

The highest normal monthly rainfall of 347.8 mm was received in the month of July, followed by June (293.8 mm), August (282.5 mm) and September (224.1 mm). The lowest normal rainfall (10.7 mm) was received in January. Karbi Anglong has registered highest maximum rainfall of 601.1 mm in the month of July in 1989.The variation in rainfall was maximum in January (123.9%), followed by December (117.5%) and November (103.4%) whereas minimum in the month of July (28.7%). The seasonal and annual rainfall situation in Karbi Anglong is presented in Table 3.1.1.15.

Table 3.1.1.14. Monthly rainfall (mm) in Karbi Anglong during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 10.7 | 0.0 | 62.1 | 123.9 | Jul | 347.8 | 214.3 | 601.1 | 28.7 |
| Feb | 27.7 | 0.2 | 81.9 | 71.3 | Aug | 282.5 | 133.0 | 525.5 | 31.2 |
| Mar | 53.4 | 7.0 | 130.2 | 64.7 | Sep | 224.1 | 103.1 | 372.2 | 31.0 |
| Apr | 129.8 | 12.2 | 238.3 | 42.9 | Oct | 144.7 | 28.2 | 330.7 | 59.9 |
| May | 192.4 | 58.5 | 435.2 | 39.9 | Nov | 28.4 | 0.0 | 117.4 | 103.4 |
| Jun | 293.8 | 142.4 | 490.3 | 30.9 | Dec | 12.5 | 0.0 | 48.7 | 117.5 |

Table 3.1.1.15. Seasonal and annual rainfall (mm) in Karbi Anglong during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min | Max | |
| Pre-monsoon | 414.0 (23.69) | 212.8 | 692.5 | 25.4 |
| Monsoon | 1148.2 (65.69) | 781.3 | 1480.2 | 16.0 |
| Post-monsoon | 185.6 (10.62) | 44.3 | 351.4 | 46.5 |
| Annual | 1747.8 | 1286.7 | 2303.5 | 14.3 |

Note: Figures in parenthesis indicate per cent to total

Karbi Anglong has received normal annual rainfall of 1747.8 mm during 1975-2007 with maximum annual rainfall of 2303.5 mm in the year 1988 and minimum annual rainfall of 1286.7 mm in the year 2006. Maximum of the rainfall was concentrated during the monsoon season (65.69%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (46.5%) and minimum in monsoon season (16.0%).

*Rainfall in Nagaland*

The weekly and monthly rainfall situations in Nagaland are presented in Table 3.1.1.16 and Table 3.1.1.17. The highest normal monthly rainfall was received in 28$^{th}$ SMW (113.0 mm), followed by 27$^{th}$ (105.7 mm) and 30$^{th}$ SMW (96.6 mm) in Nagaland during 1975-2007. The lowest normal rainfall was registered in 49$^{th}$ SMW (2.2 mm). The highest maximum weekly rainfall of 285.3 mm was received in 28$^{th}$ SMW in 1981. The variation in weekly rainfall was maximum in 44$^{th}$ SMW (270.1%), followed by 23$^{rd}$ SMW (233.5%) and 50$^{th}$ SMW (231.3%).

The highest normal monthly rainfall of 450.1 mm was received in the month of July, followed by August (394.0 mm), June (341.4 mm) and September (311.1 mm). The lowest normal rainfall was received in December (16.8 mm). Nagaland has registered highest maximum rainfall of 679.7.1 mm in the month of July in 1989. The variation in rainfall was maximum in Decemebr (102.6%), followed by November (88.3%) and January (80.3%) whereas, minimum in the month of August (25.9%).

Table 3.1.1.16. Weekly rainfall (mm) in Nagaland during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 2.3 | 0.0 | 17.0 | 194.4 | 27 | 105.7 | 29.1 | 250.0 | 42.5 |
| 2 | 4.9 | 0.0 | 61.6 | 222.3 | 28 | 113.0 | 26.8 | 285.3 | 50.7 |
| 3 | 4.8 | 0.0 | 18.4 | 115.1 | 29 | 94.7 | 31.4 | 157.1 | 33.5 |
| 4 | 4.1 | 0.0 | 25.2 | 133.3 | 30 | 96.6 | 10.6 | 187.1 | 50.2 |
| 5 | 8.7 | 0.0 | 35.5 | 118.3 | 31 | 80.5 | 1.9 | 190.8 | 51.0 |
| 6 | 9.2 | 0.0 | 37.1 | 114.2 | 32 | 93.8 | 2.8 | 291.8 | 65.6 |
| 7 | 11.1 | 0.0 | 58.5 | 146.2 | 33 | 94.9 | 16.1 | 244.6 | 54.4 |
| 8 | 13.7 | 0.0 | 52.7 | 105.6 | 34 | 94.1 | 6.3 | 167.0 | 45.1 |
| 9 | 11.8 | 0.0 | 29.4 | 84.7 | 35 | 79.1 | 12.2 | 154.8 | 40.5 |
| 10 | 10.4 | 0.0 | 56.1 | 144.1 | 36 | 82.1 | 17.8 | 148.1 | 48.7 |
| 11 | 13.5 | 0.0 | 47.2 | 98.7 | 37 | 77.4 | 11.3 | 202.0 | 61.5 |
| 12 | 21.5 | 0.0 | 92.5 | 109.2 | 38 | 62.5 | 13.9 | 145.5 | 55.4 |
| 13 | 23.1 | 0.0 | 85.2 | 79.6 | 39 | 68.4 | 0.4 | 150.3 | 61.3 |
| 14 | 28.8 | 0.0 | 96.1 | 85.4 | 40 | 44.6 | 0.4 | 126.4 | 71.9 |
| 15 | 32.8 | 0.0 | 86.7 | 60.1 | 41 | 38.3 | 0.0 | 131.8 | 96.3 |
| 16 | 35.8 | 0.0 | 91.1 | 72.3 | 42 | 30.8 | 0.0 | 152.6 | 105.8 |
| 17 | 48.7 | 0.0 | 119.0 | 57.0 | 43 | 13.4 | 0.0 | 68.1 | 132.8 |
| 18 | 46.0 | 1.9 | 128.2 | 60.7 | 44 | 10.8 | 0.0 | 143.3 | 270.1 |
| 19 | 43.0 | 16.0 | 119.0 | 57.5 | 45 | 6.0 | 0.0 | 27.5 | 133.2 |
| 20 | 63.1 | 17.6 | 228.3 | 75.5 | 46 | 5.1 | 0.0 | 48.1 | 183.1 |
| 21 | 51.7 | 0.4 | 142.9 | 73.1 | 47 | 5.3 | 0.0 | 47.9 | 196.9 |
| 22 | 66.7 | 10.8 | 192.3 | 70.7 | 48 | 5.7 | 0.0 | 52.0 | 209.9 |
| 23 | 76.4 | 2.3 | 233.5 | 62.5 | 49 | 2.2 | 0.0 | 19.7 | 229.7 |
| 24 | 81.4 | 10.4 | 158.8 | 49.6 | 50 | 5.2 | 0.0 | 55.8 | 231.3 |
| 25 | 85.6 | 20.7 | 208.9 | 56.9 | 51 | 2.5 | 0.0 | 15.8 | 176.5 |
| 26 | 87.6 | 24.9 | 202.8 | 47.8 | 52 | 4.5 | 0.0 | 44.4 | 211.1 |

Table 3.1.1.17. Monthly rainfall (mm) in Nagaland during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 19.9 | 0.0 | 82.6 | 80.3 | Jul | 450.1 | 236.6 | 679.7 | 28.0 |
| Feb | 44.6 | 0.5 | 103.0 | 56.8 | Aug | 394.0 | 262.3 | 744.4 | 25.9 |
| Mar | 70.7 | 11.7 | 191.2 | 58.6 | Sep | 311.1 | 141.9 | 486.1 | 30.2 |
| Apr | 157.0 | 6.8 | 286.1 | 42.7 | Oct | 134.0 | 5.6 | 233.0 | 44.7 |
| May | 241.4 | 98.7 | 500.1 | 37.8 | Nov | 23.2 | 0.0 | 72.6 | 88.3 |
| Jun | 341.4 | 91.1 | 539.3 | 34.7 | Dec | 16.8 | 0.0 | 69.8 | 102.6 |

The seasonal and annual rainfall situation in Nagaland is presented in Table 3.1.1.18.

| Table 3.1.1.18. Seasonal and annual rainfall (mm) in Nagaland during 1975-2007 | | | | |
|---|---|---|---|---|
| Season | Normal (%) | Extremes | | CV (%) |
| | | Min | Max | |
| Pre-monsoon | 533.5 (24.21) | 191.3 | 871.3 | 28.8 |
| Monsoon | 1496.6 (67.90) | 860.7 | 2052.1 | 20.0 |
| Post-monsoon | 173.9 (7.89) | 36.8 | 259.5 | 34.0 |
| Annual | 2204.0 | 1281.9 | 2843.6 | 18.1 |

Note: Figures in parenthesis indicate per cent to total

Nagaland has received normal annual rainfall of 2204.0 mm during 1975-2007 with maximum annual rainfall of 2843.6 mm in the year 1993 and minimum annual rainfall of 1281.9 mm in the year 1997. Maximum of the rainfall was concentrated during the monsoon season (67.90%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (34.0%) and minimum in monsoon season (20.0%).

*Rainfall in* Manipur

The weekly and monthly rainfall situations in Manipur are presented in Table 3.1.1.19 and Table 3.1.1.20.

| Table 3.1.1.19. Weekly rainfall (mm) in Manipur during 1975-2007 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
| | | Min | Max | | | | Min | Max | |
| 1 | 2.0 | 0.0 | 26.7 | 274.4 | 27 | 61.1 | 25.9 | 116.7 | 38.0 |
| 2 | 2.5 | 0.0 | 18.6 | 196.0 | 28 | 63.9 | 15.9 | 115.7 | 47.1 |
| 3 | 1.6 | 0.0 | 17.9 | 215.4 | 29 | 59.1 | 19.2 | 145.3 | 48.9 |
| 4 | 1.9 | 0.0 | 21.3 | 263.1 | 30 | 56.4 | 8.0 | 146.6 | 56.5 |
| 5 | 7.8 | 0.0 | 60.6 | 159.6 | 31 | 65.8 | 7.0 | 174.9 | 61.0 |
| 6 | 7.1 | 0.0 | 78.9 | 203.2 | 32 | 60.1 | 4.5 | 173.1 | 65.9 |
| 7 | 9.4 | 0.0 | 81.3 | 179.6 | 33 | 57.7 | 11.8 | 151.7 | 58.0 |
| 8 | 10.7 | 0.0 | 82.4 | 155.2 | 34 | 51.8 | 6.4 | 112.1 | 52.3 |
| 9 | 10.6 | 0.0 | 54.0 | 137.3 | 35 | 53.7 | 9.1 | 140.3 | 62.7 |
| 10 | 9.9 | 0.0 | 102.1 | 191.0 | 36 | 50.1 | 8.9 | 120.0 | 56.4 |
| 11 | 11.4 | 0.0 | 40.8 | 102.7 | 37 | 46.8 | 5.9 | 126.7 | 57.9 |
| 12 | 23.6 | 0.0 | 106.7 | 129.8 | 38 | 40.8 | 1.1 | 98.1 | 68.8 |
| 13 | 21.9 | 0.0 | 164.5 | 143.2 | 39 | 46.5 | 0.0 | 144.8 | 82.5 |
| 14 | 21.5 | 0.0 | 112.9 | 108.0 | 40 | 36.6 | 0.7 | 132.1 | 83.7 |
| 15 | 30.8 | 0.0 | 139.3 | 100.9 | 41 | 32.3 | 0.0 | 126.7 | 115.2 |
| 16 | 27.2 | 0.0 | 127.9 | 106.9 | 42 | 31.5 | 0.0 | 135.5 | 108.2 |
| 17 | 33.3 | 0.0 | 147.7 | 90.9 | 43 | 12.5 | 0.0 | 71.2 | 139.0 |
| 18 | 35.8 | 0.0 | 149.5 | 91.2 | 44 | 13.9 | 0.0 | 90.6 | 163.5 |
| 19 | 32.7 | 2.9 | 79.9 | 66.5 | 45 | 9.9 | 0.0 | 71.8 | 170.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 44.8 | 1.4 | 155.9 | 76.5 | 46 | 7.0 | 0.0 | 62.7 | 224.9 |
| 21 | 39.7 | 0.2 | 134.8 | 86.3 | 47 | 3.3 | 0.0 | 36.0 | 208.1 |
| 22 | 35.7 | 4.1 | 101.0 | 72.9 | 48 | 5.1 | 0.0 | 62.6 | 237.3 |
| 23 | 61.5 | 3.3 | 199.4 | 70.0 | 49 | 1.1 | 0.0 | 26.1 | 443.3 |
| 24 | 61.6 | 16.0 | 122.5 | 46.4 | 50 | 3.9 | 0.0 | 49.4 | 293.0 |
| 25 | 58.6 | 23.3 | 126.1 | 51.0 | 51 | 3.3 | 0.0 | 52.3 | 295.7 |
| 26 | 59.1 | 14.0 | 108.6 | 41.7 | 52 | 4.8 | 0.0 | 61.2 | 285.8 |

The highest normal monthly rainfall was received in 31st SMW (65.8 mm), followed by 28th SMW (63.9 mm) and 24th SMW (61.6 mm) in Manipur during 1975-2009. The lowest normal rainfall was registered in 49th SMW (1.1 mm). The highest maximum weekly rainfall of 199.4 mm was received in 23rdSMW in 1985. The variation in weekly rainfall was maximum in 49th SMW (443.3%), followed by 51st SMW (295.7%) and 50th SMW (293.0%).

Table 3.1.1.20. Monthly rainfall (mm) in Manipur during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 9.6 | 0.0 | 48.3 | 120.6 | Jul | 274.1 | 170.5 | 427.2 | 23.2 |
| Feb | 37.5 | 0.2 | 179.0 | 104.7 | Aug | 250.7 | 138.6 | 533.3 | 30.5 |
| Mar | 69.2 | 2.2 | 179.6 | 71.1 | Sep | 201.6 | 80.1 | 370.9 | 34.5 |
| Apr | 122.7 | 0.0 | 331.3 | 55.3 | Oct | 119.1 | 7.1 | 268.6 | 59.6 |
| May | 168.3 | 43.7 | 314.8 | 39.5 | Nov | 31.5 | 0.0 | 94.4 | 84.5 |
| Jun | 242.7 | 124.3 | 424.8 | 29.5 | Dec | 14.3 | 0.0 | 62.9 | 138.1 |

The highest normal monthly rainfall of 274.1 mm was received in the month of July, followed by August (250.7 mm), June (242.7 mm) and September (201.6 mm). The lowest normal rainfall was received in January (9.6 mm). Manipur has registered highest maximum rainfall of 533.3 mm in the month of August in 1993.The variation in rainfall was maximum in December (138.1%), followed by January (120.6%) and February (104.7%) whereas minimum in the month of July (23.2%).

Table 3.1.1.21. Seasonal and annual rainfall (mm) in Manipur during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min | Max | |
| Pre-monsoon | 407.4 (26.43) | 187.8 | 668.8 | 27.4 |
| Monsoon | 969.1 (62.87) | 795.1 | 1263.7 | 12.7 |
| Post-monsoon | 164.9 (10.70) | 46.1 | 347.5 | 48.7 |
| Annual | 1541.4 | 1133.8 | 2013.3 | 12.5 |

Note: Figures in parenthesis indicate per cent to total

The seasonal and annual rainfall situation in Manipur is presented in Table 3.1.1.21. Manipur has received normal annual rainfall of 1541.4 mm during 1975-2007 with maximum annual rainfall of 2013.3 mm in the year 1979 and minimum annual rainfall of 1133.8 mm in the year 1993. Maximum of the rainfall was concentrated during the monsoon season (62.87%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (48.7%) and minimum in monsoon season (12.7%).

*Rainfall in Tripura*

The weekly and monthly rainfall situations in Tripura are presented in Table 3.1.1.22 and Table 3.1.1.23.

Table 3.1.1.22. Weekly rainfall (mm) in Tripura during 1975-2007

| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| 1 | 0.6 | 0.0 | 16.0 | 443.1 | 27 | 102.3 | 4.7 | 274.8 | 73.0 |
| 2 | 1.5 | 0.0 | 26.0 | 315.6 | 28 | 93.3 | 5.8 | 448.0 | 109.9 |
| 3 | 1.7 | 0.0 | 17.3 | 251.0 | 29 | 105.8 | 8.4 | 495.9 | 103.6 |
| 4 | 1.2 | 0.0 | 16.8 | 319.9 | 30 | 90.9 | 4.8 | 261.6 | 83.2 |
| 5 | 6.3 | 0.0 | 114.0 | 319.9 | 31 | 96.7 | 11.7 | 451.0 | 96.7 |
| 6 | 4.0 | 0.0 | 18.9 | 163.2 | 32 | 52.5 | 6.8 | 126.3 | 56.4 |
| 7 | 4.9 | 0.0 | 31.2 | 151.0 | 33 | 62.7 | 5.3 | 305.1 | 110.4 |
| 8 | 10.7 | 0.0 | 149.4 | 250.6 | 34 | 77.7 | 7.8 | 200.6 | 64.2 |
| 9 | 8.7 | 0.0 | 101.7 | 231.3 | 35 | 63.1 | 8.6 | 189.1 | 67.2 |
| 10 | 2.3 | 0.0 | 41.4 | 326.3 | 36 | 55.4 | 4.3 | 248.8 | 100.5 |
| 11 | 9.7 | 0.0 | 74.3 | 190.4 | 37 | 58.4 | 6.0 | 120.6 | 56.4 |
| 12 | 25.3 | 0.0 | 168.6 | 174.1 | 38 | 58.8 | 0.0 | 186.1 | 81.5 |
| 13 | 22.2 | 0.0 | 125.2 | 133.8 | 39 | 49.8 | 0.0 | 152.4 | 78.6 |
| 14 | 33.8 | 0.0 | 157.5 | 121.7 | 40 | 48.4 | 0.0 | 128.4 | 77.3 |
| 15 | 28.4 | 0.0 | 147.0 | 138.6 | 41 | 53.2 | 0.0 | 200.0 | 111.2 |
| 16 | 40.9 | 0.0 | 151.6 | 104.7 | 42 | 40.8 | 0.0 | 165.1 | 122.8 |
| 17 | 42.0 | 0.0 | 185.3 | 103.0 | 43 | 10.7 | 0.0 | 80.3 | 154.7 |
| 18 | 73.4 | 0.0 | 345.0 | 117.5 | 44 | 17.0 | 0.0 | 100.8 | 168.5 |
| 19 | 88.4 | 0.0 | 404.6 | 109.3 | 45 | 13.7 | 0.0 | 109.7 | 220.8 |
| 20 | 82.7 | 0.0 | 247.0 | 84.8 | 46 | 9.8 | 0.0 | 115.1 | 255.0 |
| 21 | 87.5 | 0.0 | 293.8 | 83.0 | 47 | 7.2 | 0.0 | 107.9 | 305.8 |
| 22 | 93.3 | 0.0 | 317.7 | 84.0 | 48 | 6.2 | 0.0 | 77.5 | 281.8 |
| 23 | 102.4 | 0.0 | 387.6 | 90.4 | 49 | 0.2 | 0.0 | 3.1 | 331.9 |
| 24 | 100.0 | 2.3 | 432.8 | 99.0 | 50 | 2.0 | 0.0 | 22.3 | 253.4 |
| 25 | 91.9 | 17.9 | 310.0 | 66.4 | 51 | 2.4 | 0.0 | 40.7 | 380.4 |
| 26 | 89.7 | 0.0 | 334.3 | 98.1 | 52 | 6.3 | 0.0 | 120.4 | 346.8 |

The highest normal monthly rainfall was received in 29th SMW (105.8 mm), followed by 23rd SMW (102.4 mm) and 27th SMW (102.3 mm) in Tripura during 1975-2007. The lowest normal rainfall was registered in 49th SMW (0.2 mm). The highest maximum weekly rainfall of 495.9 mm was received in 29th SMW in 2007. The variation in weekly rainfall was maximum in 1st SMW (443.1%), followed by 1st SMW (443.1%) and 51st SMW (380.4%).

The highest normal monthly rainfall of 431.8 mm was received in the month of July, followed by June (413.2 mm), May (369.6 mm) and August (313.1 mm). The lowest normal rainfall was received in January (6.1 mm). Tripura has registered highest maximum rainfall of 1313.6 mm in the month of June in 1976.The variation in rainfall was maximum in December (189.7%), followed by January (157.8%) and February (122.8%) whereas, minimum in the month of September (36.7%).

Table 3.1.1.23. Monthly rainfall (mm) in Tripura during 1975-2007

| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | Min | Max | |
| Jan | 6.1 | 0.0 | 34.1 | 157.8 | Jul | 431.8 | 74.6 | 846.0 | 43.1 |
| Feb | 29.4 | 0.0 | 156.6 | 122.8 | Aug | 313.1 | 101.3 | 728.2 | 45.4 |
| Mar | 61.3 | 0.0 | 262.4 | 103.4 | Sep | 236.7 | 83.8 | 431.0 | 36.7 |
| Apr | 160.9 | 0.0 | 456.6 | 63.7 | Oct | 164.3 | 10.7 | 349.2 | 50.4 |
| May | 369.6 | 104.2 | 741.4 | 49.0 | Nov | 40.7 | 0.0 | 173.8 | 113.1 |
| Jun | 413.2 | 123.1 | 1313.6 | 59.1 | Dec | 12.5 | 0.0 | 120.9 | 189.7 |

The seasonal and annual rainfall situation in Tripura is presented in Table 3.1.1.24.

Table 3.1.24. Seasonal and annual rainfall (mm) in Tripura during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min | Max | |
| Pre-monsoon | 627.2 (28.01) | 159.7 | 1119.5 | 40.8 |
| Monsoon | 1394.7 (62.28) | 753.6 | 2841.0 | 32.0 |
| Post-monsoon | 217.6 (9.72) | 21.1 | 429.6 | 48.7 |
| Annual | 2239.5 | 1404.2 | 3656.4 | 24.6 |

Note: Figures in parenthesis indicate per cent to total

Tripura has received normal annual rainfall of 2239.5 mm during 1975-2009 with maximum annual rainfall of 3656.4 mm in the year 1976 and minimum annual rainfall of 1404.2 mm in the year 1994. Maximum of the rainfall was concentrated during the monsoon season (62.28%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (48.7%) and minimum in monsoon season (32.0%).

*Rainfall in Mizoram*

The weekly and monthly rainfall situations in Mizoram are presented in Table 3.1.1.25 and Table 3.1.1.26.

The highest normal weekly rainfall was received in 27$^{th}$ SMW (129.7 mm), followed by 29$^{th}$ SMW (122.0 mm) and 24$^{th}$ SMW (119.1 mm) in Mizoram during 1975-2007. The lowest normal rainfall was registered in 49$^{th}$ SMW (0.6 mm). The highest maximum weekly rainfall of 596.7 mm was received in 29$^{th}$ SMW in 1993. The variation in weekly rainfall was maximum in 1$^{st}$ SMW (394.2%), followed by 51$^{st}$ SMW (382.4%) and 8$^{th}$ SMW (295.5%).

| Table 3.1.1.25. Weekly rainfall (mm) in Mizoram during 1975-2007 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Week | Normal | Extremes | | CV (%) | Week | Normal | Extremes | | CV (%) |
| | | Min | Max | | | | Min | Max | |
| 1 | 0.8 | 0.0 | 17.9 | 394.2 | 27 | 129.7 | 17.0 | 548.4 | 85.3 |
| 2 | 1.5 | 0.0 | 19.7 | 262.1 | 28 | 98.1 | 19.2 | 336.3 | 86.2 |
| 3 | 2.4 | 0.0 | 34.1 | 282.7 | 29 | 122.0 | 37.1 | 596.7 | 89.2 |
| 4 | 0.7 | 0.0 | 7.3 | 288.7 | 30 | 103.7 | 19.8 | 373.1 | 84.8 |
| 5 | 5.7 | 0.0 | 71.6 | 230.3 | 31 | 105.1 | 13.6 | 486.2 | 97.8 |
| 6 | 5.4 | 0.0 | 42.1 | 180.2 | 32 | 68.8 | 12.8 | 147.6 | 53.4 |
| 7 | 7.3 | 0.0 | 44.6 | 132.7 | 33 | 79.6 | 9.7 | 284.0 | 79.3 |
| 8 | 16.3 | 0.0 | 273.3 | 295.5 | 34 | 90.2 | 9.6 | 294.9 | 70.7 |
| 9 | 9.9 | 0.0 | 57.4 | 163.9 | 35 | 66.4 | 9.2 | 189.4 | 55.0 |
| 10 | 7.9 | 0.0 | 60.6 | 173.2 | 36 | 68.7 | 10.2 | 199.2 | 68.8 |
| 11 | 13.1 | 0.0 | 77.4 | 166.3 | 37 | 67.5 | 6.4 | 223.6 | 63.9 |
| 12 | 32.5 | 0.0 | 200.1 | 153.6 | 38 | 56.5 | 1.5 | 137.4 | 66.3 |
| 13 | 37.2 | 0.0 | 305.0 | 155.3 | 39 | 56.4 | 1.0 | 150.5 | 71.9 |
| 14 | 36.4 | 0.0 | 279.3 | 151.7 | 40 | 54.4 | 0.0 | 132.2 | 65.4 |
| 15 | 43.4 | 0.0 | 238.7 | 127.1 | 41 | 56.9 | 0.0 | 328.1 | 129.5 |
| 16 | 51.9 | 0.0 | 200.6 | 100.5 | 42 | 43.8 | 0.0 | 149.6 | 94.9 |
| 17 | 48.9 | 3.1 | 145.2 | 86.0 | 43 | 11.5 | 0.0 | 72.3 | 155.2 |
| 18 | 76.5 | 2.5 | 331.5 | 113.1 | 44 | 18.6 | 0.0 | 134.4 | 170.4 |
| 19 | 86.0 | 2.8 | 355.9 | 102.9 | 45 | 16.6 | 0.0 | 145.7 | 223.7 |
| 20 | 91.1 | 0.4 | 310.7 | 80.2 | 46 | 10.5 | 0.0 | 77.8 | 189.8 |
| 21 | 82.2 | 2.4 | 280.9 | 83.1 | 47 | 9.4 | 0.0 | 107.8 | 249.3 |
| 22 | 91.2 | 1.7 | 249.1 | 70.9 | 48 | 9.4 | 0.0 | 103.7 | 232.4 |
| 23 | 106.9 | 4.0 | 334.1 | 78.7 | 49 | 0.6 | 0.0 | 4.0 | 207.8 |
| 24 | 119.1 | 5.6 | 455.7 | 92.7 | 50 | 2.0 | 0.0 | 22.3 | 235.5 |
| 25 | 94.1 | 20.4 | 277.3 | 64.0 | 51 | 4.0 | 0.0 | 68.6 | 382.4 |
| 26 | 117.4 | 4.4 | 484.6 | 89.4 | 52 | 3.7 | 0.0 | 43.2 | 251.9 |

| Table 3.1.1.26. Monthly rainfall (mm) in Mizoram during 1975-2007 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | Normal | Extremes | | CV (%) | Month | Normal | Extremes | | CV (%) |
| | | Min | Max | | | | Min | Max | |
| Jan | 6.7 | 0.0 | 34.1 | 145.8 | Jul | 501.0 | 130.5 | 880.5 | 39.7 |
| Feb | 36.3 | 0.0 | 286.3 | 139.7 | Aug | 363.1 | 142.8 | 738.3 | 39.8 |
| Mar | 93.4 | 2.6 | 338.0 | 91.1 | Sep | 264.6 | 108.1 | 466.2 | 35.9 |
| Apr | 196.0 | 20.9 | 592.9 | 61.3 | Oct | 178.5 | 8.3 | 534.2 | 59.6 |
| May | 372.3 | 121.6 | 887.9 | 55.8 | Nov | 50.8 | 0.0 | 266.8 | 115.0 |
| Jun | 465.7 | 92.5 | 1140.7 | 52.0 | Dec | 11.8 | 0.0 | 70.9 | 152.6 |

The highest normal monthly rainfall of 501.0 mm was received in the month of July, followed by June (465.7 mm), May (372.3 mm) and August (363.1 mm). The lowest normal rainfall was received in January (6.7 mm). Mizoram has registered highest maximum rainfall of 1140.7 mm in the month of June in 1976.The variation in rainfall was maximum in December (152.6%), followed by January (145.8%) and February (139.7%) whereas, minimum in the month of September (35.9%).

The seasonal and annual rainfall situation in Mizoram is presented in Table 3.1.1.27. Mizoram has received normal annual rainfall of 2540.2 mm during 1975-2007 with maximum annual rainfall of 4368.8 mm in the year 1993 and minimum annual rainfall of 1391.4 mm in the year 2000. Maximum of the rainfall was concentrated during the monsoon season (62.77%), followed by pre-monsoon and post-monsoon season. The maximum variation in seasonal rainfall was observed in the post-monsoon season (53.0%) and minimum in monsoon season (28.6%).

Table 3.1.1.27. Seasonal and annual rainfall (mm) in Mizoram during 1975-2007

| Season | Normal (%) | Extremes | | CV (%) |
|---|---|---|---|---|
| | | Min | Max | |
| Pre-monsoon | 704.7 (27.74) | 219.4 | 1631.6 | 45.6 |
| Monsoon | 1594.4 (62.77) | 648.9 | 2573.6 | 28.6 |
| Post-monsoon | 241.1 (9.49) | 20.7 | 559.6 | 53.0 |
| Annual | 2540.2 | 1391.4 | 4368.8 | 27.7 |

Note: Figures in parenthesis indicate per cent to total

### 3.1.2 Trend in seasonal and annual rainfall

The linear trends of seasonal and annual rainfall in NEH of India are presented in Fig. 3.1 to Fig. 3.10 and the trend coefficients and their probabilities are presented in Table 3.1.2.1 and Table 3.1.2.2.

Table 3.1.2.1. Linear trend coefficients of seasonal rainfall in NEH of India

| **Pre-monsoon** | | | | | | |
|---|---|---|---|---|---|---|
| State/District | 1975-1989 | | 1990-2007 | | 1975-2007 | |
| | B | P | b | p | b | P |
| Sikkim | 8.09 | 0.44 | 23.99*** | 0.00 | 7.30** | 0.02 |
| Darjeeling | 4.55 | 0.34 | 3.93 | 0.34 | 1.52 | 0.32 |
| Meghalaya | 11.79 | 0.25 | -2.74 | 0.61 | 2.11 | 0.41 |
| Arunachal | -1.85 | 0.85 | -4.37 | 0.53 | -1.71 | 0.54 |
| Karbi Anglong | 5.75 | 0.50 | -5.02 | 0.14 | -0.27 | 0.89 |
| Nagaland | -0.80 | 0.91 | -0.95 | 0.91 | -2.05 | 0.47 |
| Manipur | 5.92 | 0.44 | -5.08 | 0.29 | 1.11 | 0.59 |
| Tripura | -2.94 | 0.87 | -16.08 | 0.12 | -6.80 | 0.15 |
| Mizoram | 6.32 | 0.74 | -32.85** | 0.03 | -3.47 | 0.56 |
| **Monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2007 | | 1975-2007 | |
| | B | p | b | p | b | P |
| Sikkim | 5.12 | 0.77 | -26.16 | 0.42 | 1.96 | 0.85 |
| Darjeeling | 19.02 | 0.37 | -16.64 | 0.47 | 0.52 | 0.95 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Meghalaya | 46.25** | 0.01 | 48.76 | 0.07 | 13.57 | 0.12 |
| Arunachal | 11.61 | 0.20 | -1.95 | 0.82 | -4.99 | 0.12 |
| Karbi Anglong | 15.72 | 0.15 | -6.18 | 0.45 | -4.84 | 0.15 |
| Nagaland | 16.68 | 0.20 | -23.66 | 0.07 | -16.72*** | 0.00 |
| Manipur | 7.05 | 0.37 | -12.25** | 0.02 | 1.25 | 0.59 |
| Tripura | -40.32 | 0.18 | 7.56 | 0.68 | -13.01 | 0.11 |
| Mizoram | 13.62 | 0.51 | -34.26 | 0.16 | -12.58 | 0.13 |
| **Post-monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2007 | | 1975-2007 | |
| | b | p | b | p | b | p |
| Sikkim | -0.85 | 0.89 | 7.40** | 0.03 | -0.72 | 0.67 |
| Darjeeling | -5.07 | 0.49 | 5.88 | 0.14 | -0.08 | 0.97 |
| Meghalaya | 10.15 | 0.09 | 6.50 | 0.22 | 4.28** | 0.03 |
| Arunachal | -3.88 | 0.23 | 0.44 | 0.90 | 0.24 | 0.84 |
| Karbi Anglong | 8.84 | 0.13 | 3.79 | 0.29 | 2.71 | 0.09 |
| Nagaland | -0.87 | 0.82 | 0.23 | 0.94 | -0.55 | 0.62 |
| Manipur | 7.69 | 0.17 | -1.16 | 0.73 | 1.17 | 0.44 |
| Tripura | 5.91 | 0.28 | -2.05 | 0.71 | 1.27 | 0.17 |
| Mizoram | 11.77 | 0.19 | -9.13 | 0.07 | 0.41 | 0.87 |

** & *** indicates significance at 5% and 1% level, respectively

Table 3.1.2.2 Linear trend coefficients of annual rainfall in NEH of India

| State/District | 1975-1989 | | 1990-2007 | | 1975-2007 | |
|---|---|---|---|---|---|---|
| | b | p | b | P | B | p |
| Sikkim | 12.37 | 0.56 | 5.23 | 0.88 | 8.54 | 0.44 |
| Darjeeling | 18.50 | 0.44 | -6.83 | 0.78 | 1.96 | 0.82 |
| Meghalaya | 68.20** | 0.01 | 52.52 | 0.09 | 19.97 | 0.06 |
| Arunachal | 5.88 | 0.72 | -5.89 | 0.61 | -6.47 | 0.17 |
| Karbi-Anglong | 30.32 | 0.06 | -7.41 | 0.49 | -2.40 | 0.61 |
| Nagaland | 15.01 | 0.37 | -24.38 | 0.20 | -19.32** | 0.01 |
| Manipur | 20.66** | 0.04 | -18.49** | 0.04 | 3.53 | 0.32 |
| Tripura | -37.34 | 0.29 | -10.57 | 0.67 | -17.22 | 0.09 |
| Mizoram | 31.71 | 0.34 | -76.24** | 0.04 | -15.62 | 0.23 |

** & *** indicates significance at 5% and 1% level, respectively

**Trend in pre-monsoon rainfall**

The trends in pre-monsoon rainfall are positive but insignificant in the NEH states of India, except Arunachal Pradesh, Nagaland and Tripura where the trends are negative and insignificant during 1975 to 1989. Importantly these trends turned out to be negative during 1990 to 2007, except Sikkim and Darjeeling. The negative trend of pre-monsoon rainfall was significant in case of Mizoram, and the positive trend was significant for Sikkim. For the period of 1975-2007, the trend for rainfall is significant for Sikkim.

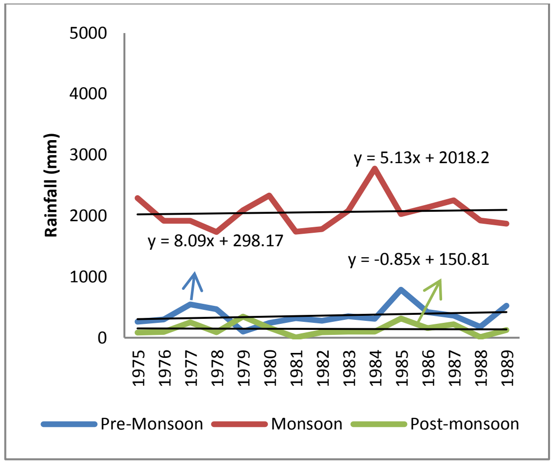



Fig. 1(a) Seasonal (1975-1989)

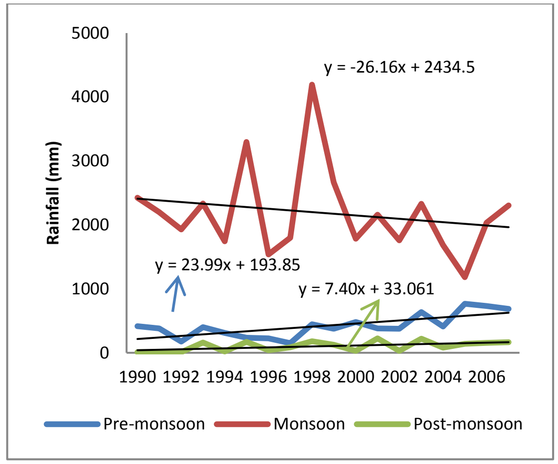



Fig. 1(b) Seasonal (1990-2007)

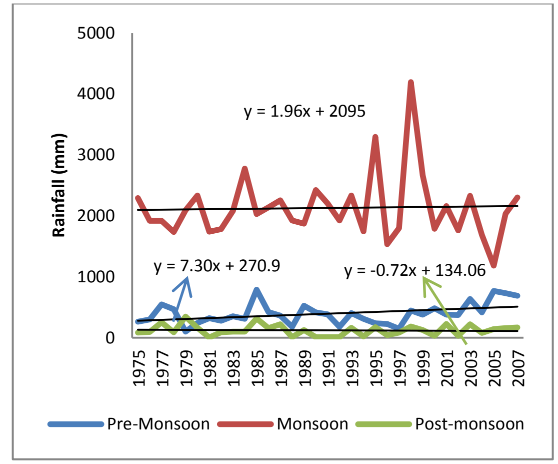



Fig. 1(c) Seasonal (1975-2007)

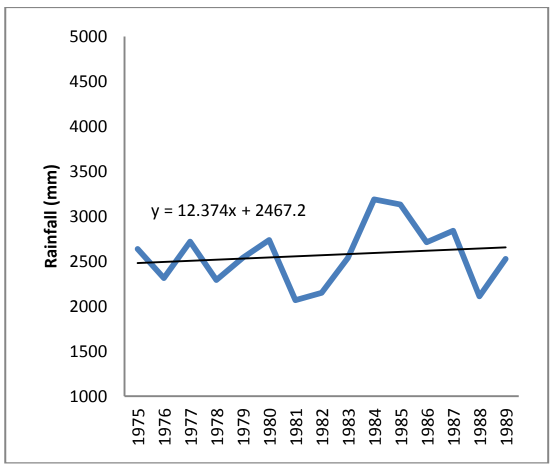



Fig. 1(d) Annual (1975-1989)

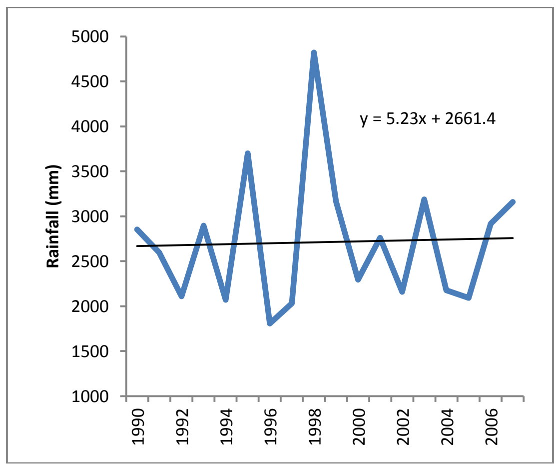



Fig. 1(e) Annual (1990-2007)

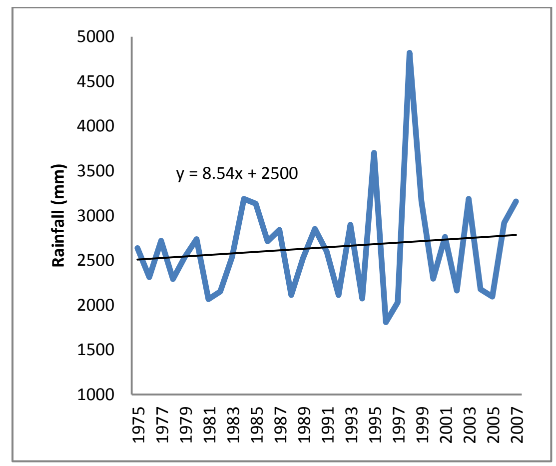



Fig. 1(f) Annual (1975-2007)

Fig. 3.1. Seasonal and annual rainfall situation in Sikkim

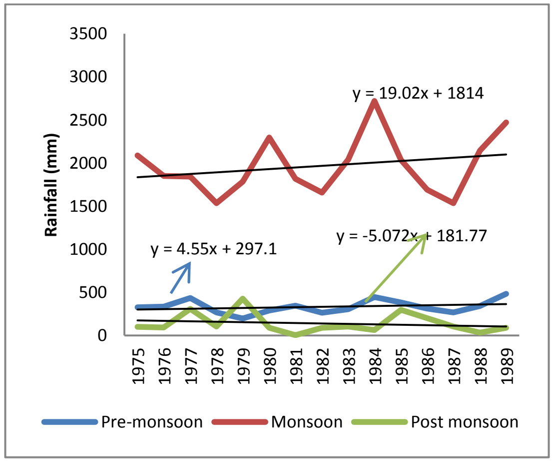



Fig.2(a) Seasonal (1975-1989)

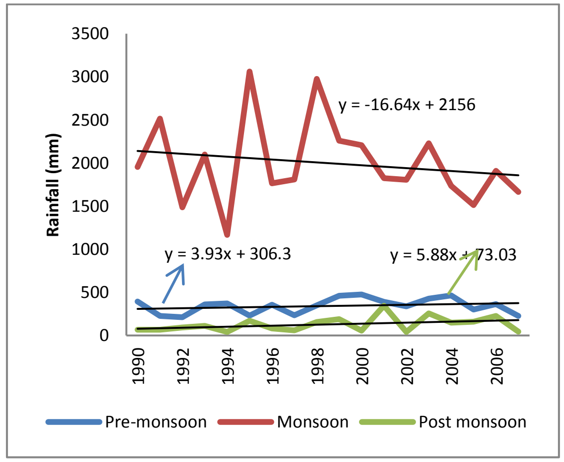



Fig. 2(b) Seasonal (1990-2007)

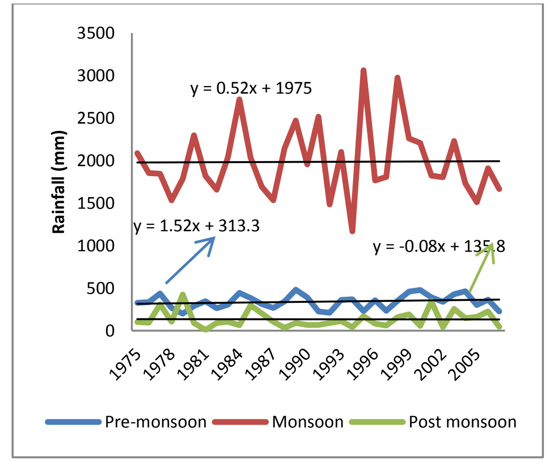



Fig. 2(c) Seasonal (1975-2007)

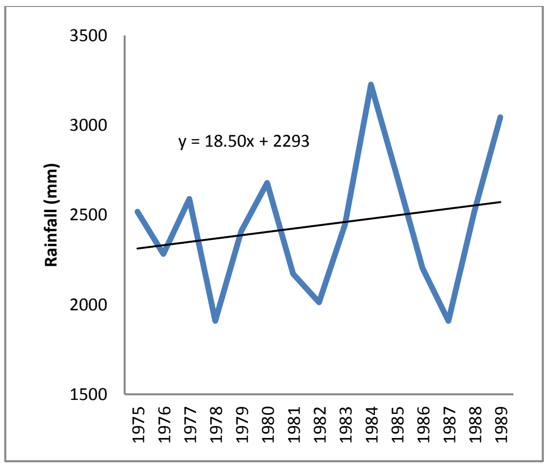



Fig. 2(d) Annual (1975-1989)

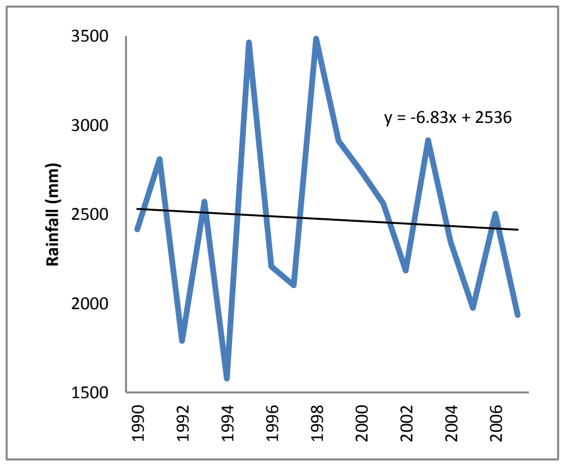



Fig. 2(e) Annual (1990-2007)

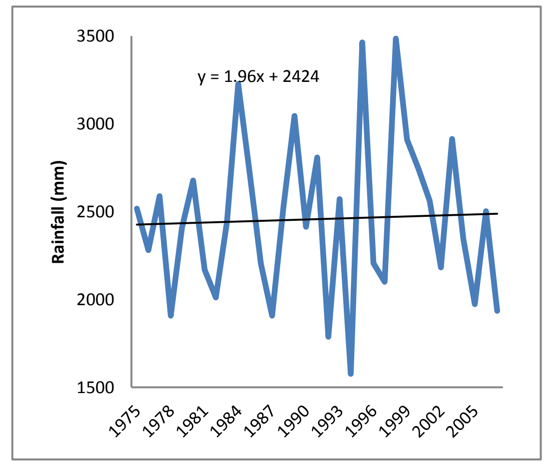



Fig. 2(f) Annual (1975-2007)

Fig. 3.2. Seasonal and annual rainfall situation in Darjeeling

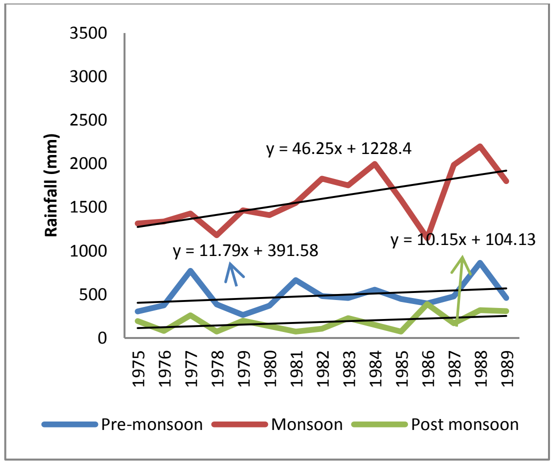



Fig. 3(a) Seasonal (1975-1989)

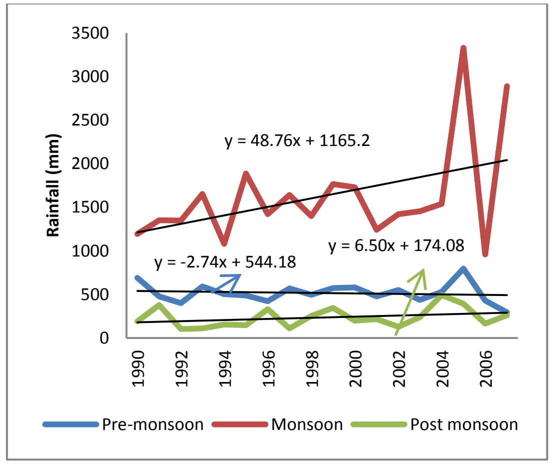



Fig. 3(b) Seasonal (1990-2007)

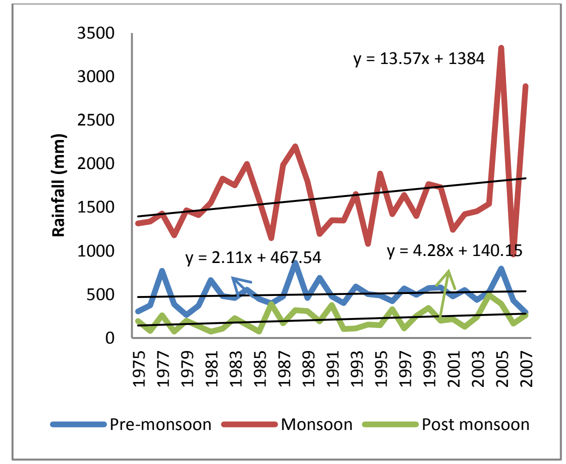



Fig. 3(c) Seasonal (1975-2007)

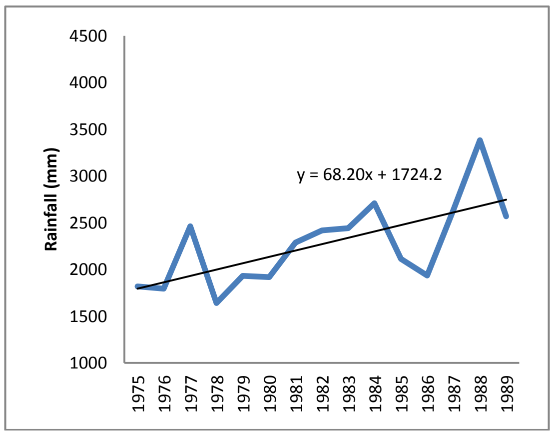



Fig. 3(d) Annual (1975-1989)

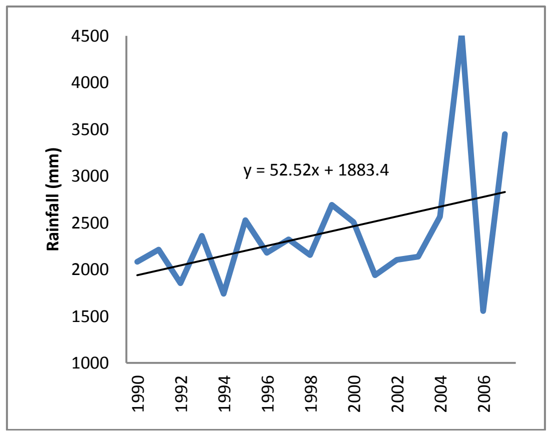



Fig. 3(e) Annual (1990-2007)

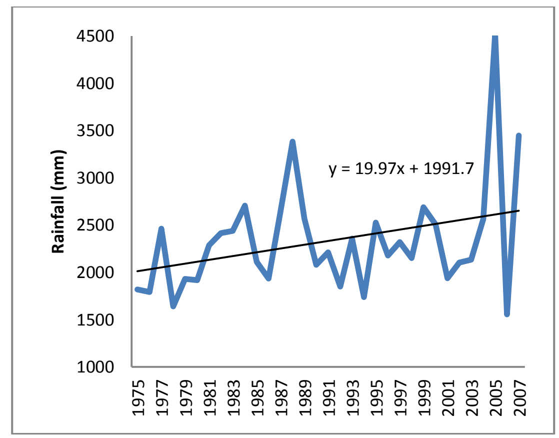



Fig. 3(f) Annual (1975-2007)

Fig. 3.3. Seasonal and annual rainfall situation in Meghalaya

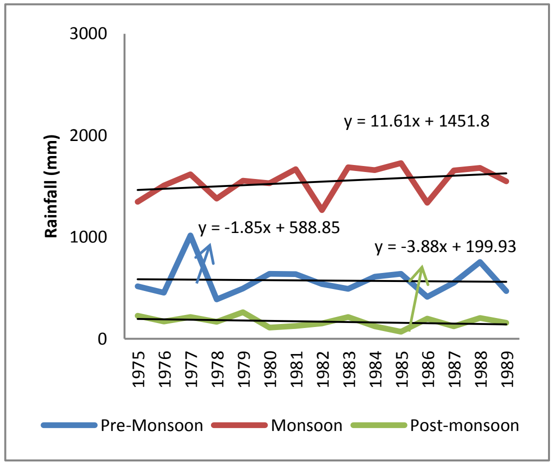



Fig.4(a) Seasonal (1975-1989)

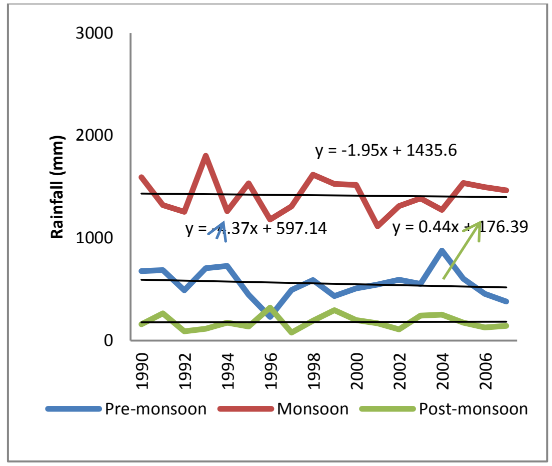



Fig. 4(b) Seasonal (1990-2007)

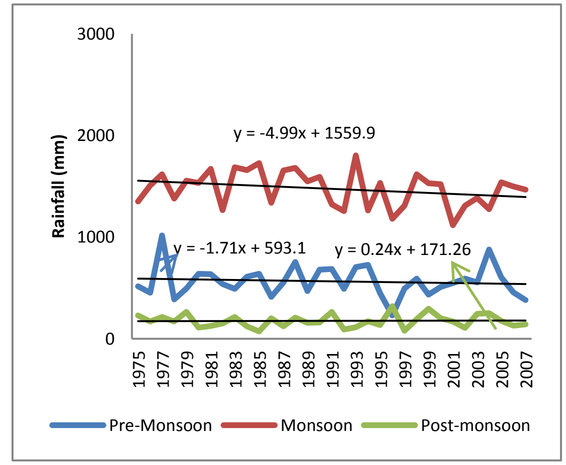



Fig. 4 (c) Seasonal (1975-2007)

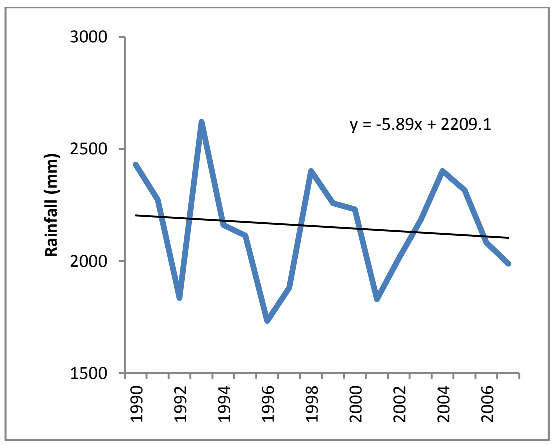



Fig. 4(d) Annual (1975-1989)

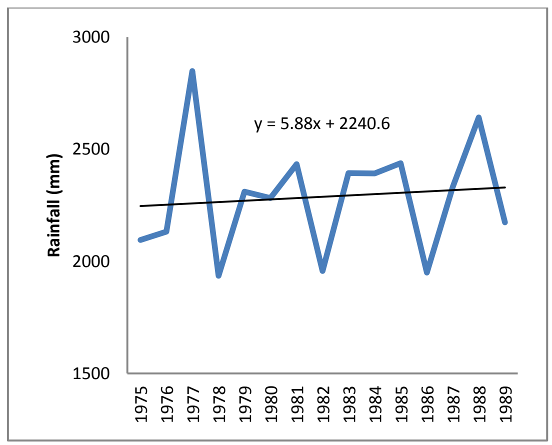



Fig. 4(e) Annual (1990-2007)

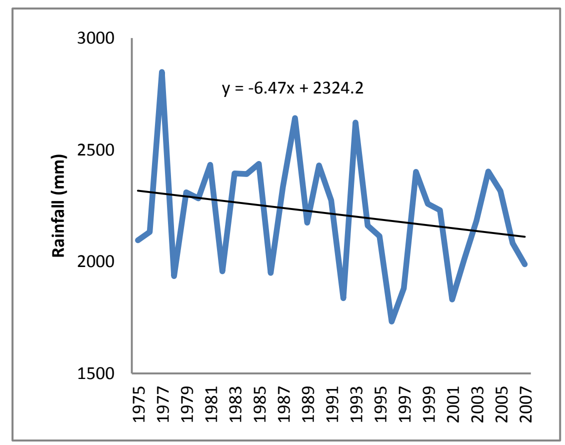



Fig. 4(f) Annual (1975-2007)

Fig. 3.4. Seasonal and annual rainfall situation in Arunachal Pradesh

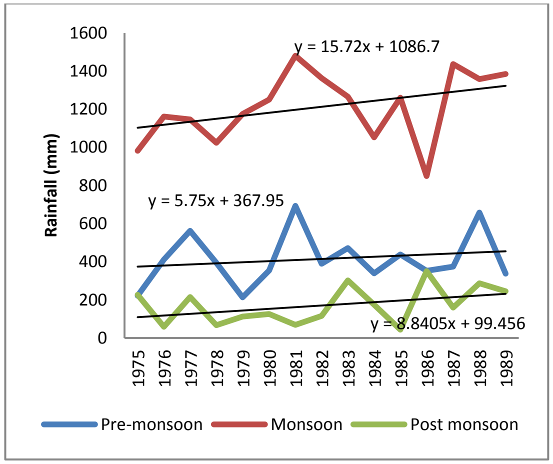



Fig. 5(a) Seasonal (1975-1989)

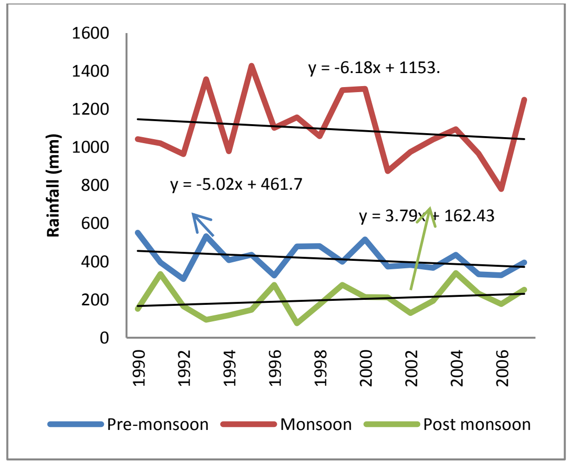



Fig. 5(b) Seasonal (1990-2007)

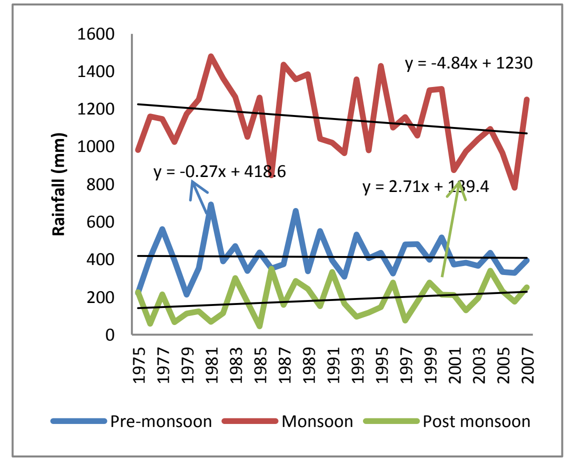



Fig. 5(c) Seasonal (1975-2007)

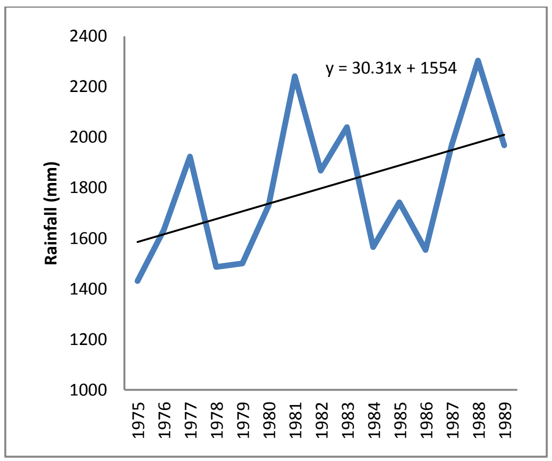



Fig. 5(d) Annual (1975-1989)

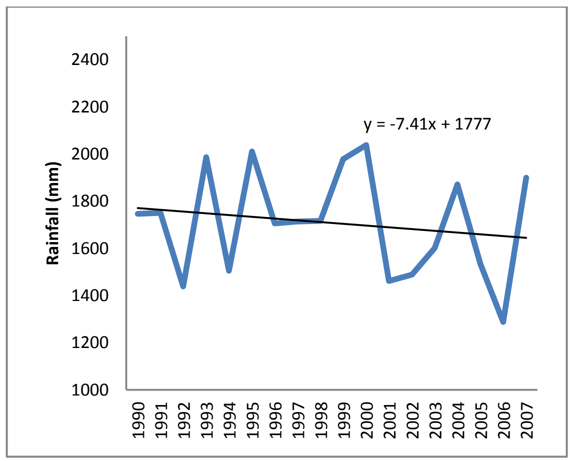



Fig. 5(e) Annual (1990-2007)

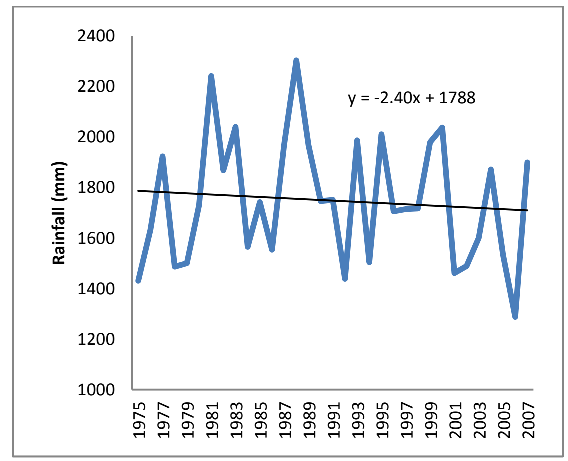



Fig. 5(f) Annual (1975-2007)

Fig. 3.5. Seasonal and annual rainfall situation in Karbi Anglong

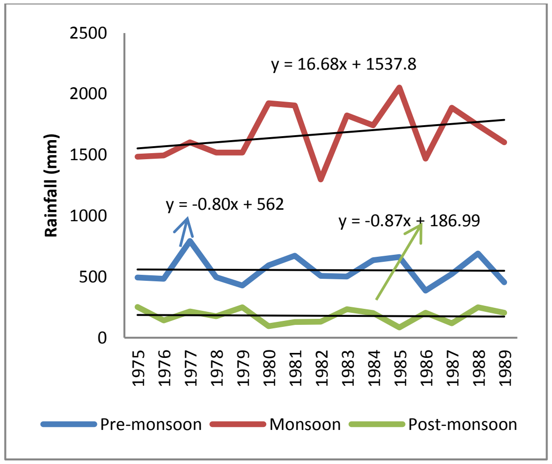



Fig. 6(a) Seasonal (1975-1989)

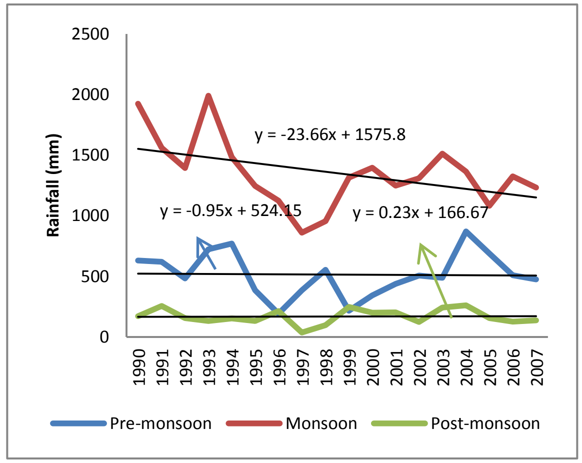



Fig. 6(b) Seasonal (1990-2007)

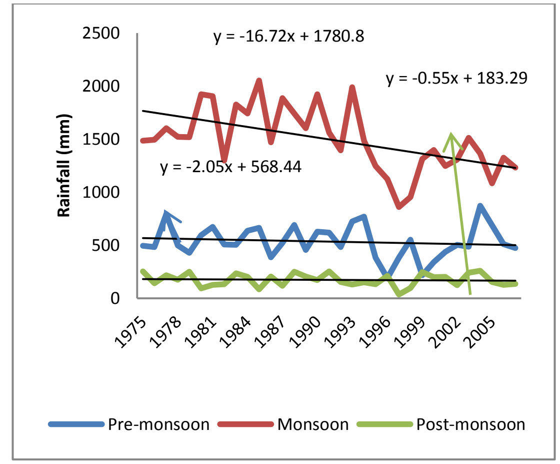



Fig. 6(c) Seasonal (1975-2007)

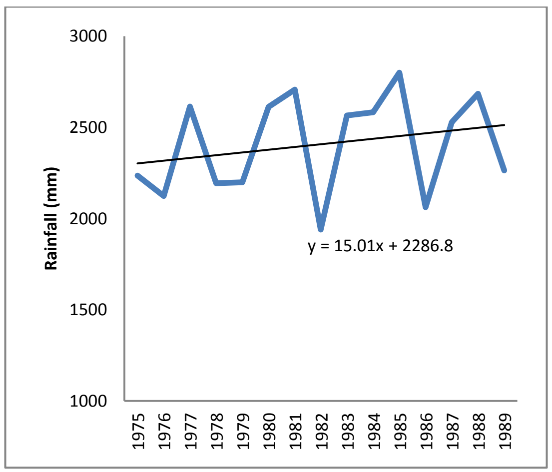



Fig. 6(d) Annual (1975-1989)

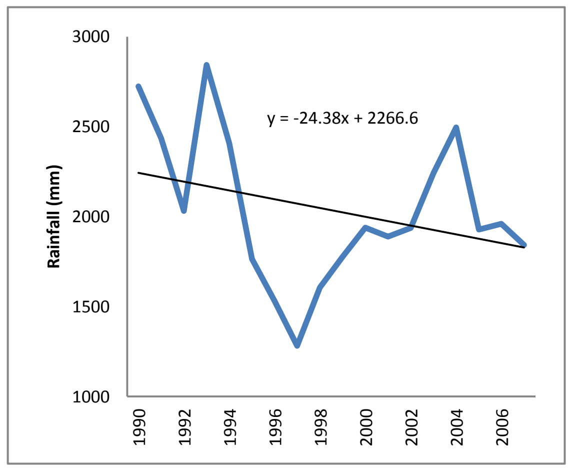



Fig. 6(e) Annual (1990-2007)

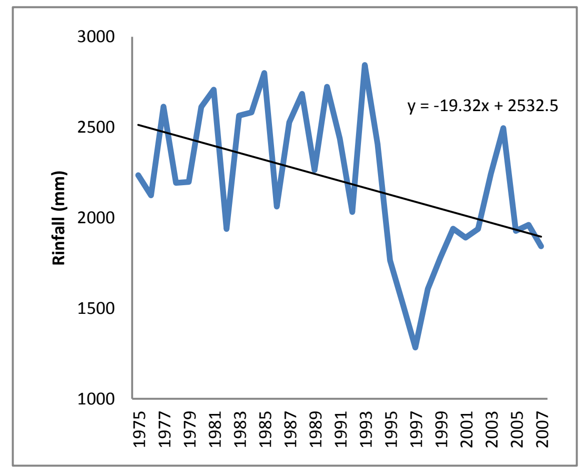



Fig. 6(f) Annual (1975-2007)

Fig. 3.6. Seasonal and annual rainfall situation in Nagaland

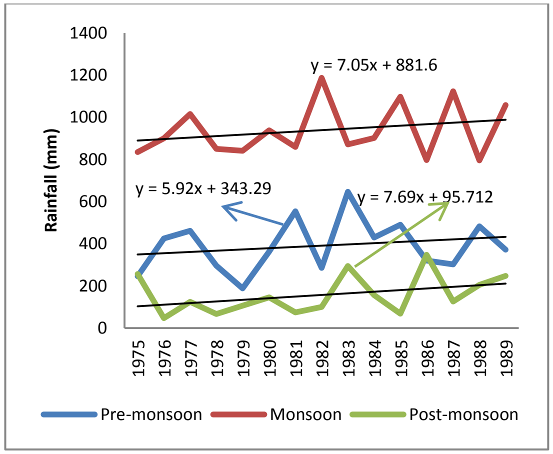



Fig. 7(a) Seasonal (1975-1989)

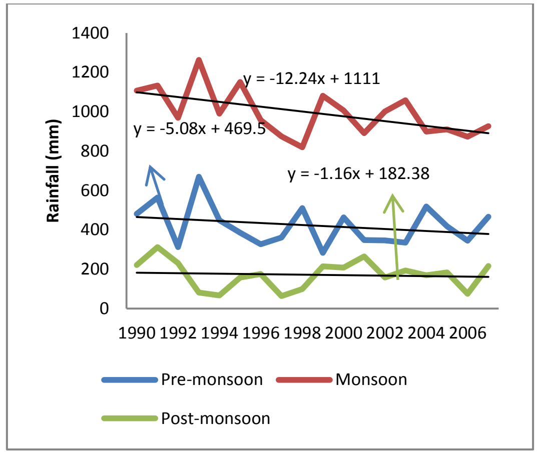



Fig. 7(b) Seasonal (1990-2007)

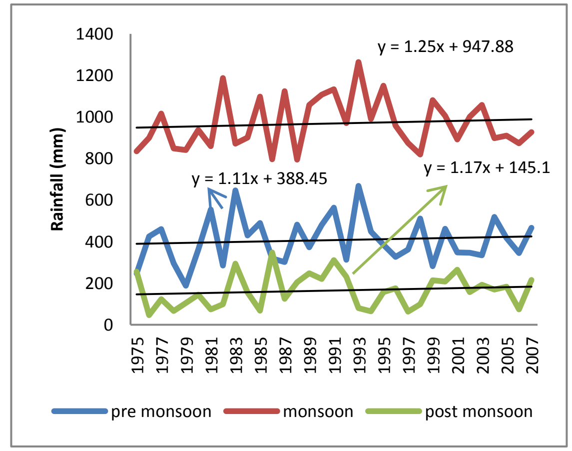



Fig. 7(c) Seasonal (1975-2007)

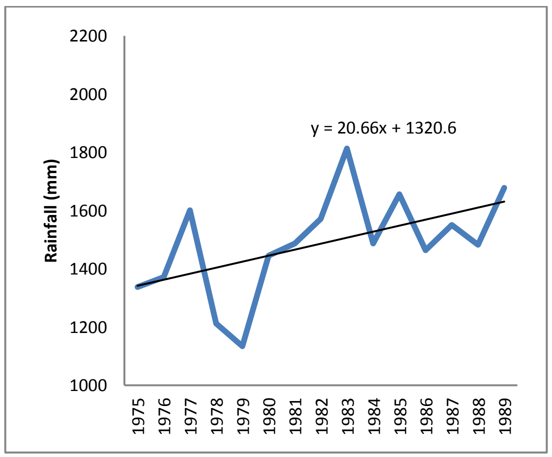



Fig. 7(d) Annual (1975-1989)

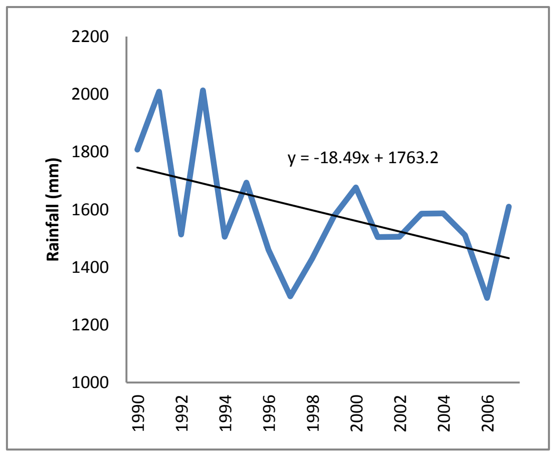



Fig. 7(e) Annual (1990-2007)

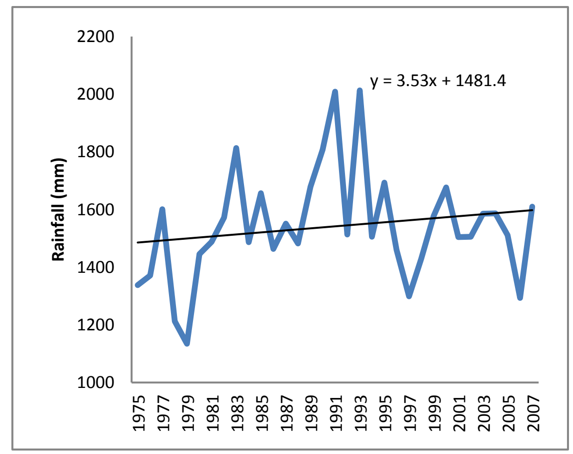



Fig. 7(f) Annual (1975-2007)

Fig. 3.7. Seasonal and annual rainfall situation in Manipur

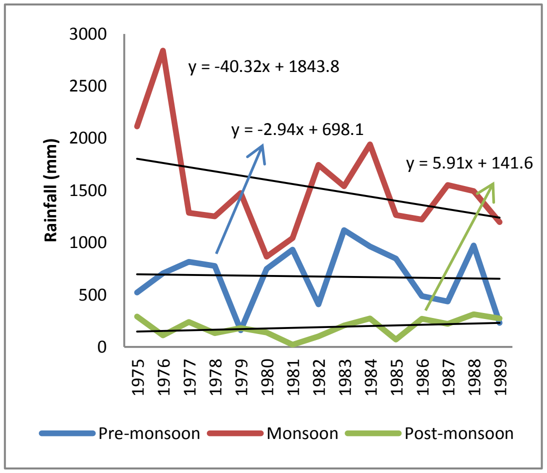



Fig. 8(a) Seasonal (1975-1989)

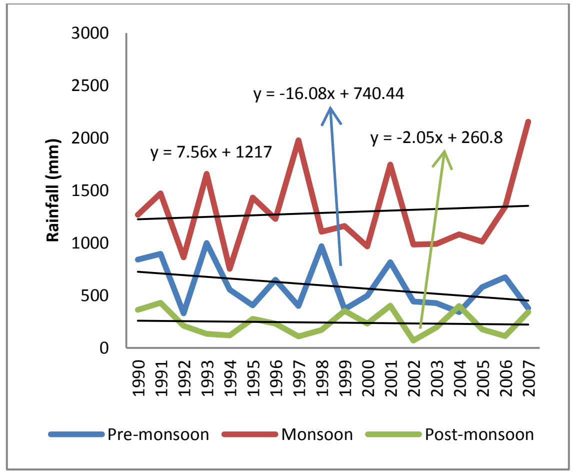



Fig. 8(b) Seasonal (1990-2007)

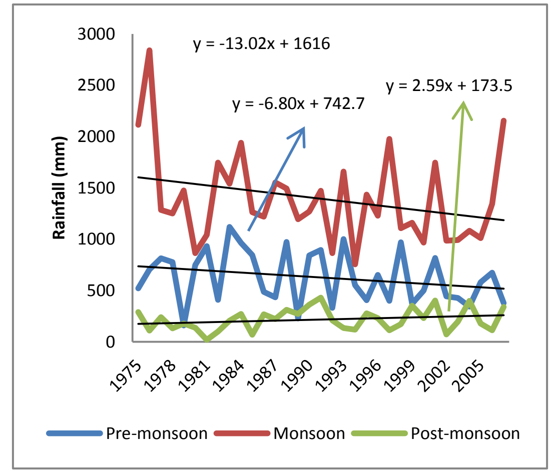



Fig. 8(c) Seasonal (1975-2007)

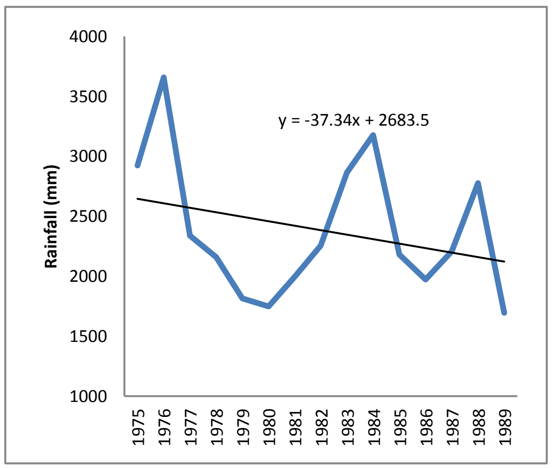



Fig. 8(d) Annual (1975-1989)

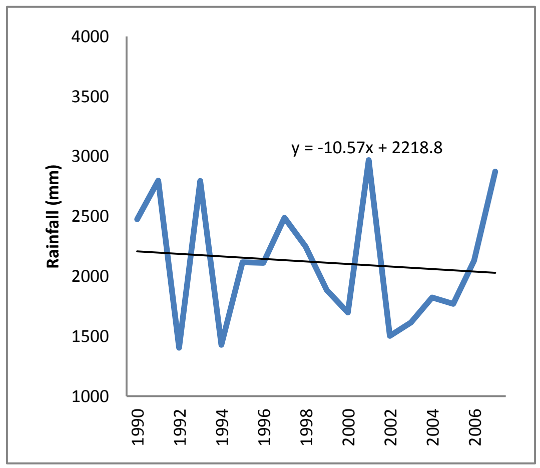



Fig. 8(e) Annual (1990-2007)

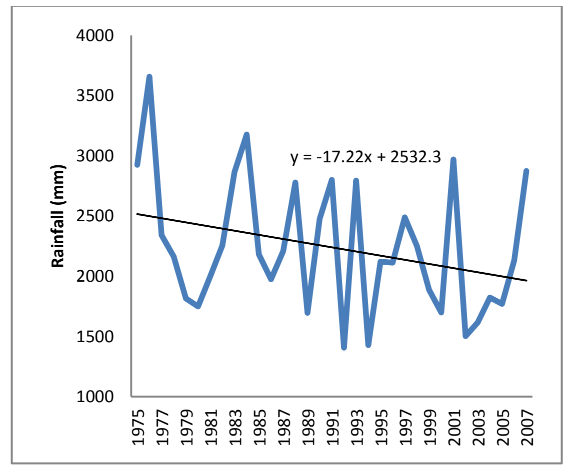



Fig. 8(f) Annual (1975-2007)

Fig. 3.8. Seasonal and annual rainfall situation in Tripura

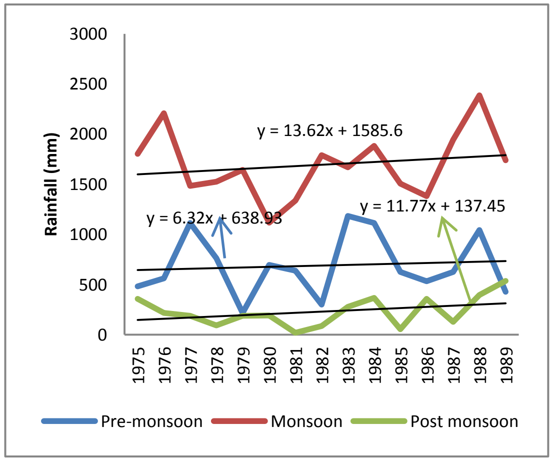



Fig. 9(a) Seasonal (1975-1989)

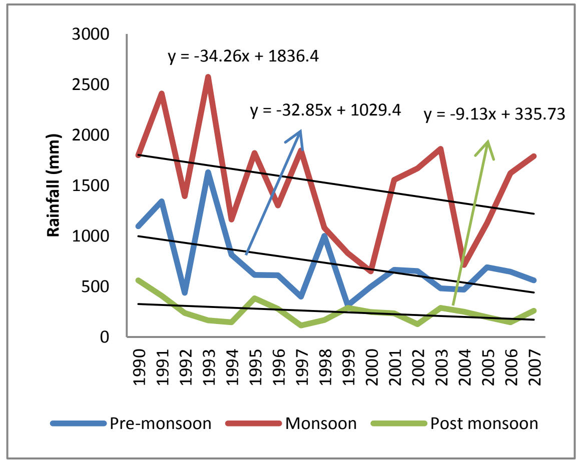



Fig. 9(b) Seasonal (1990-2007)

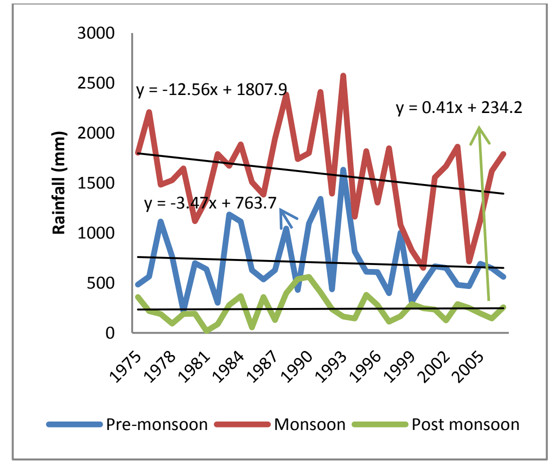



Fig. 9(c) Seasonal (1975-2007)

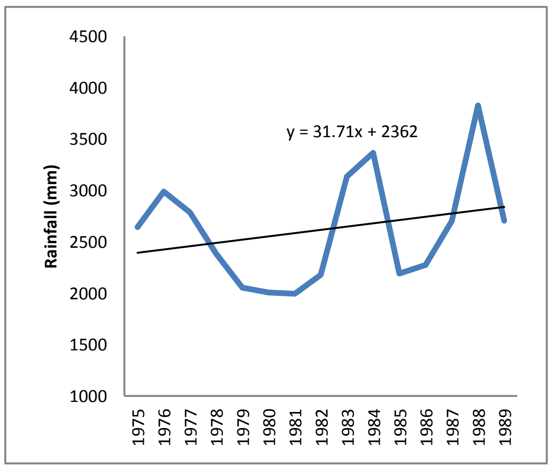



Fig. 9(d) Annual (1975-1989)

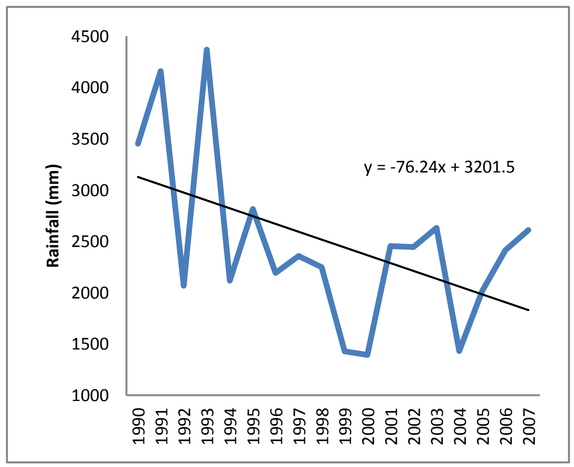



Fig. 9(e) Annual (1990-2007)

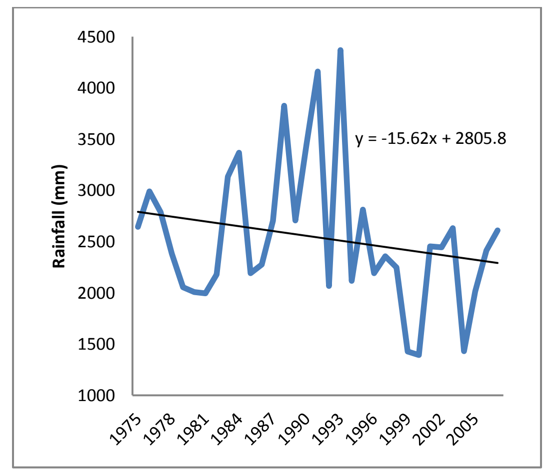



Fig. 9(f) Annual (1975-2007)

Fig. 3.9. Seasonal and annual rainfall situation in Mizoram

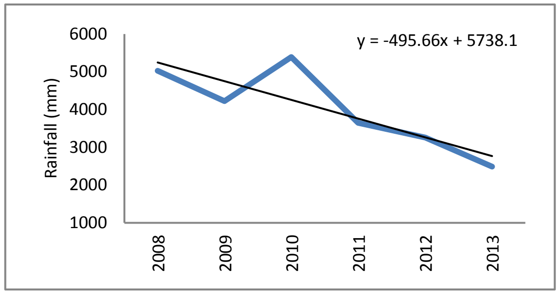



Fig. 10(a) Meghalaya

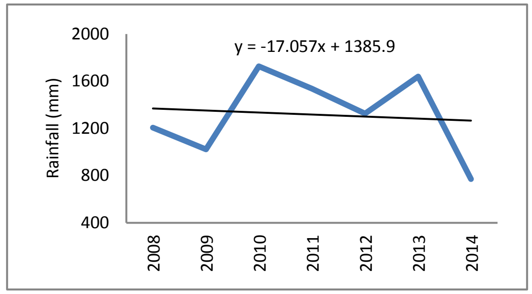



Fig. 10(b) Manipur

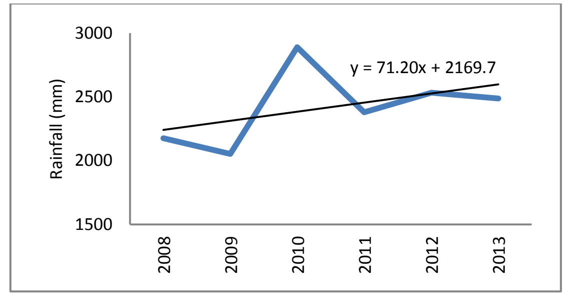



Fig. 10(c) Mizoram

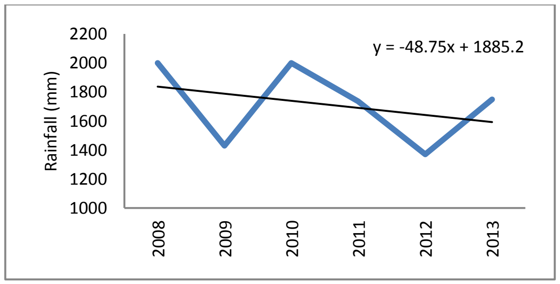



Fig. 10(d) Nagaland

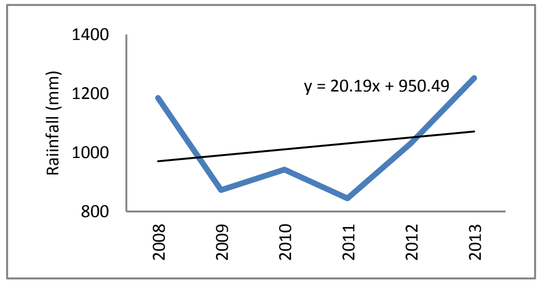



Fig. 10(e) Karbi-Anglong

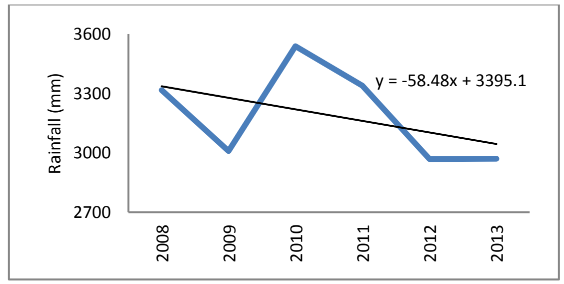



Fig.10 (f) Darjeeling

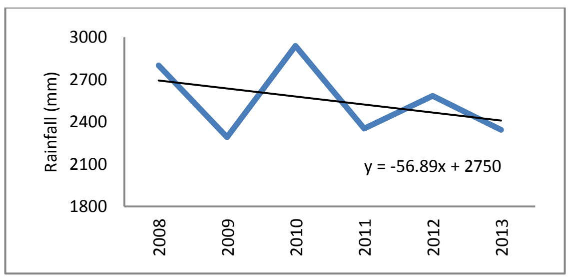



Fig. 10(g) Sikkim

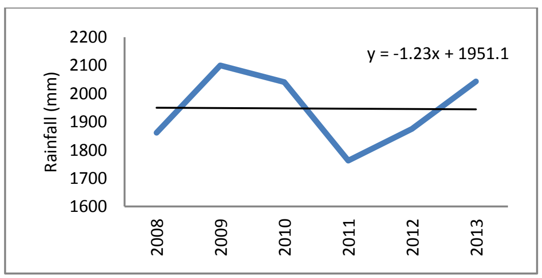



Fig.10 (h) Tripura

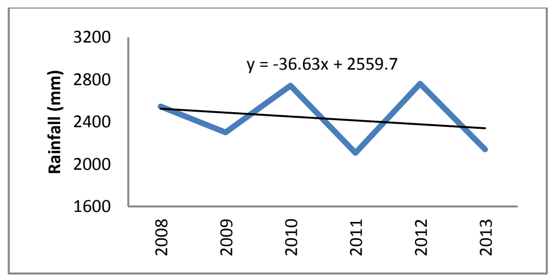



Fig. 10(i) Arunachal Pradesh

Fig. 3.10. Recent (2008-13) rainfall trend in North Eastern Hill region

**Trend in monsoon rainfall**

The trends in monsoon rainfall are also positive and insignificant in the NEH states of India, except Tripura where the trend was negative but insignificant during 1975 to 1989. The positive trend is significant for Meghalaya. These trends turned out to be negative during 1990 to 2007, except Meghalaya and Tripura. The negative trend of monsoon rainfall was significant in case of Manipur. For the complete study period of 1975-2007, the trend was negative and significant for Nagaland.

**Trend in post-monsoon rainfall**

The trends in post-monsoon rainfall are positive and insignificant for Meghalaya, Karbi Anglong, Manipur, Tripura and Mizoram and it negative for Sikkim, Darjeeling, Arunachal Pradesh and Nagaland during 1975 to 1989.Unlike the pre-monsoon and monsoon rainfall, the trends for post monsoon rainfall were positive during 1990 to 2007, except Manipur, Tripura and Mizoram. The positive trend of post-monsoon rainfall was significant in case of Sikkim. For the complete study period of 1975-2007, the trend was positive and significant for Meghalaya.

**Trend in annual rainfall**

The annual rainfalls have exhibited positive trend in NEH states during 1975-1989, except in Tripura. The positive trends in annual rainfall are significant in case of Meghalaya and Manipur. The trends have become negative during 1990-2007 in all the states of NEH, except Meghalaya. The negative trends are significant in case of Manipur and Mizoram. The trend was negative and significant for Nagaland for the entire study period of 1975-2007.

**Trend in annual rainfall in North Eastern Himalayan region during 2008-2013/14**

The rainfalls have declined in all the states during 2008-2013, except Mizoram and Karbi Anglong (Fig. 3.10). The decline in rainfall was statistically significant in Meghalaya.

### 3.1.3 Probability of rainfall

To know the probability of getting a dry or wet week Markov Chain analysis was performed and the results of Markov chain model is presented in Table 3.1.3.

Table 3.1.3. Frequency of getting probable wet and dry weeks in NEH India

| Season | Frequency (%) | | | | Range | | | |
|---|---|---|---|---|---|---|---|---|
| | P(W) | P(D) | P(D/D) | P(W/D) | P(W) | P(D) | P(D/D) | P(W/D) |
| Sikkim | | | | | | | | |
| Pre-monsoon | 23.81 | 76.19 | 76.19 | 23.81 | 0.00-0.84 | 0.15-1.00 | 0.22-1.00 | 0.00-0.77 |
| Monsoon | 100.00 | 0.00 | 16.67 | 55.56 | 0.69-1.00 | 0.00-0.30 | 0.00-1.00 | 0.00-1.00 |
| Post-monsoon | 0.00 | 100.00 | 100.00 | 0.00 | 0.00-0.42 | 0.57-1.00 | 0.71-1.00 | 0.00-0.28 |
| Annual | 44.23 | 55.77 | 61.54 | 28.85 | | | | |
| Darjeeling | | | | | | | | |
| Pre-monsoon | 23.81 | 76.19 | 76.19 | 23.81 | 0.00-0.87 | 0.12-1.00 | 0.16-1.00 | 0.00-0.83 |
| Monsoon | 100.00 | 0.00 | 11.11 | 72.22 | 0.81-1.00 | 0.00-0.18 | 0.00-0.50 | 0.50-1.00 |
| Post-monsoon | 15.38 | 84.62 | 100.00 | 0.00 | 0.00-0.57 | 0.42-1.00 | 0.60-1.00 | 0.00-0.40 |
| Annual | 48.08 | 51.92 | 59.62 | 34.62 | | | | |
| Meghalaya | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pre-monsoon | 33.33 | 66.66 | 76.19 | 23.81 | 0.00-0.94 | 0.06-1.00 | 0.00-1.00 | 0.00-1.00 |
| Monsoon | 100.00 | 0.00 | 11.11 | 61.11 | 0.88-1.00 | 0.00-0.12 | 0.00-1.00 | 0.00-1.00 |
| Post-monsoon | 23.08 | 76.92 | 84.62 | 15.38 | 0.00-0.79 | 0.21-1.00 | 0.00-1.00 | 0.00-1.00 |
| Annual | 53.85 | 46.15 | 55.77 | 34.62 | | | | |
| Arunachal Pradesh | | | | | | | | |
| Pre-monsoon | 38.09 | 61.91 | 71.43 | 19.04 | 0.00-0.91 | 0.09-1.00 | 0.00-1.00 | 0.00-1.00 |
| Monsoon | 94.44 | 5.56 | 16.67 | 61.11 | 0.09-1.00 | 0.00-0.91 | 0.00-0.80 | 0.00-1.00 |
| Post-monsoon | 15.39 | 84.61 | 84.62 | 15.38 | 0.00-0.70 | 0.30-1.00 | 0.17-1.00 | 0.03-0.83 |
| Annual | 51.92 | 48.08 | 55.77 | 32.69 | | | | |
| Karbi Anglong | | | | | | | | |
| Pre-monsoon | 33.33 | 66.67 | 76.19 | 23.81 | 0.00-0.84 | 0.15-1.00 | 0.16-1.00 | 0.00-0.83 |
| Monsoon | 100.00 | 0.00 | 11.11 | 61.11 | 0.69-1.00 | 0.00-0.30 | 0.00-1.00 | 0.00-1.00 |
| Post-monsoon | 15.38 | 84.62 | 92.31 | 7.69 | 0.00-0.72 | 0.27-1.00 | 0.16-1.00 | 0.00-0.83 |
| Annual | 51.92 | 48.08 | 57.69 | 32.69 | | | | |
| Nagaland | | | | | | | | |
| Pre-monsoon | 42.86 | 57.14 | 76.19 | 23.81 | 0.00-0.93 | 0.06-1.00 | 0.00-1.00 | 0.00-1.00 |
| Monsoon | 100.00 | 0.00 | 16.67 | 55.56 | 0.84-1.00 | 0.00-0.15 | 0.00-1.00 | 0.00-1.00 |
| Post-monsoon | 23.08 | 76.92 | 92.31 | 7.69 | 0.00-0.72 | 0.27-1.00 | 0.20-1.00 | 0.00-0.80 |
| Annual | 57.69 | 42.31 | 59.62 | 30.77 | | | | |
| Manipur | | | | | | | | |
| Pre-monsoon | 28.57 | 71.43 | 85.71 | 19.05 | 0.00-0.72 | 0.27-1.00 | 0.27-1.00 | 0.00-0.72 |
| Monsoon | 100.00 | 0.00 | 11.11 | 88.89 | 0.66-1.00 | 0.00-0.33 | 0.00-0.50 | 0.50-1.00 |
| Post-monsoon | 7.69 | 92.31 | 92.31 | 7.69 | 0.03-0.66 | 0.33-0.96 | 0.36-0.96 | 0.03-0.63 |
| Annual | 48.08 | 51.92 | 61.54 | 40.38 | | | | |
| Tripura | | | | | | | | |
| Pre-monsoon | 28.57 | 71.43 | 80.95 | 19.05 | 0.00-0.87 | 0.12-1.00 | 0.00-1.00 | 0.00-1.00 |
| Monsoon | 100.00 | 0.00 | 27.78 | 72.22 | 0.69-0.96 | 0.03-0.30 | 0.00-0.50 | 0.50-1.00 |
| Post-monsoon | 23.08 | 76.92 | 84.62 | 15.38 | 0.00-0.66 | 0.33-1.00 | 0.36-1.00 | 0.00-0.63 |
| Annual | 51.92 | 48.08 | 63.46 | 36.54 | | | | |
| Mizoram | | | | | | | | |
| Pre-monsoon | 28.57 | 71.43 | 71.43 | 28.57 | 0.00-0.84 | 0.15-1.00 | 0.00-1.00 | 0.00-1.00 |
| Monsoon | 100.00 | 0.00 | 5.56 | 83.33 | 0.81-1.00 | 0.00-0.18 | 0.00-0.50 | 0.00-1.00 |
| Post-monsoon | 23.08 | 76.92 | 100.00 | 0.00 | 0.00-0.81 | 0.18-1.00 | 0.50-1.00 | 0.00-0.50 |
| Annual | 51.92 | 48.08 | 55.77 | 40.38 | | | | |

The results of Markov Chain analysis indicates that in a year about more than 50 per cent of the weeks have the probability that they will be wet in Meghalaya, Arunachal Pradesh, Karbi Anglong, Nagaland Tripura and Mizoram. All the monsoon weeks have the probability of being wet week in all the hill districts of North Eastern Himalaya (NEH), except the $21^{st}$ SMW in Arunachal Pradesh and the probability values ranged from 66-100 per cent during the monsoon period ($22^{nd}$ to $39^{th}$ SMW).

About 57.14 to 76.19 per cent of the pre-monsoon weeks in the NEH states will probably be dry weeks. The occurrence of wet week (33.33%) in pre-monsoon period will be beneficial for the rice production for land preparation and starts sowing for the early variety rice.

Markov chain analysis revealed that cent per cent and 92.31 per cent of the weeks have the probabilities to be dry in Sikkim and Manipur, respectively during the post monsoon seasons which may hamper the profoundly the *rabi* crops in these states. In other North Eastern states more than 76 per cent of the weeks have the probabilities to be a dry week.

***Conditional probability***

The frequency of conditional probability for a given dry week to be preceded by another dry week is highest during post-monsoon season (more than 84% weeks), followed by pre-monsoon and monsoon season. More than 55 per cent of the SMWs in a given year have the probability of being dry week preceded by another dry week in the region. Within the monsoon period, 27.78 per cent of the dry weeks, have the probability of being preceded by another dry week in Tripura. And this long dry spell may affect rice crop especially in areas with soils having low water holding capacity.

### 3.1.4 Onset of Monsoon in North Easrern Himamalayas of India

The onset of monsoon is very important in the perspective of agricultural practices. The arrival of monsoon across the NEH states is presented in Table 3.1.4.

Table 3.1.4. Onset of monsoon in NEH of India

| State/District | June | | | July | | | August | | Sept |
|---|---|---|---|---|---|---|---|---|---|
| | $1^{st}$ week | $2^{nd}$ week | Beyond $2^{nd}$ week | $1^{st}$ week | $2^{nd}$ week | Beyond $2^{nd}$ week | $1^{st}$ week | $2^{nd}$ week | $2^{nd}$ |
| Darjeeling | 14 (42.43) | 11 (33.33) | 8 (24.24) | | | | | | |
| Karbi Anglong | 17 (51.52) | 8 (24.24) | 8 (24.24) | | | | | | |
| Nagaland | 22 (66.67) | 3 (9.09) | 8 (24.24) | | | | | | |
| Meghalaya | 23 (69.70) | 6 (18.18) | 4 (12.12) | | | | | | |
| Arunachal Pradesh | 20 (60.61) | 6 (18.18) | 7 (21.21) | | | | | | |
| Mizoram | 19 (57.58) | 9 (27.27) | 3 (9.09) | 1 (3.03) | 1 (3.03) | | | | |
| Sikkim | 8 (24.24) | 15 (45.45) | 8 (24.24) | 1 (3.03) | 1 (3.03) | | | | |
| Manipur | 11 (35.48) | 8 (25.81) | 9 (29.03) | 2 (6.45) | | | 1 (3.23) | | |
| Tripura | 4 (12.50) | 2 (6.25) | 12 (37.50) | 3 (9.38) | 3 (9.38) | 5 (15.63) | | 2 (6.25) | 1 (3.13) |

Note: Figures in parenthesis indicate percentage to total

The table shows that in Meghalaya, Nagaland and Arunachal Pradesh the monsoon has set in 1st week of June in 60.61 to 69.70 per cent of the years under study but in Sikkim, Manipur and Tripura it was only 12.50 to 35.48 per cent of the years. In case of Sikkim, Darjeeling, Mizoram, Manipur and Karbi Anglong the monsoon has set in 2nd week of June in case of 25.81 to 45.45 per cent of the years. In case of Mizoram, Sikkim, Manipur and Tripura in some of the years arrival of monsoon was beyond June.

## 3.2 Temperature Trends in North Eastern Himalayas of India

### 3.2.1 Descriptive statistics for minimum and maximum temperatures

*Minimum and maximum temperatures in Sikkim*

The monthly temperature situation in Sikkim is presented in Table 3.2.1.1.

Table 3.2.1.1. Monthly temperature in Sikkim

| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 8.0 | 6.3 | 14.3 | 9.8 | 20.6 | 17.5 | 22.6 | 5.2 |
| February | 10.1 | 8.5 | 15.0 | 11.0 | 22.8 | 20.7 | 25.9 | 5.8 |
| March | 13.7 | 11.9 | 20.8 | 6.9 | 26.9 | 24.1 | 29.0 | 4.3 |
| April | 17.5 | 15.7 | 24.7 | 5.0 | 29.1 | 26.4 | 31.4 | 5.0 |
| May | 19.5 | 17.0 | 24.0 | 4.4 | 29.2 | 27.4 | 32.1 | 4.1 |
| June | 21.3 | 20.0 | 25.6 | 2.8 | 29.3 | 27.8 | 31.6 | 3.0 |
| July | 21.9 | 20.0 | 25.4 | 4.2 | 28.8 | 27.2 | 30.1 | 2.0 |
| August | 22.0 | 20.7 | 23.5 | 2.8 | 29.4 | 28.1 | 30.9 | 1.9 |
| September | 21.1 | 19.9 | 22.3 | 2.7 | 28.8 | 27.9 | 30.5 | 2.2 |
| October | 18.4 | 16.4 | 20.4 | 4.8 | 28.0 | 26.4 | 29.2 | 2.6 |
| November | 13.6 | 11.8 | 15.6 | 7.0 | 25.8 | 24.7 | 27.3 | 2.7 |
| December | 9.8 | 8.1 | 12.2 | 9.2 | 22.5 | 21.0 | 23.9 | 3.4 |

In Sikkim, the normal minimum temperature was highest (22.0$^0$C) in the month of August, followed by July and June. The lowest normal minimum temperature was registered in January (8.0$^0$C). The variation in minimum temperature was higher in the months of February and January. The highest normal maximum temperature was in the month of August (29.4$^0$C), followed by June and May. The variation in maximum temperature was higher in the months of February and January.

Table 3.2.1.2 Seasonal and annual temperature in Sikkim

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 13.8 | 12.5 | 15.0 | 4.5 | 25.7 | 23.9 | 27.2 | 3.0 |
| Monsoon | 21.6 | 20.5 | 22.8 | 2.7 | 29.1 | 28.5 | 30.2 | 1.4 |
| Post-monsoon | 13.9 | 12.4 | 15.5 | 4.8 | 25.5 | 24.4 | 26.6 | 2.1 |
| Annual | 16.4 | 15.4 | 17.4 | 3.2 | 26.8 | 25.8 | 27.7 | 1.5 |

The seasonal and annual temperature situation in Sikkim is presented in Table 3.2.1.2. The normal annual minimum and maximum temperature were 16.4$^0$C and 26.8$^0$C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Descriptive statistics for minimum and maximum temperatures in Darjeeling*

The monthly temperature situation in Darjeeling is presented in Table 3.2.1.3.

Table 3.2.1.3. Monthly temperature in Darjeeling during 1975-2009

| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 8.1 | 6.1 | 10.0 | 9.9 | 20.7 | 17.4 | 22.7 | 5.3 |
| February | 10.3 | 8.5 | 13.5 | 10.6 | 23.0 | 20.4 | 25.8 | 5.7 |
| March | 14.0 | 12.1 | 15.8 | 6.6 | 27.3 | 24.6 | 29.4 | 4.3 |
| April | 17.8 | 15.9 | 20.0 | 5.0 | 29.9 | 27.0 | 32.4 | 4.9 |
| May | 19.9 | 17.3 | 21.4 | 4.2 | 30.1 | 28.3 | 33.1 | 4.0 |
| June | 21.7 | 20.4 | 23.7 | 2.9 | 29.9 | 28.6 | 32.3 | 3.3 |
| July | 22.2 | 20.3 | 26.2 | 4.4 | 29.1 | 27.7 | 30.5 | 1.9 |
| August | 22.3 | 20.9 | 23.6 | 2.7 | 29.7 | 28.4 | 30.9 | 1.9 |
| September | 21.5 | 20.0 | 22.6 | 2.9 | 29.1 | 28.3 | 30.6 | 2.0 |
| October | 18.6 | 16.6 | 20.3 | 4.4 | 28.4 | 27.0 | 29.7 | 2.5 |
| November | 13.8 | 12.0 | 16.0 | 6.9 | 26.1 | 25.0 | 27.6 | 2.6 |
| December | 9.7 | 8.0 | 12.3 | 8.8 | 22.7 | 21.0 | 24.3 | 3.4 |

In Darjeeling, the normal minimum temperature was highest (22.3$^0$C) in the month of August, followed by July and June. The lowest normal minimum temperature was registered in January (8.1$^0$C). The variation in minimum temperature was registered higher in the months of February and January. The highest normal maximum temperature was in the month of May (30.1$^0$C), followed by April and June (29.9$^0$C). The variation in maximum temperature was higher in the months of February and January.

Table 3.2.1.4. Seasonal and annual temperature in Darjeeling during 1975-2009

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 14.0 | 12.7 | 15.2 | 4.5 | 26.2 | 24.4 | 27.7 | 3.0 |
| Monsoon | 21.9 | 20.7 | 24.6 | 3.3 | 29.5 | 28.9 | 30.4 | 1.5 |
| Post-monsoon | 14.1 | 12.7 | 15.6 | 4.6 | 25.7 | 24.7 | 27.0 | 2.0 |
| Annual | 16.7 | 15.7 | 17.9 | 3.4 | 27.1 | 26.2 | 28.2 | 1.5 |

The seasonal and annual temperature situation in Darjeeling is presented in Table 3.2.1.4. The normal annual minimum and maximum temperature were 16.7$^0$C and 27.1$^0$C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Meghalaya*

The monthly temperature situation in Meghalaya is presented in Table 3.2.1.5.

Table 3.2.1.5. Monthly temperature in Meghalaya during 1975-2009

| Month | Min. Temp. (⁰C) | | | CV (%) | Max. Temp. (⁰C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.6 | 8.3 | 11.4 | 7.6 | 22.2 | 20.4 | 23.9 | 4.3 |
| February | 11.8 | 10.1 | 14.3 | 8.8 | 24.6 | 22.1 | 28.1 | 5.2 |
| March | 15.5 | 14.2 | 17.7 | 5.5 | 28.1 | 25.0 | 30.4 | 4.3 |
| April | 19.0 | 17.1 | 21.5 | 4.6 | 29.4 | 26.4 | 31.8 | 4.5 |
| May | 21.2 | 19.9 | 22.5 | 3.4 | 29.9 | 27.3 | 31.6 | 3.4 |
| June | 23.3 | 22.3 | 26.1 | 3.2 | 30.6 | 28.9 | 33.8 | 2.9 |
| July | 23.7 | 22.5 | 24.4 | 1.8 | 30.3 | 29.3 | 31.6 | 2.0 |
| August | 23.7 | 23.0 | 24.4 | 1.5 | 30.8 | 29.7 | 32.4 | 1.9 |
| September | 23.0 | 21.8 | 24.7 | 2.3 | 30.3 | 28.8 | 31.9 | 2.3 |
| October | 20.4 | 19.0 | 22.0 | 3.5 | 29.2 | 27.8 | 30.6 | 2.3 |
| November | 15.6 | 13.9 | 17.6 | 5.5 | 26.8 | 25.8 | 27.8 | 2.1 |
| December | 11.2 | 9.0 | 13.7 | 8.8 | 23.8 | 22.4 | 25.0 | 3.3 |

In Meghalaya, the normal minimum temperature was highest (23.7⁰C) in the month of July and August, followed by June. The lowest normal minimum temperature was registered in January (9.6⁰C). The variation in minimum temperature was higher in the months of February and December. The highest normal maximum temperature was in the month of August (30.8⁰C), followed by June and July. The variation in maximum temperature was higher in the months of February and April.

Table 3.2.1.6. Seasonal and annual temperature in Meghalaya during 1975-2009

| Season | Min. Temp. (⁰C) | | | CV (%) | Max. Temp. (⁰C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.4 | 14.6 | 16.7 | 3.3 | 26.9 | 25.5 | 28.5 | 2.7 |
| Monsoon | 23.4 | 22.8 | 24.7 | 1.9 | 30.5 | 29.8 | 31.6 | 1.4 |
| Post-monsoon | 15.7 | 14.5 | 17.2 | 3.8 | 26.6 | 25.6 | 27.5 | 1.9 |
| Annual | 18.2 | 17.6 | 19.1 | 2.4 | 28.0 | 27.2 | 29.0 | 1.5 |

The seasonal and annual temperature situation in Meghalaya is presented in Table 3.2.1.6. The normal annual minimum and maximum temperature were 18.2⁰C and 28.0⁰C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Arunachal Pradesh*

The monthly temperature situation in Arunachal Pradesh is presented in Table 3.2.1.7.

| Table 3.2.1.7. Monthly temperature in Arunachal Pradesh | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.7 | 8.5 | 11.4 | 7.5 | 22.7 | 21.1 | 24.8 | 4.3 |
| February | 12.0 | 10.3 | 14.2 | 8.6 | 24.8 | 22.1 | 28.8 | 5.5 |
| March | 15.6 | 14.3 | 17.7 | 5.0 | 28.1 | 24.9 | 30.6 | 4.4 |
| April | 19.1 | 17.3 | 21.5 | 4.4 | 29.2 | 25.9 | 32.0 | 4.5 |
| May | 21.7 | 20.3 | 23.1 | 3.3 | 30.3 | 27.7 | 31.9 | 3.3 |
| June | 24.1 | 23.0 | 27.0 | 3.0 | 31.6 | 29.6 | 34.7 | 3.1 |
| July | 24.9 | 23.4 | 29.8 | 5.6 | 31.3 | 30.3 | 32.7 | 2.0 |
| August | 24.8 | 24.0 | 26.8 | 3.0 | 31.9 | 30.7 | 33.6 | 1.9 |
| September | 24.1 | 22.4 | 29.2 | 5.9 | 31.1 | 29.7 | 32.9 | 2.4 |
| October | 21.0 | 19.2 | 24.3 | 5.3 | 29.9 | 28.6 | 31.4 | 2.4 |
| November | 15.5 | 13.5 | 17.4 | 6.0 | 27.4 | 25.9 | 28.5 | 2.4 |
| December | 11.0 | 8.9 | 13.0 | 8.5 | 24.1 | 22.8 | 25.6 | 3.4 |

In Arunachal Pradesh, the normal minimum temperature was highest (24.9$^0$C) in the month of July, followed by August, June and September. The lowest normal minimum temperature was registered in January (9.7$^0$C). The variation in minimum temperature was higher in the months of February and December. The highest normal maximum temperature was in the month of August (31.9$^0$C), followed by June and July. The variation in maximum temperature was highest in the month of February.

| Table 3.2.1.8. Seasonal and annual temperature in Arunachal Pradesh | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.6 | 14.5 | 16.9 | 3.2 | 27.0 | 25.5 | 29.1 | 2.9 |
| Monsoon | 24.4 | 23.5 | 27.2 | 4.1 | 31.5 | 30.9 | 32.6 | 1.4 |
| Post-monsoon | 15.8 | 14.4 | 17.3 | 4.6 | 27.1 | 26.1 | 28.3 | 2.1 |
| Annual | 18.6 | 17.8 | 20.0 | 3.5 | 28.5 | 27.6 | 29.5 | 1.6 |

The seasonal and annual temperature situation in Arunachal Pradesh is presented in Table 3.2.1.8. The normal annual minimum and maximum temperature were 18.6$^0$C and 28.5$^0$C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Karbi Anglong*

The monthly temperature situation in Karbi Anglong is presented in Table 3.2.1.9. In Karbi Anglong, the normal minimum temperature was highest (23.5$^0$C) in the month of August, followed by July and June. The lowest normal minimum temperature was registered in January (9.4$^0$C). The variation in minimum temperature was higher in the months of February and December. The highest normal maximum temperature was in the month of August (30.8$^0$C), followed by June and July. The variation in maximum temperature was highest in the month of February.

| Table 3.2.1.9. Monthly temperature in Karbi Anglong | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Min. Temp. (⁰C) | | | CV (%) | Max. Temp. (⁰C) | | | CV (%) |
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.4 | 8.1 | 11.0 | 7.3 | 21.9 | 20.1 | 23.9 | 4.5 |
| February | 11.6 | 10.1 | 13.8 | 8.4 | 24.3 | 21.6 | 28.2 | 5.2 |
| March | 15.3 | 14.0 | 17.3 | 5.3 | 27.6 | 24.3 | 30.0 | 4.5 |
| April | 18.6 | 16.6 | 20.9 | 4.5 | 28.8 | 25.8 | 31.3 | 4.4 |
| May | 20.9 | 19.5 | 22.1 | 3.3 | 29.6 | 26.9 | 31.1 | 3.4 |
| June | 23.0 | 22.2 | 23.9 | 1.8 | 30.6 | 28.8 | 33.8 | 3.2 |
| July | 23.4 | 22.5 | 24.2 | 1.7 | 30.3 | 28.8 | 31.7 | 2.1 |
| August | 23.5 | 22.9 | 24.0 | 1.4 | 30.8 | 29.7 | 32.5 | 2.0 |
| September | 22.7 | 21.6 | 24.9 | 2.5 | 30.2 | 28.9 | 31.8 | 2.2 |
| October | 20.2 | 18.7 | 21.8 | 3.8 | 29.1 | 27.9 | 30.6 | 2.5 |
| November | 15.4 | 13.5 | 17.3 | 5.7 | 26.7 | 25.5 | 28.1 | 2.4 |
| December | 10.9 | 8.8 | 12.8 | 8.5 | 23.5 | 21.9 | 25.1 | 3.7 |

| Table 3.2.1.10. Seasonal and annual temperature in Karbi Anglong | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Season | Min. Temp. (⁰C) | | | CV (%) | Max. Temp. (⁰C) | | | CV (%) |
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.1 | 14.4 | 16.4 | 3.0 | 26.5 | 24.9 | 28.4 | 2.9 |
| Monsoon | 23.2 | 22.6 | 24.0 | 1.5 | 30.5 | 29.6 | 31.7 | 1.5 |
| Post-monsoon | 15.5 | 14.3 | 16.9 | 3.9 | 26.5 | 25.3 | 27.8 | 2.2 |
| Annual | 17.9 | 17.4 | 18.8 | 2.2 | 27.8 | 26.8 | 28.9 | 1.7 |

The seasonal and annual temperature situation in Karbi Anglong is presented in Table 3.2.1.10. The normal annual minimum and maximum temperature were 17.9⁰C and 27.8⁰C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Nagaland*

The monthly temperature situation in Nagaland is presented in Table 3.2.1.11.

| Table 3.2.1.11. Monthly temperature in Nagaland during 1975-2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Min. Temp. (⁰C) | | | CV (%) | Max. Temp. (⁰C) | | | CV (%) |
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.7 | 8.4 | 11.3 | 7.3 | 23.4 | 21.5 | 25.5 | 4.4 |
| February | 12.3 | 10.6 | 14.3 | 7.9 | 25.3 | 22.4 | 29.5 | 5.5 |
| March | 15.8 | 14.5 | 17.8 | 5.4 | 28.4 | 25.1 | 30.9 | 4.5 |
| April | 19.2 | 17.3 | 21.5 | 4.2 | 29.4 | 26.1 | 32.3 | 4.5 |
| May | 21.9 | 20.7 | 23.2 | 3.0 | 30.8 | 28.0 | 32.2 | 3.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| June | 24.2 | 23.3 | 24.9 | 1.7 | 32.2 | 30.2 | 35.4 | 3.2 |
| July | 24.7 | 23.8 | 26.3 | 1.8 | 32.0 | 31.0 | 33.3 | 2.0 |
| August | 24.8 | 24.3 | 25.3 | 1.2 | 32.6 | 31.3 | 34.3 | 1.9 |
| September | 23.9 | 22.7 | 24.8 | 1.9 | 31.7 | 30.3 | 33.5 | 2.4 |
| October | 21.0 | 19.4 | 22.7 | 3.6 | 30.5 | 29.2 | 32.1 | 2.5 |
| November | 15.6 | 13.4 | 17.4 | 6.0 | 28.0 | 26.3 | 29.6 | 2.4 |
| December | 10.9 | 9.0 | 12.8 | 8.5 | 24.8 | 23.1 | 26.7 | 3.7 |

In Nagaland, the normal minimum temperature was highest (24.8$^0$C) in the month of August, followed by July and June. The lowest normal minimum temperature was registered in January (9.7$^0$C). The variation in minimum temperature was higher in the months of December and February. The highest normal maximum temperature was in the month of August (32.6$^0$C), followed by June and July. The variation in maximum temperature was higher in the months of February and April.

Table 3.2.1.12. Seasonal and annual temperature in Nagaland during 1975-2009

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.8 | 14.7 | 17.0 | 3.1 | 27.5 | 25.8 | 29.6 | 3.0 |
| Monsoon | 24.4 | 23.9 | 25.1 | 1.3 | 32.1 | 31.4 | 33.2 | 1.4 |
| Post-monsoon | 15.8 | 14.8 | 17.2 | 3.8 | 27.8 | 26.6 | 29.4 | 2.2 |
| Annual | 18.7 | 18.1 | 19.6 | 2.1 | 29.1 | 28.0 | 30.2 | 1.7 |

The seasonal and annual temperature situation in Nagaland is presented in Table 3.2.1.12.The normal annual minimum and maximum temperature were 18.7$^0$C and 29.1$^0$C, respectively. The variations in seasonal and annual minimum temperature were comparatively higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Manipur*

The monthly temperature situation in Manipur is presented in Table 3.2.1.13. In Manipur, the normal minimum temperature was highest (23.7$^0$C) in the month of July, followed by August and June. The lowest normal minimum temperature was registered in January (9.3$^0$C), followed by December. The variation in minimum temperature was higher in the months of December and January. The highest normal maximum temperature was in the month of August (31.1$^0$C), followed by June and July. The variation in maximum temperature was higher in the months of February and January.

Table 3.2.1.13. Monthly temperature in Manipur during 1975-2009

| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.3 | 7.9 | 12.5 | 9.3 | 22.5 | 20.5 | 24.6 | 4.6 |
| February | 11.6 | 10.2 | 13.8 | 8.2 | 24.7 | 21.9 | 29.0 | 5.4 |
| March | 15.4 | 14.1 | 17.4 | 5.6 | 28.0 | 24.6 | 30.5 | 4.5 |
| April | 18.7 | 16.8 | 20.9 | 4.3 | 29.1 | 26.2 | 31.6 | 4.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May | 21.0 | 19.8 | 22.2 | 3.0 | 29.9 | 27.1 | 31.3 | 3.4 |
| June | 23.2 | 22.3 | 23.8 | 1.7 | 30.8 | 29.0 | 34.1 | 3.2 |
| July | 23.7 | 22.8 | 25.8 | 2.4 | 30.6 | 29.7 | 32.0 | 2.1 |
| August | 23.6 | 23.0 | 24.3 | 1.4 | 31.1 | 29.8 | 32.7 | 1.9 |
| September | 22.8 | 21.7 | 24.0 | 2.1 | 30.4 | 29.2 | 32.0 | 2.2 |
| October | 20.3 | 18.7 | 21.9 | 4.1 | 29.5 | 28.2 | 31.0 | 2.4 |
| November | 15.3 | 13.4 | 17.2 | 5.8 | 27.0 | 25.8 | 28.6 | 2.4 |
| December | 10.7 | 8.7 | 14.0 | 10.4 | 24.0 | 22.3 | 25.9 | 4.0 |

The seasonal and annual temperature situation in Manipur is presented in Table 3.2.1.14.

Table 3.2.1.14. Seasonal and annual temperature in Manipur during 1975-2009

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.2 | 14.4 | 16.3 | 2.9 | 26.8 | 25.4 | 29.0 | 2.9 |
| Monsoon | 23.3 | 22.8 | 24.1 | 1.5 | 30.7 | 30.1 | 31.9 | 1.3 |
| Post-monsoon | 15.4 | 14.3 | 16.8 | 4.2 | 26.8 | 25.7 | 28.4 | 2.3 |
| Annual | 18.0 | 17.4 | 18.9 | 2.3 | 28.1 | 27.2 | 29.3 | 1.6 |

The normal annual minimum and maximum temperature were 18.0$^0$C and 28.1$^0$C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Tripura*

The monthly temperature situation in Tripura is presented in Table 3.2.1.15.

In Tripura, the normal minimum temperature was highest (23.2$^0$C) in the month of August and followed by July, June and September. The lowest normal minimum temperature was registered in January (9.2$^0$C). The variation in minimum temperature was higher in the months of December and January. The highest normal maximum temperature was registered in the month of June (30.6$^0$C), followed by August and May. The variations in maximum temperature were comparatively higher in the months of February and April.

Table 3.2.1.15. Monthly temperature in Tripura during 1975-2009

| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.2 | 7.9 | 11.0 | 8.4 | 22.9 | 21.2 | 24.7 | 4.0 |
| February | 11.6 | 10.1 | 14.2 | 8.3 | 25.3 | 22.9 | 28.3 | 4.7 |
| March | 15.7 | 14.1 | 17.3 | 5.9 | 28.7 | 25.3 | 30.9 | 4.1 |
| April | 19.1 | 16.8 | 21.3 | 4.6 | 30.1 | 27.5 | 32.2 | 4.2 |
| May | 21.0 | 19.7 | 22.3 | 3.1 | 30.4 | 28.6 | 32.6 | 3.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| June | 22.8 | 21.8 | 24.2 | 2.1 | 30.6 | 29.2 | 34.2 | 3.0 |
| July | 23.1 | 22.1 | 24.0 | 1.9 | 30.1 | 29.1 | 31.2 | 1.6 |
| August | 23.2 | 22.0 | 23.9 | 1.8 | 30.5 | 29.7 | 31.5 | 1.4 |
| September | 22.5 | 21.5 | 25.9 | 3.2 | 30.1 | 29.0 | 31.3 | 1.9 |
| October | 20.1 | 18.7 | 21.5 | 3.6 | 29.3 | 28.2 | 30.5 | 1.9 |
| November | 15.5 | 13.9 | 17.6 | 5.8 | 27.2 | 26.0 | 28.5 | 2.1 |
| December | 10.8 | 8.5 | 12.9 | 8.6 | 24.2 | 23.0 | 25.5 | 2.9 |

Table 3.2.1.16. Seasonal and annual temperature in Tripura during 1975-2009

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.3 | 14.5 | 16.5 | 3.1 | 27.5 | 26.1 | 28.9 | 2.6 |
| Monsoon | 22.9 | 21.9 | 24.1 | 1.9 | 30.3 | 29.9 | 31.5 | 1.2 |
| Post-monsoon | 15.5 | 14.6 | 16.8 | 3.6 | 26.9 | 26.1 | 27.8 | 1.7 |
| Annual | 17.9 | 17.2 | 18.7 | 2.2 | 28.2 | 27.5 | 29.1 | 1.3 |

Table 3.2.1.17. Monthly temperature in Mizoram during 1975-2009

| Month | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| January | 9.3 | 7.9 | 11.0 | 8.0 | 22.4 | 20.7 | 24.2 | 4.1 |
| February | 11.8 | 10.3 | 14.2 | 8.0 | 24.9 | 22.5 | 27.9 | 4.8 |
| March | 15.8 | 14.2 | 17.3 | 5.9 | 28.5 | 26.3 | 30.6 | 3.6 |
| April | 19.1 | 16.9 | 21.3 | 4.5 | 29.8 | 27.1 | 31.9 | 3.9 |
| May | 21.1 | 19.8 | 22.3 | 3.0 | 30.0 | 27.8 | 31.9 | 3.2 |
| June | 23.0 | 22.1 | 24.3 | 2.0 | 30.4 | 28.9 | 34.0 | 3.0 |
| July | 23.3 | 22.6 | 24.1 | 1.7 | 30.1 | 29.1 | 31.3 | 1.7 |
| August | 23.3 | 22.4 | 24.1 | 1.6 | 30.5 | 29.6 | 31.7 | 1.5 |
| September | 22.6 | 21.5 | 23.6 | 1.8 | 30.0 | 28.8 | 31.2 | 1.9 |
| October | 20.2 | 18.9 | 21.6 | 3.5 | 29.2 | 28.0 | 30.4 | 1.9 |
| November | 15.6 | 14.0 | 17.7 | 5.8 | 26.8 | 25.9 | 27.9 | 2.1 |
| December | 10.9 | 8.6 | 12.9 | 8.4 | 23.8 | 22.6 | 25.3 | 3.1 |

The seasonal and annual temperature situation in Tripura is presented in Table 3.2.1.16. The normal annual minimum and maximum temperature were 17.9$^0$C and 28.2$^0$C, respectively. The variations in seasonal and annual minimum temperature were higher than the variations in maximum temperature.

*Minimum and maximum temperatures in Mizoram*

The monthly temperature situation in Mizoram is presented in Table 3.2.1.17. In Mizoram, the normal minimum temperature was highest (23.3$^0$C) in the month of July and August, followed by June. The lowest normal minimum temperature was registered in

January (9.3$^0$C). The variation in minimum temperature was higher in the months of December and February. The highest normal maximum temperature was in the month of August (30.5$^0$C), followed by June. The variation in maximum temperature was higher in the months of February and January.

The seasonal and annual temperature situation in Mizoram is presented in Table 3.2.1.18. The normal annual minimum and maximum temperature were 18.0$^0$C and 28.0$^0$C in Mizoram. The variations in seasonal and annual minimum temperature were comparatively higher than the variations in maximum temperature.

Table 3.2.1.18. Seasonal and annual temperature Mizoram during 1975-2009

| Season | Min. Temp. ($^0$C) | | | CV (%) | Max. Temp. ($^0$C) | | | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | Normal | Extremes | | | Normal | Extremes | | |
| | | Min | Max | | | Min | Max | |
| Pre-monsoon | 15.4 | 14.6 | 16.5 | 3.0 | 27.1 | 26.0 | 28.6 | 2.4 |
| Monsoon | 23.0 | 22.3 | 23.8 | 1.5 | 30.2 | 29.6 | 31.4 | 1.2 |
| Post-monsoon | 15.6 | 14.7 | 16.9 | 3.5 | 26.6 | 25.8 | 27.6 | 1.8 |
| Annual | 18.0 | 17.5 | 18.8 | 2.0 | 28.0 | 27.3 | 28.9 | 1.2 |

### 3.2.2 Trends in minimum and maximum temperatures

The linear trends for seasonal and annual minimum temperature in NEH of India are presented in Fig. 3.11 to 3.19 and the coefficients and their probabilities are presented in Table 3.2.2.1 and Table 3.2.2.2.

Table 3.2.2.1. Linear trend coefficients of seasonal minimum temperature in NEH of India

| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
|---|---|---|---|---|---|---|
| **Pre-monsoon** | | | | | | |
| | b | P | b | P | b | p |
| Sikkim | 0.01 | 0.76 | 0.06*** | 0.00 | 0.04** | 0.03 |
| Darjeeling | 0.01 | 0.87 | 0.06*** | 0.00 | 0.04*** | 0.00 |
| Meghalaya | 0.00 | 0.84 | 0.05** | 0.01 | 0.03*** | 0.00 |
| Arunachal | -0.01 | 0.55 | 0.05** | 0.01 | 0.03*** | 0.00 |
| Karbi Anglong | -0.01 | 0.49 | 0.04** | 0.02 | 0.03*** | 0.00 |
| Nagaland | -0.02 | 0.44 | 0.04** | 0.04 | 0.03*** | 0.00 |
| Manipur | -0.01 | 0.56 | 0.02 | 0.24 | 0.02*** | 0.00 |
| Tripura | 0.01 | 0.38 | 0.05** | 0.01 | 0.03*** | 0.00 |
| Mizoram | 0.01 | 0.72 | 0.05*** | 0.00 | 0.03*** | 0.00 |
| **Monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | b | P | b | p | b | p |
| Sikkim | -0.02 | 0.50 | 0.04** | 0.02 | 0.04*** | 0.00 |
| Darjeeling | -0.02 | 0.47 | 0.07** | 0.01 | 0.04*** | 0.00 |
| Meghalaya | 0.01 | 0.57 | 0.05** | 0.01 | 0.03*** | 0.00 |
| Arunachal | 0.00 | 0.97 | 0.09** | 0.05 | 0.05*** | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Karbi Anglong | 0.01 | 0.61 | 0.04*** | 0.00 | 0.02*** | 0.00 |
| Nagaland | 0.00 | 0.97 | 0.03** | 0.02 | 0.02*** | 0.00 |
| Manipur | 0.01 | 0.66 | 0.02 | 0.31 | 0.01** | 0.02 |
| Tripura | 0.01 | 0.70 | 0.05*** | 0.00 | 0.03*** | 0.00 |
| Mizoram | 0.01 | 0.60 | 0.04*** | 0.00 | 0.02*** | 0.00 |
| **Post-monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | b | P | b | p | b | p |
| Sikkim | 0.01 | 0.72 | 0.08*** | 0.00 | 0.03*** | 0.00 |
| Darjeeling | 0.02 | 0.57 | 0.07** | 0.01 | 0.03*** | 0.00 |
| Meghalaya | 0.02 | 0.42 | 0.05** | 0.03 | 0.03*** | 0.00 |
| Arunachal | 0.00 | 1.00 | 0.07** | 0.02 | 0.04*** | 0.00 |
| Karbi Anglong | 0.01 | 0.85 | 0.05** | 0.03 | 0.03*** | 0.00 |
| Nagaland | -0.01 | 0.71 | 0.04** | 0.05 | 0.03*** | 0.00 |
| Manipur | 0.01 | 0.66 | 0.02 | 0.31 | 0.01** | 0.02 |
| Tripura | 0.00 | 0.89 | 0.03 | 0.34 | 0.03** | 0.02 |
| Mizoram | 0.01 | 0.63 | 0.04** | 0.02 | 0.03*** | 0.00 |

** & *** indicates significance at 5% and 1% level, respectively

Majority of the states have experienced increase in minimum seasonal temperatures during the period of 1975-2009 but the trends were insignificant. It is alarming that the trends for minimum temperatures for pre-monsoon and monsoon seasons were positive and significant during 1990-2009, except Manipur where the trend is insignificant. For post-monsoon season, the trends were positive and significant for all the states during 1990-2009, except Manipur and Tripura where the trends are insignificant. The trends for seasonal minimum temperatures turned out to be positive and significant for all the states for all the seasons during the study period of 1975-2009.

The trends for annual minimum temperature are positive and significant for the whole study period (1975-2009) in case of all the states. The trends for 1975-89 are positive but insignificant, except in Nagaland. The positive trends are significant for the period of 1990-2009, except Manipur.

The linear trends for seasonal and annual maximum temperature in NEH of India are presented in Fig. 3.20 to 3.28 and the coefficients and their probabilities are presented in Table 3.2.2.3 and Table 3.2.2.4.

Table 3.2.2.2. Linear trend coefficients of minimum temperature in NEH of India

| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
|---|---|---|---|---|---|---|
| | b | p | b | p | b | p |
| Sikkim | 0.00 | 0.96 | 0.06*** | 0.00 | 0.04*** | 0.00 |
| Darjeeling | 0.00 | 0.97 | 0.07*** | 0.00 | 0.04*** | 0.00 |
| Meghalaya | 0.01 | 0.56 | 0.05*** | 0.00 | 0.03*** | 0.00 |
| Arunachal | 0.00 | 0.79 | 0.07** | 0.01 | 0.04*** | 0.00 |
| Karbi Anglong | 0.00 | 0.98 | 0.04*** | 0.00 | 0.03*** | 0.00 |
| Nagaland | -0.01 | 0.52 | 0.04** | 0.01 | 0.03*** | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Manipur | 0.00 | 0.83 | 0.02 | 0.23 | 0.02*** | 0.00 |
| Tripura | 0.01 | 0.38 | 0.05*** | 0.00 | 0.03*** | 0.00 |
| Mizoram | 0.01 | 0.46 | 0.04*** | 0.00 | 0.03*** | 0.00 |

** & *** indicates significance at 5% and 1% level, respectively

Table 3.2.2.3. Linear trend coefficients of seasonal maximum temperature in NEH of India

| Pre-monsoon | | | | | | |
|---|---|---|---|---|---|---|
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | B | p | b | p | b | p |
| Sikkim | 0.02 | 0.69 | 0.01 | 0.78 | -0.01 | 0.30 |
| Darjeeling | 0.03 | 0.46 | 0.00 | 0.91 | -0.02 | 0.17 |
| Meghalaya | -0.01 | 0.74 | 0.07** | 0.03 | 0.01 | 0.56 |
| Arunachal | -0.02 | 0.62 | 0.08** | 0.02 | 0.01 | 0.52 |
| Karbi Anglong | 0.01 | 0.72 | 0.09** | 0.01 | 0.02 | 0.16 |
| Nagaland | -0.02 | 0.65 | 0.09** | 0.01 | 0.02 | 0.27 |
| Manipur | -0.01 | 0.75 | 0.09** | 0.01 | 0.02 | 0.19 |
| Tripura | -0.03 | 0.45 | 0.05 | 0.08 | 0.00 | 0.80 |
| Mizoram | -0.02 | 0.61 | 0.04 | 0.15 | 0.00 | 0.97 |
| **Monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | B | P | b | p | b | p |
| Sikkim | 0.01 | 0.80 | 0.02 | 0.11 | 0.01 | 0.12 |
| Darjeeling | 0.01 | 0.61 | 0.01 | 0.50 | 0.01 | 0.41 |
| Meghalaya | 0.00 | 0.95 | 0.06*** | 0.00 | 0.02*** | 0.00 |
| Arunachal | -0.01 | 0.74 | 0.06*** | 0.00 | 0.02*** | 0.00 |
| Karbi Anglong | 0.01 | 0.56 | 0.06*** | 0.00 | 0.03*** | 0.00 |
| Nagaland | -0.01 | 0.57 | 0.06*** | 0.00 | 0.02*** | 0.00 |
| Manipur | 0.00 | 0.98 | 0.06*** | 0.00 | 0.03*** | 0.00 |
| Tripura | 0.00 | 0.85 | 0.03 | 0.09 | 0.01 | 0.06 |
| Mizoram | 0.00 | 0.83 | 0.03 | 0.05 | 0.01** | 0.02 |
| **Post-monsoon** | | | | | | |
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | b | P | b | p | b | p |
| Sikkim | 0.04 | 0.22 | -0.01 | 0.77 | 0.00 | 0.83 |
| Darjeeling | 0.05 | 0.14 | -0.02 | 0.34 | -0.01 | 0.36 |
| Meghalaya | 0.03 | 0.42 | 0.04** | 0.03 | 0.02** | 0.03 |
| Arunachal | 0.03 | 0.30 | 0.05** | 0.02 | 0.02** | 0.01 |
| Karbi Anglong | 0.01 | 0.76 | 0.05** | 0.02 | 0.02** | 0.02 |
| Nagaland | 0.04 | 0.27 | -0.05** | 0.03 | 0.03*** | 0.00 |
| Manipur | 0.03 | 0.27 | 0.05** | 0.03 | 0.03*** | 0.00 |
| Tripura | 0.00 | 0.93 | 0.02 | 0.32 | 0.01 | 0.49 |
| Mizoram | 0.01 | 0.65 | 0.03 | 0.12 | 0.01 | 0.22 |

** & *** indicates significance at 5% and 1% level, respectively

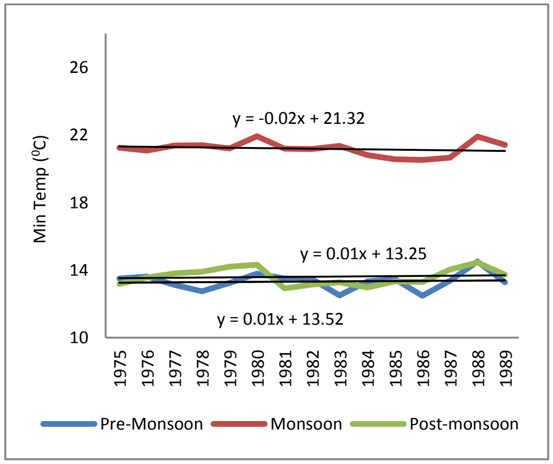



Fig. 11(a) Seasonal (1975-1989)

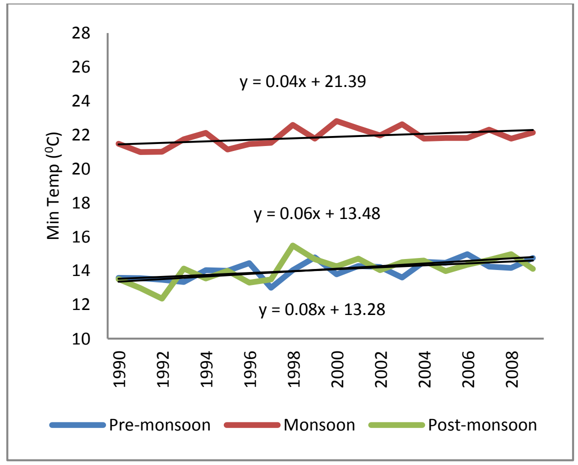



Fig. 11(b) Seasonal (1990-2009)

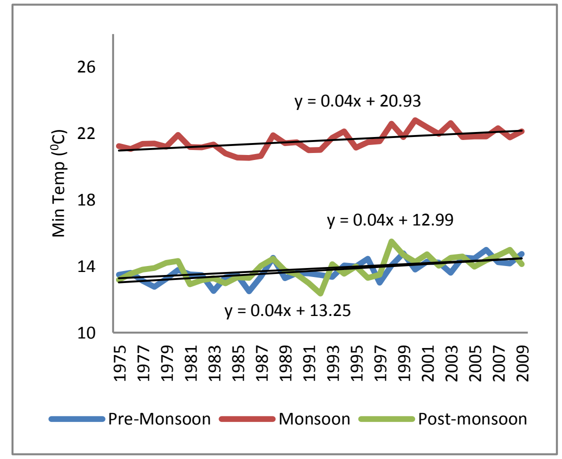



Fig. 11(c) Seasonal (1975-2009)

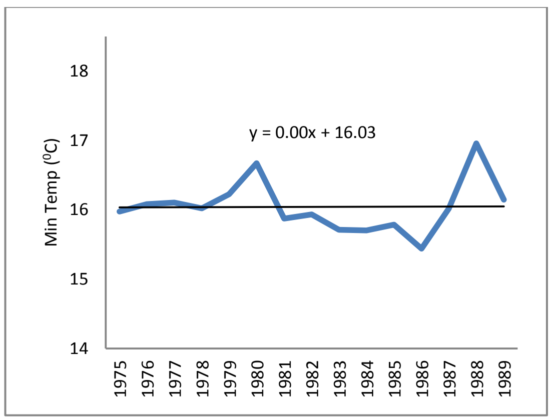



Fig. 11(d) Annual (1975-1989)

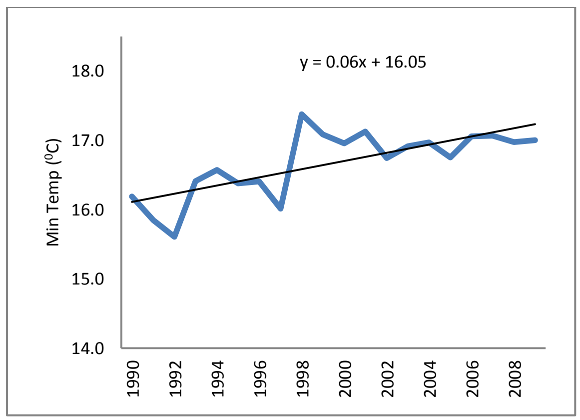



Fig. 11(e) Annual (1990-2009)

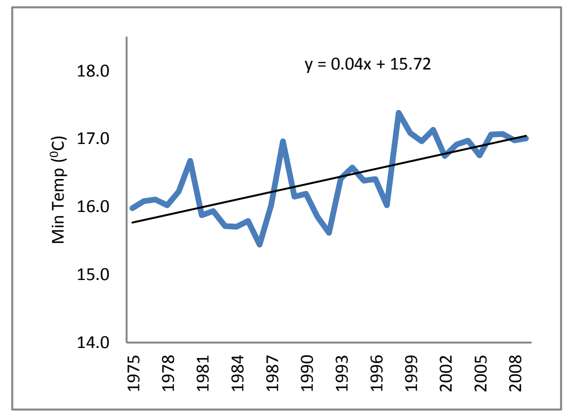



Fig. 11(f) Annual (1990-2009)

Fig. 3.11. Seasonal and annual minimum temperature in Sikkim

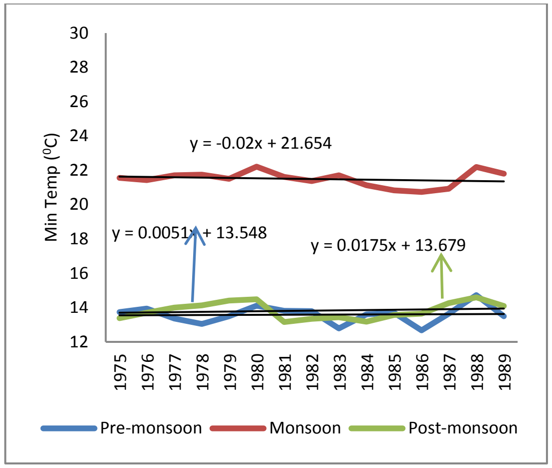



Fig. 12(a) Seasonal (1975-1989)

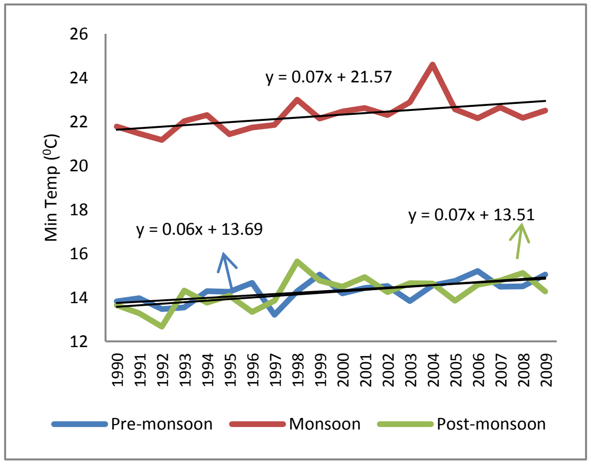



Fig. 12(b) Seasonal (1990-2009)

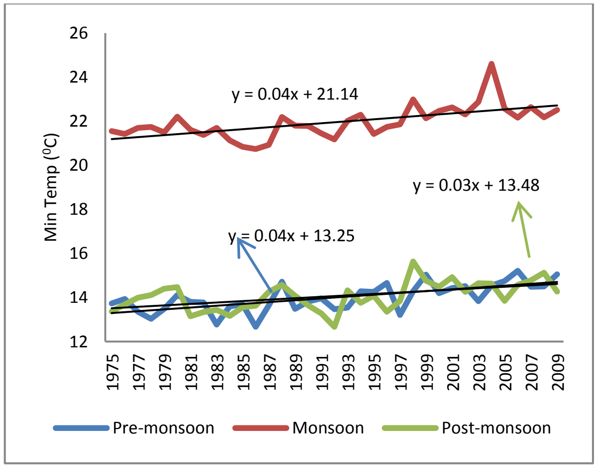



Fig. 12(c) Seasonal (1975-2009)

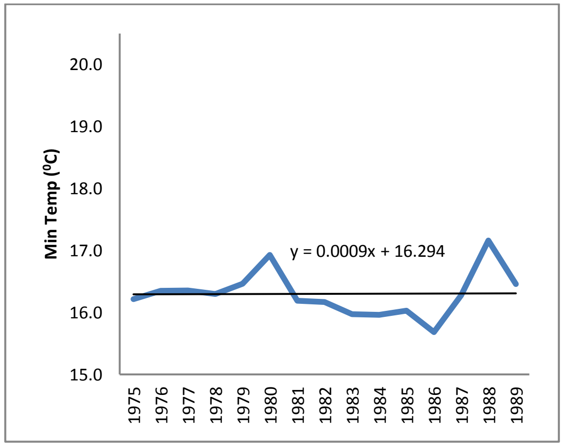



Fig. 12(d) Annual (1975-1989)

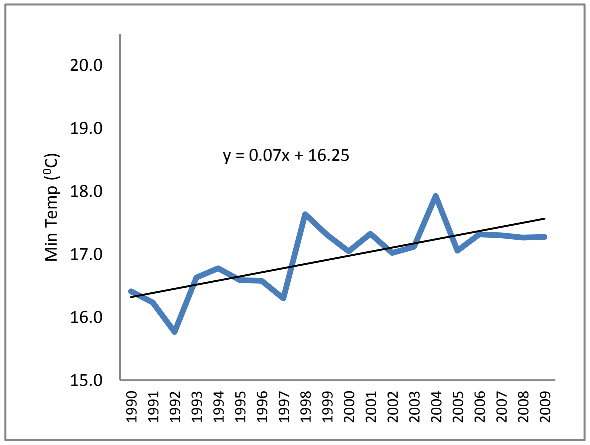



Fig. 12(e) Annual (1990-2009)

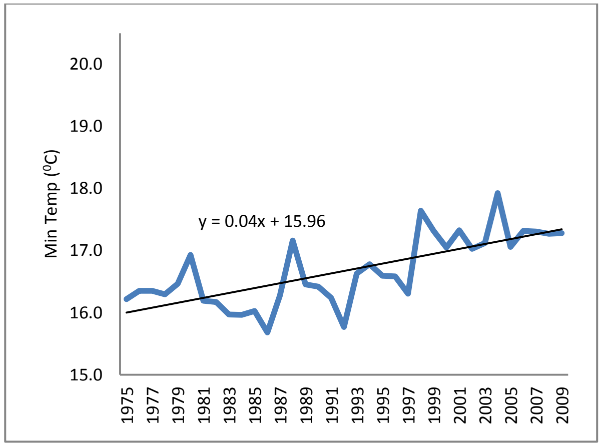



Fig. 12(f) Annual (1990-2009)

Fig. 3.12. Seasonal and annual minimum temperature in Darjeeling

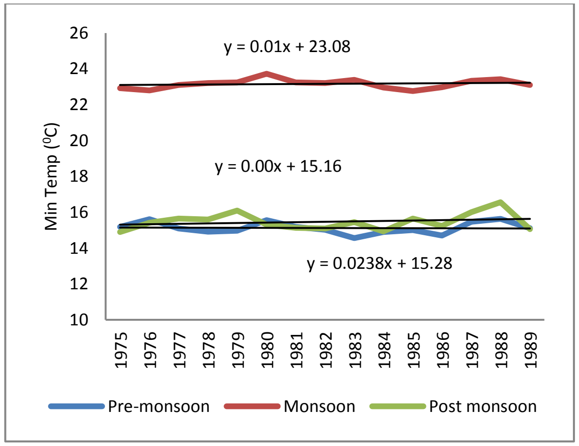



Fig. 13(a) Seasonal (1975-1989)

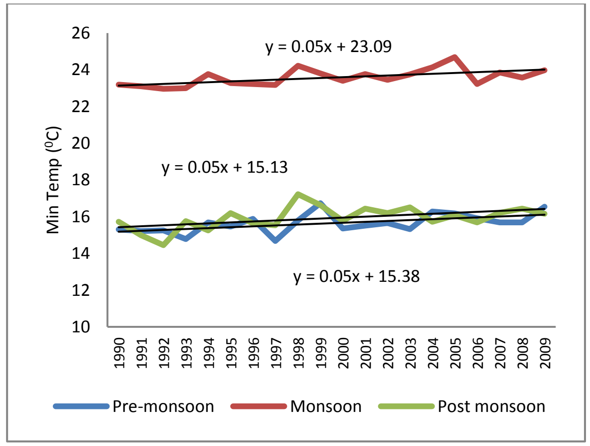



Fig. 13(b) Seasonal (1990-2009)

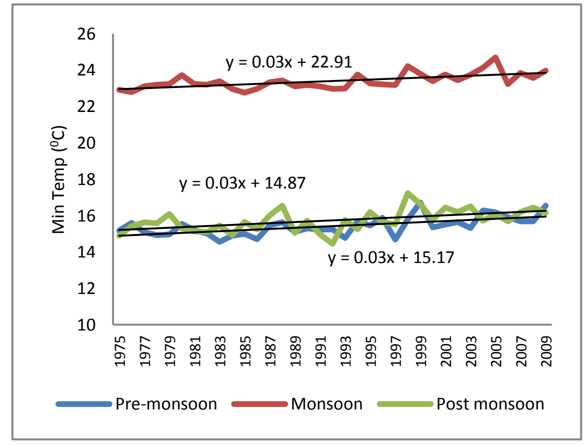



Fig. 13(c) Seasonal (1975-2009)

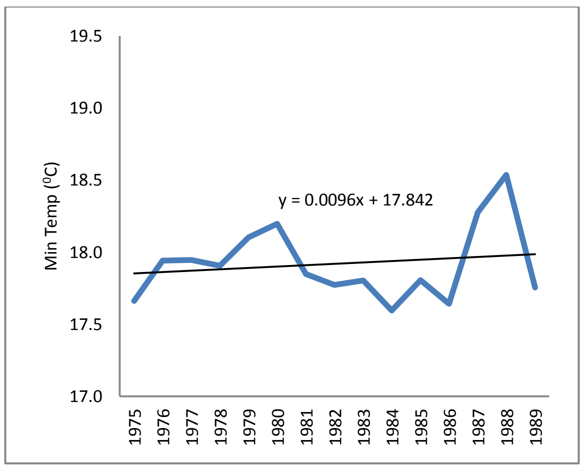



Fig. 13(d) Annual (1975-1989)

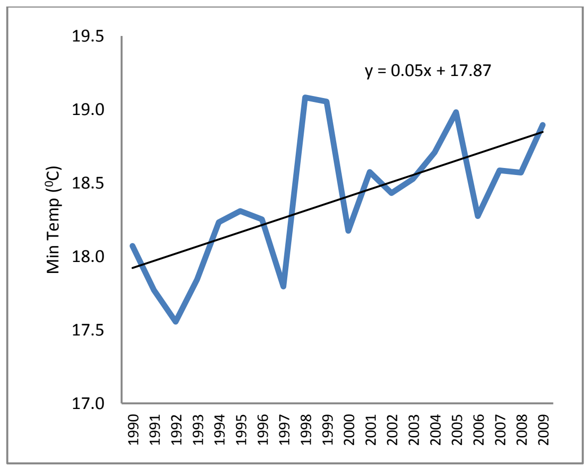



Fig. 13(e) Annual (1990-2009)

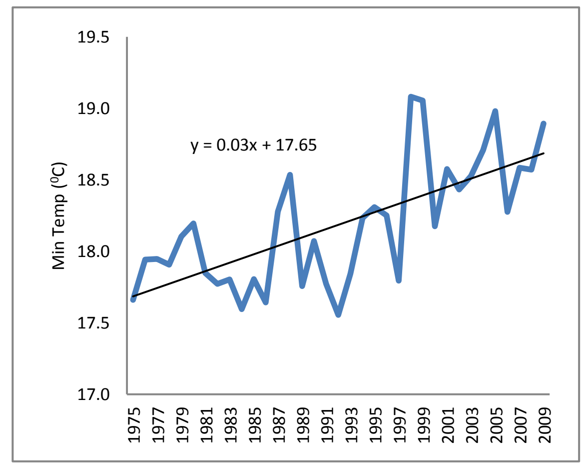



Fig. 13(f) Annual (1990-2009)

Fig. 3.13. Seasonal and annual minimum temperature in Meghalaya

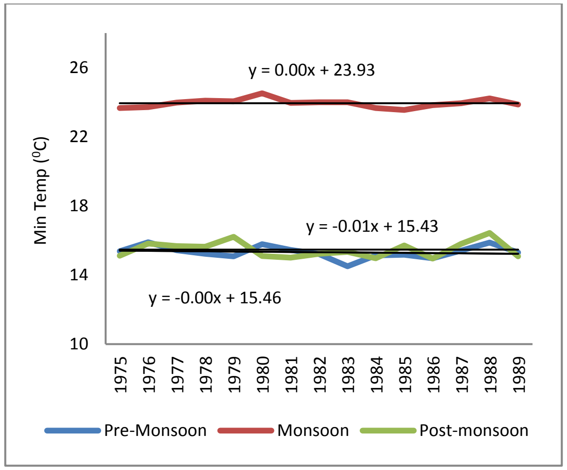



Fig. 14(a) Seasonal (1975-1989)

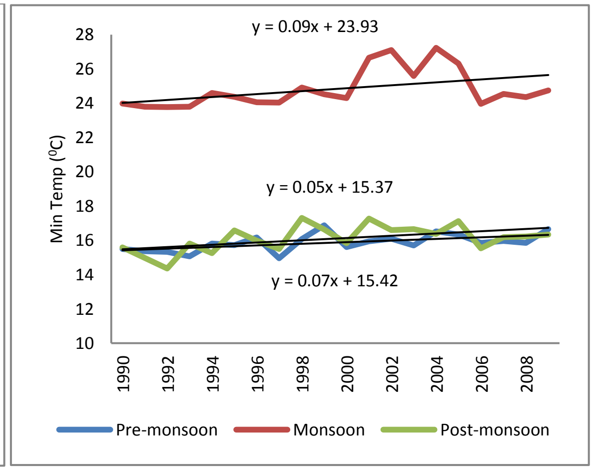



Fig. 14(b) Seasonal (1990-2009)

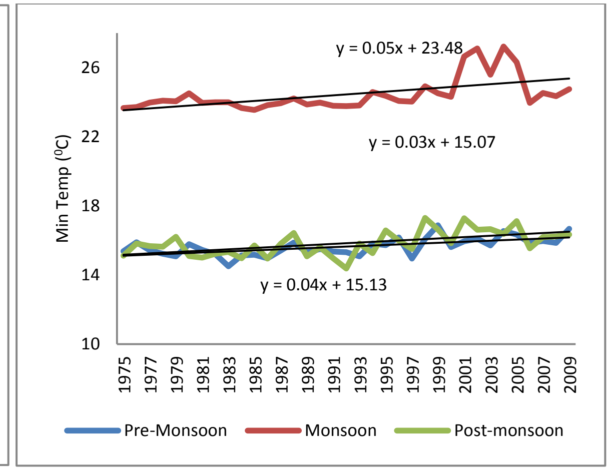



Fig. 14(c) Seasonal (1975-2009)

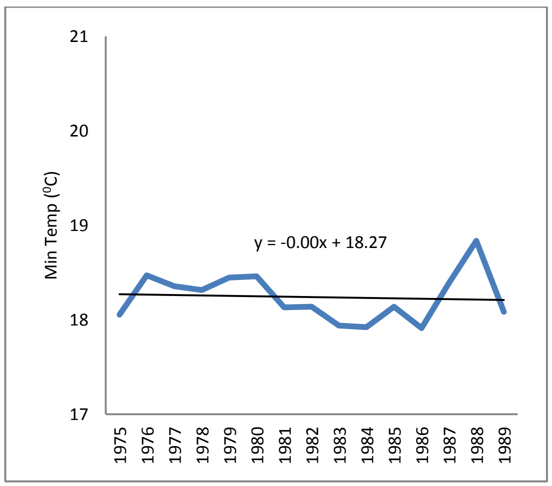



Fig. 14(d) Annual (1975-1989)

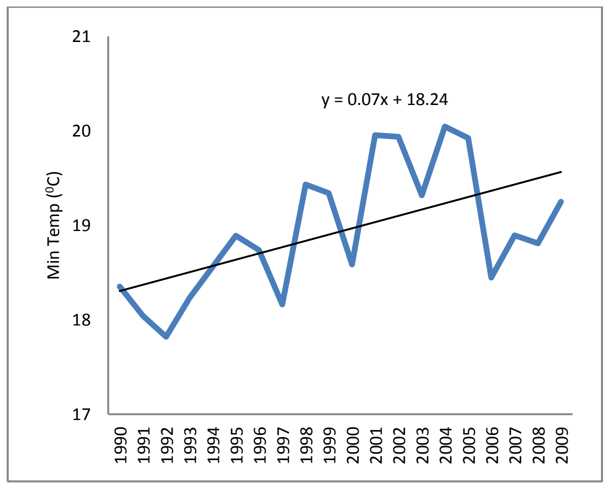



Fig. 14(e) Annual (1990-2009)

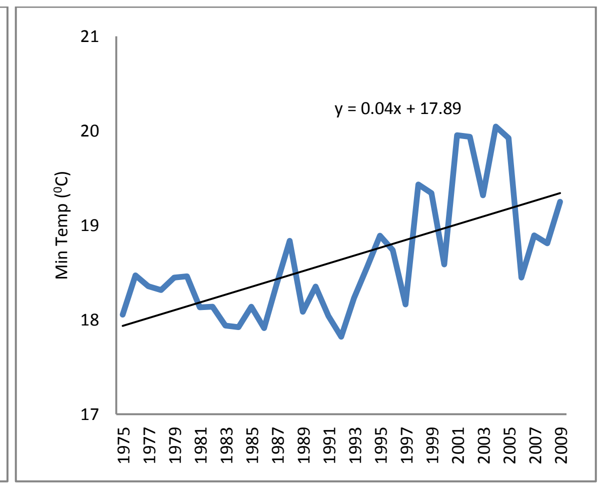



Fig. 14(f) Annual (1990-2009)

Fig. 3.14. Seasonal and annual minimum temperature in Arunachal Pradesh

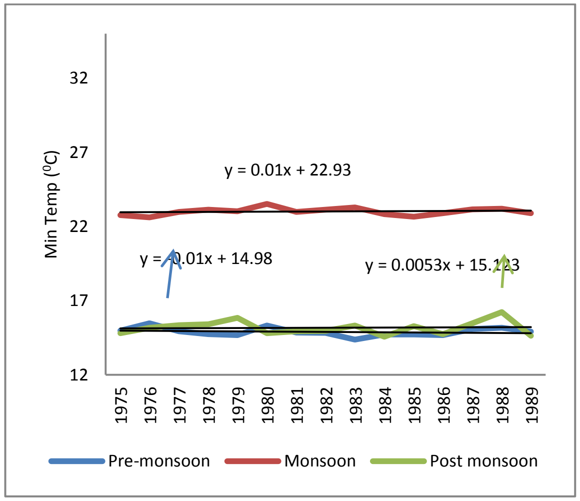



Fig. 15(a) Seasonal (1975-1989)

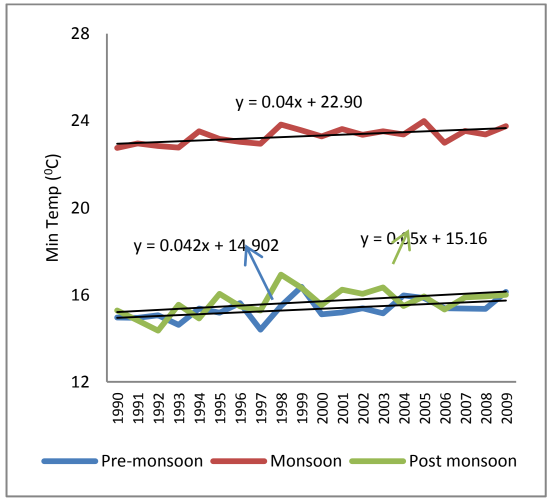



Fig. 15(b) Seasonal (1990-2009)

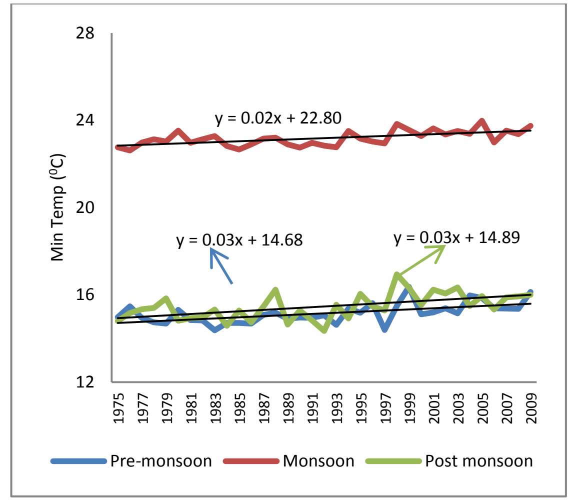



Fig. 15(c) Seasonal (1975-2009)

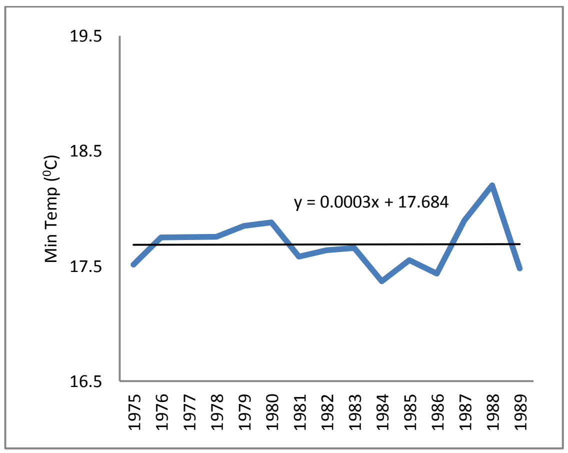



Fig. 15(d) Annual (1975-1989)

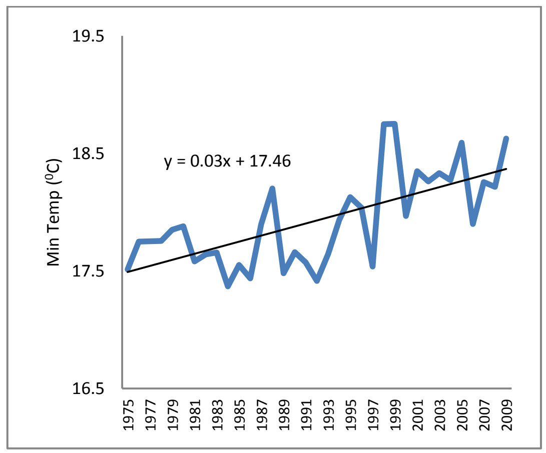



Fig. 15(e) Annual (1990-2009)

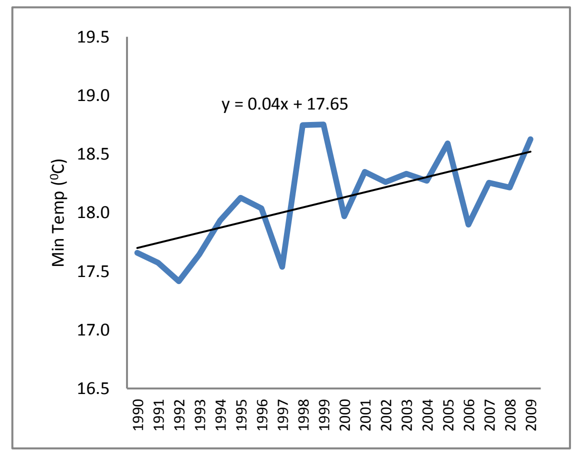



Fig. 15(f) Annual (1990-2009)

Fig. 3.15. Seasonal and annual minimum temperature in Karbi Anglong

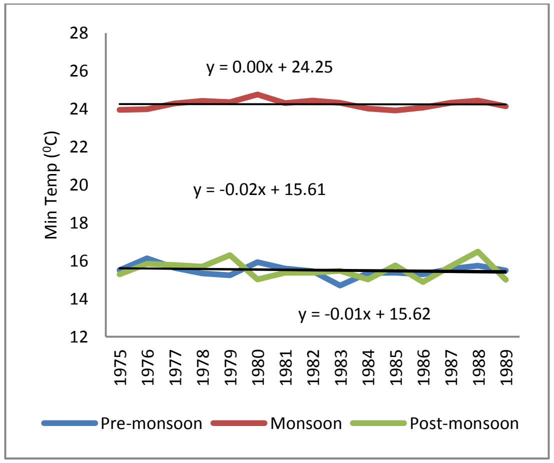



Fig. 16(a) Seasonal (1975-1989)

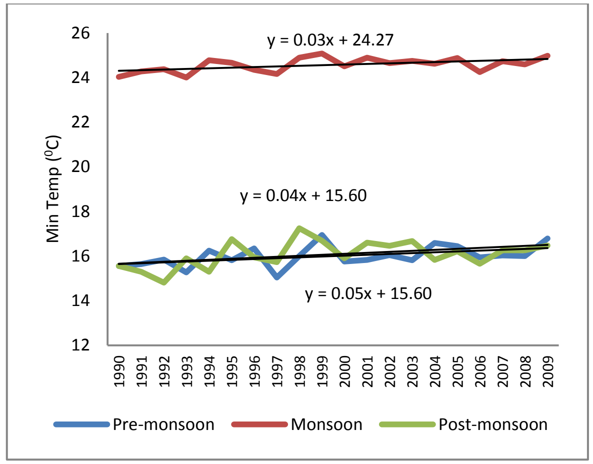



Fig. 16(b) Seasonal (1990-2009)

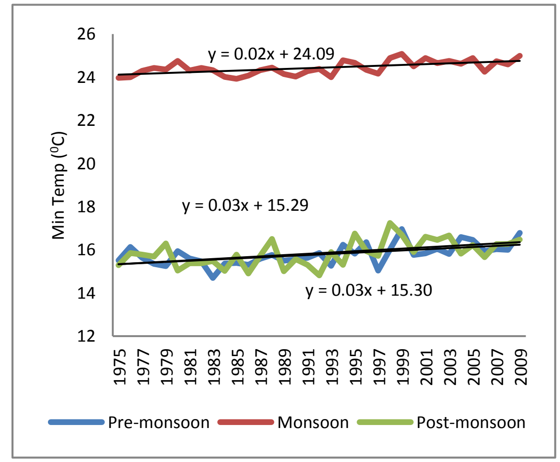



Fig. 16(c) Seasonal (1975-2009)

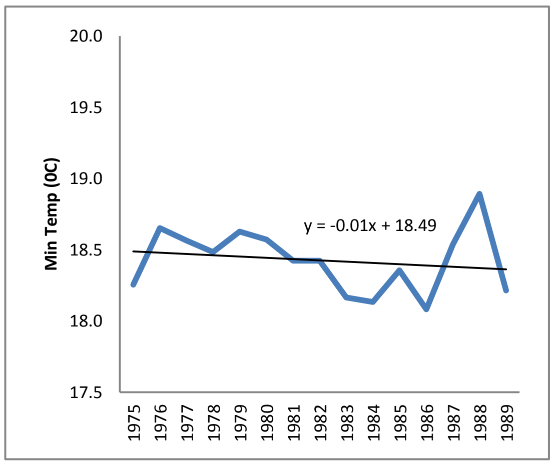



Fig. 16(d) Annual (1975-1989)

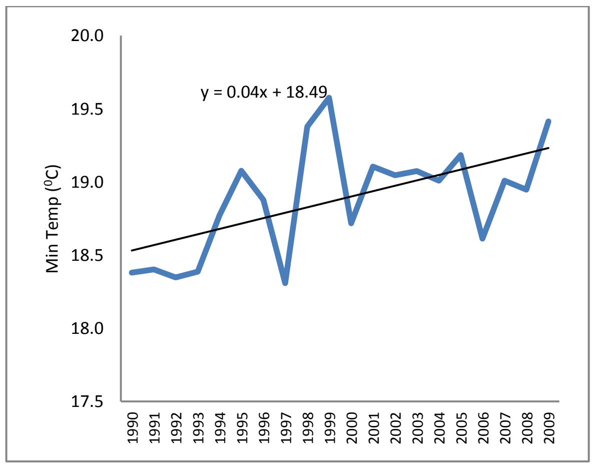



Fig. 16(e) Annual (1990-2009)

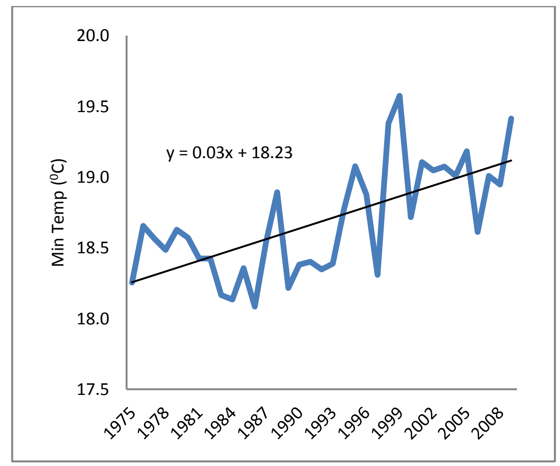



Fig. 16(f) Annual (1990-2009)

Fig. 3.16. Seasonal and annual minimum temperature in Nagaland

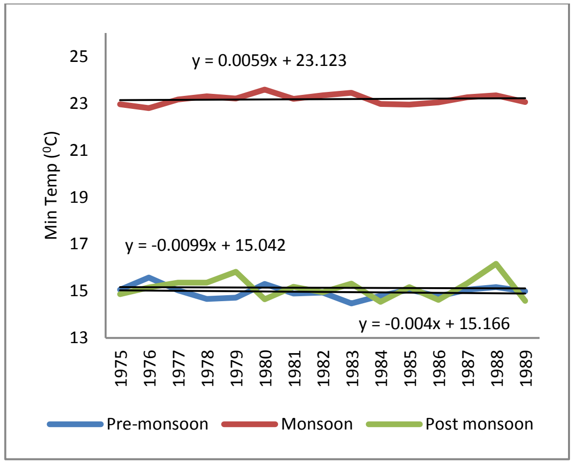



Fig. 17(a) Seasonal (1975-1989)

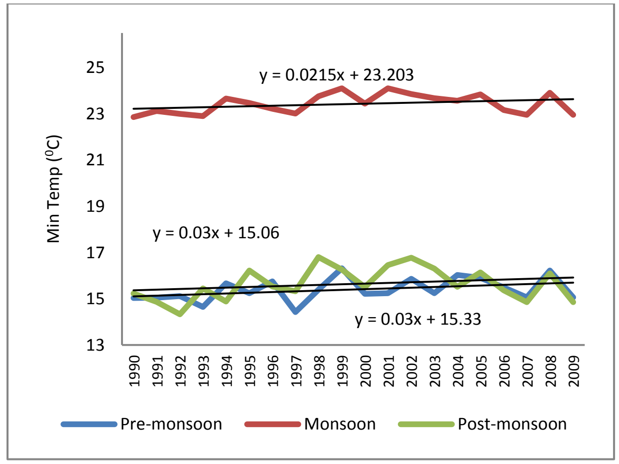



Fig. 17(b) Seasonal (1990-2009)

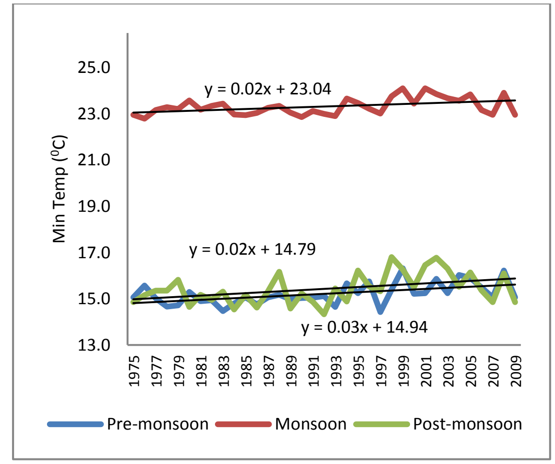



Fig. 17(c) Seasonal (1975-2009)

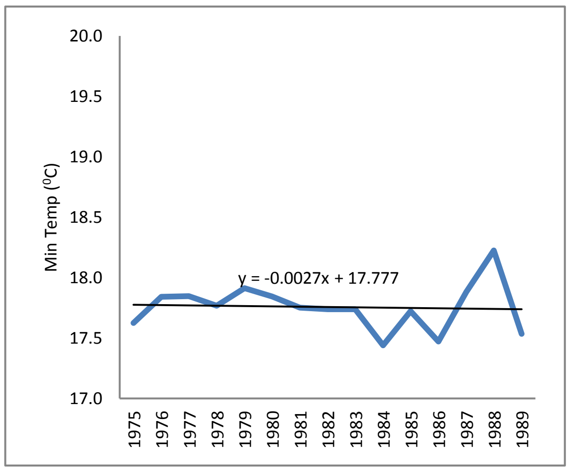



Fig. 17(d) Annual (1975-1989)

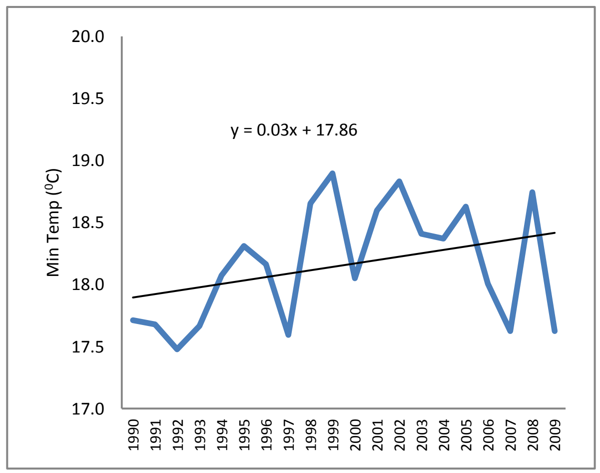



Fig. 17(e) Annual (1990-2009)

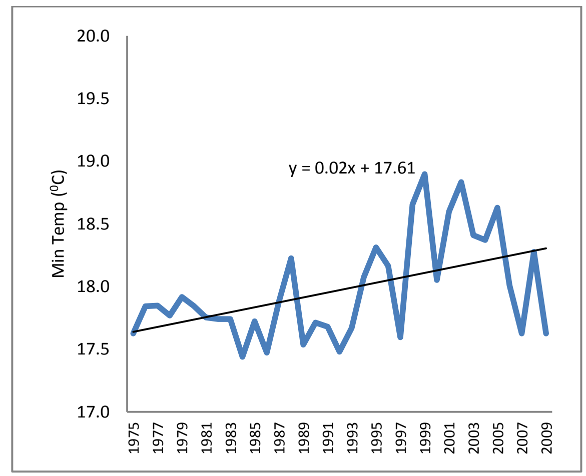



Fig.17(f) Annual (1990-2009)

Fig. 3.17. Seasonal and annual minimum temperature in Manipur

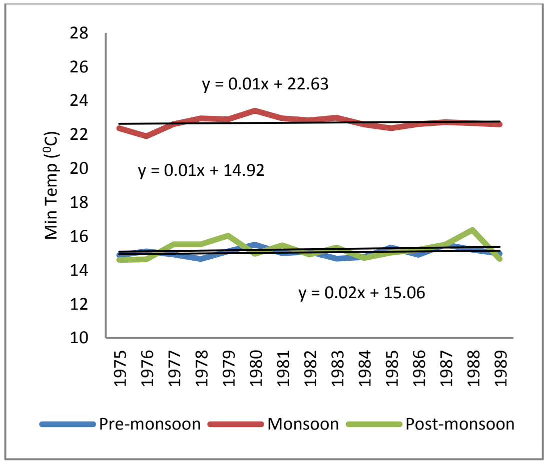



Fig. 18(a) Seasonal (1975-1989)

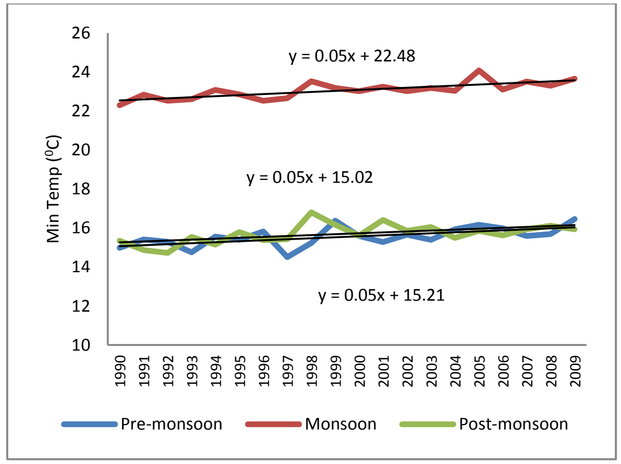



Fig. 18(b) Seasonal (1990-2009)

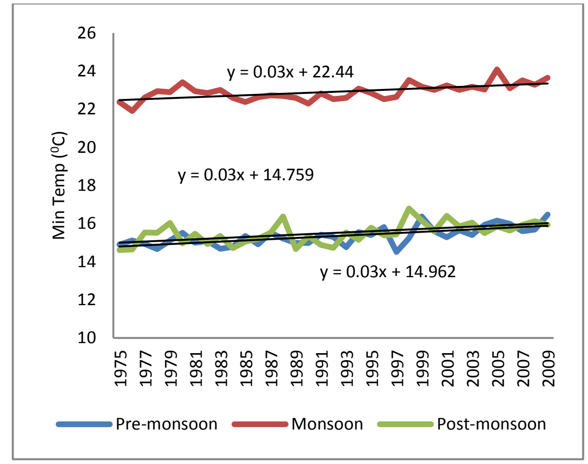



Fig. 18(c) Seasonal (1975-2009)

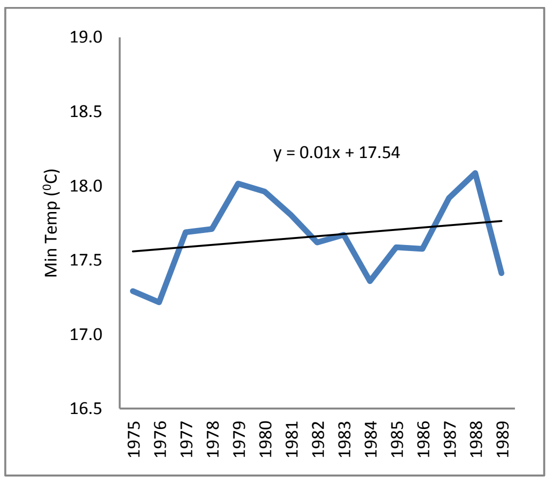



Fig. 18(d) Annual (1975-1989)

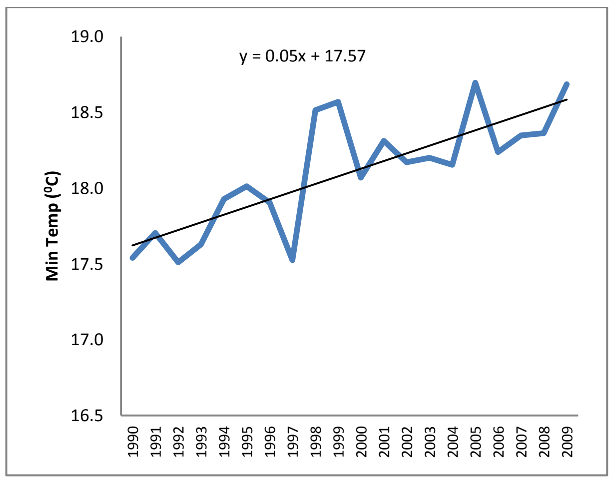



Fig. 18(e) Annual (1990-2009)

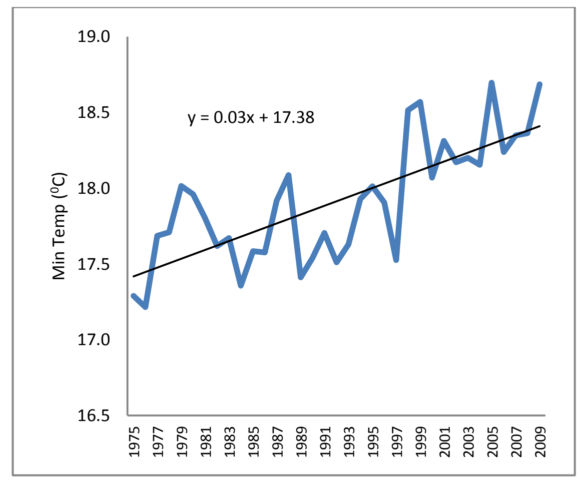



Fig.18(f) Annual (1990-2009)

Fig. 3.18. Seasonal and annual minimum temperature in Tripura

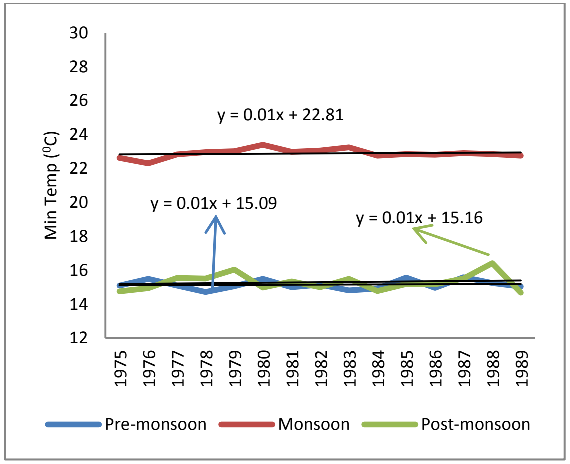



Fig. 19(a) Seasonal (1975-1989)

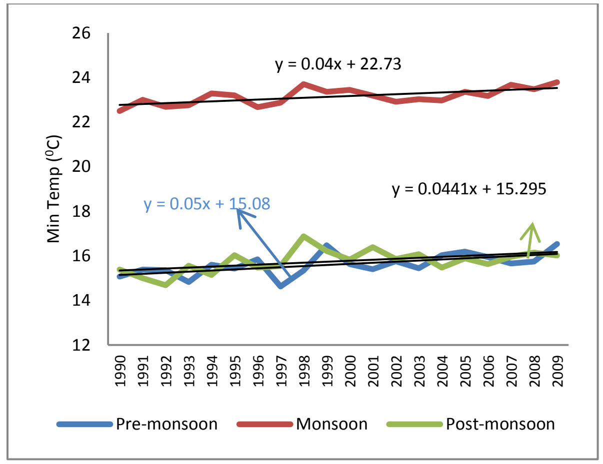



Fig. 19(b) Seasonal (1990-2009)

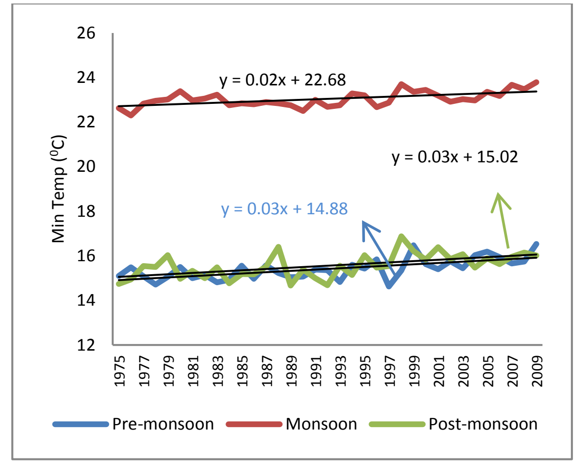



Fig. 19(c) Seasonal (1975-2009)

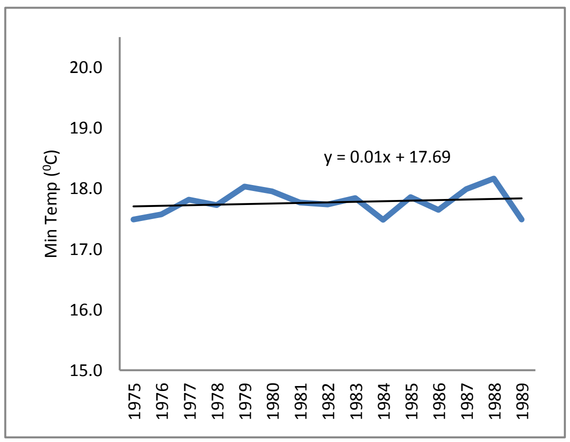



Fig. 19(d) Annual (1975-1989)

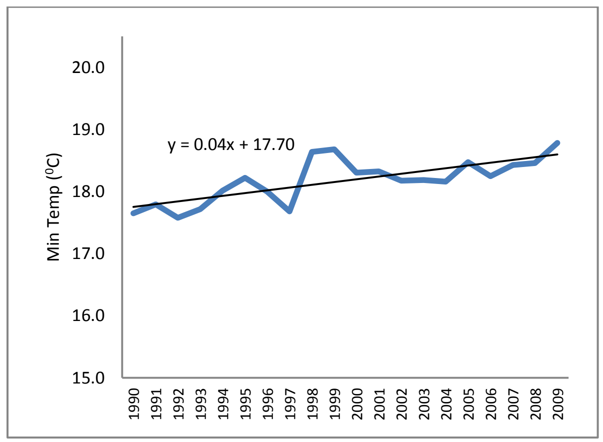



Fig. 19(e) Annual (1990-2009)

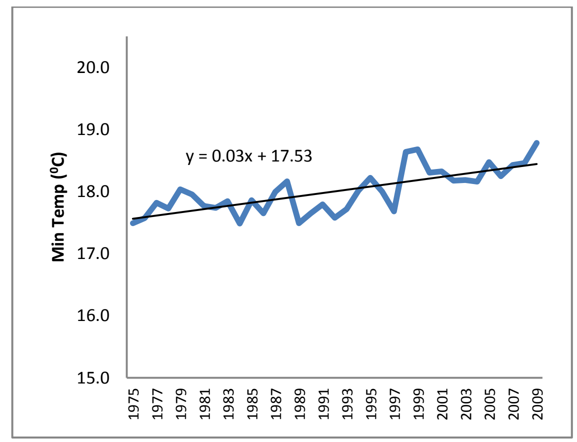



Fig. 19(f) Annual (1990-2009)

Fig. 3.19. Seasonal and annual minimum temperature in Mizoram

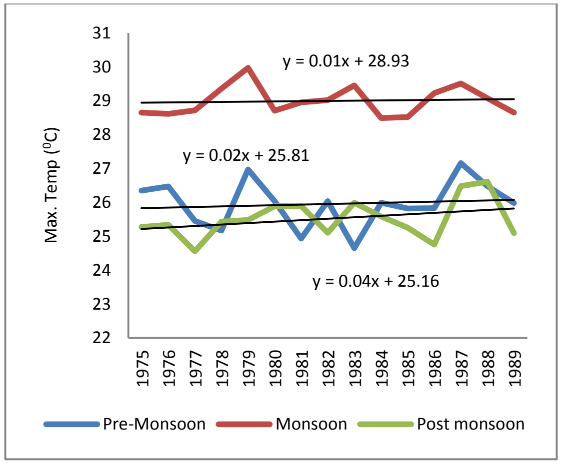



Fig. 20(a) Seasonal (1975-1989)

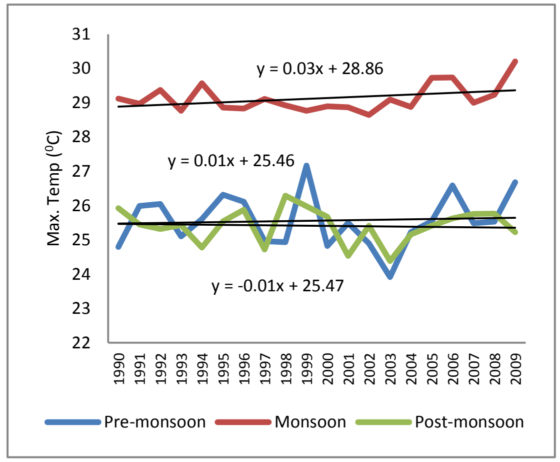



Fig. 20(b) Seasonal (1990-2009)

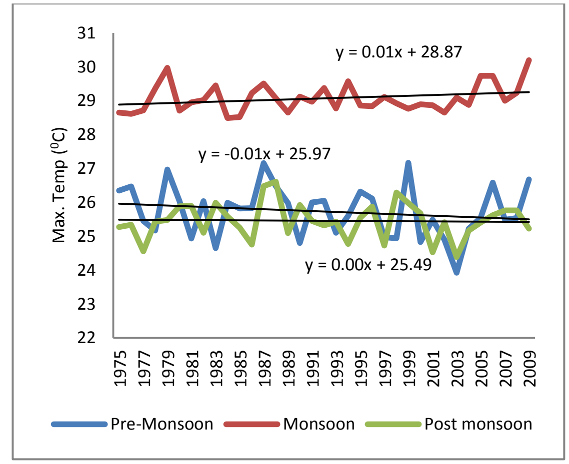



Fig. 20(c) Seasonal (1975-2009)

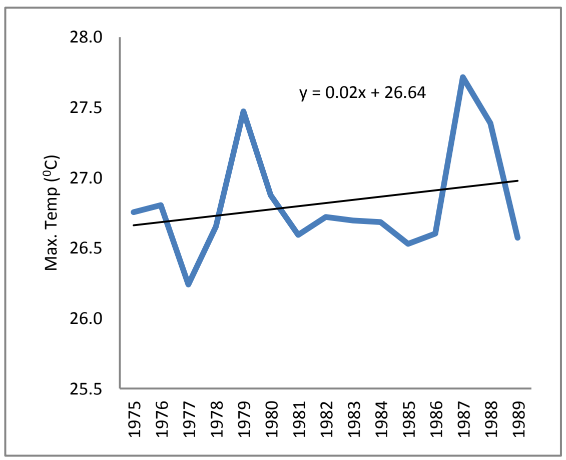



Fig. 20(d) Annual (1975-1989)

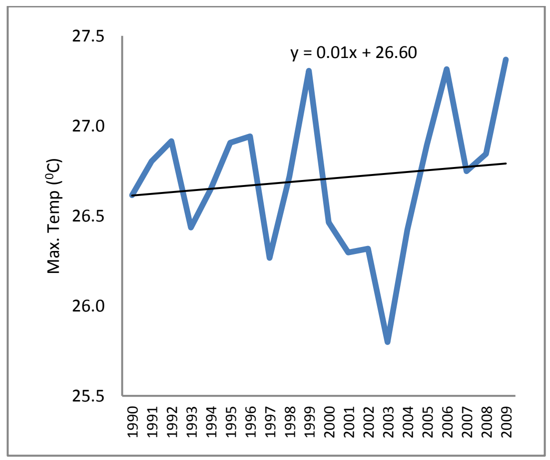



Fig. 20(e) Annual (1990-2009)

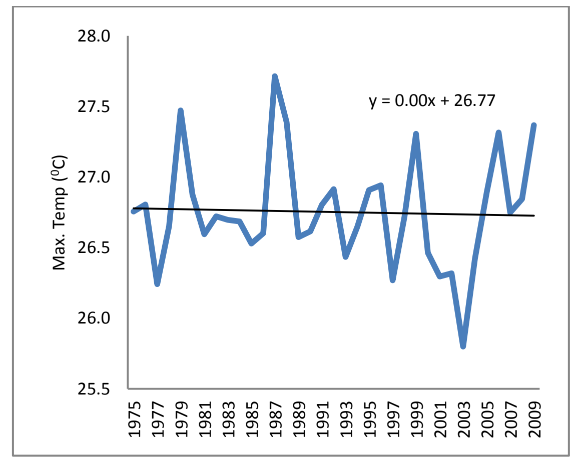



Fig.20(f) Annual (1975-2009)

Fig. 3.20. Seasonal and annual maximum temperature in Sikkim

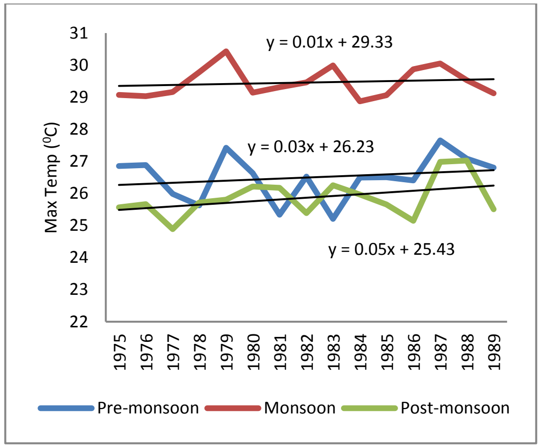



Fig. 21(a) Seasonal (1975-1989)

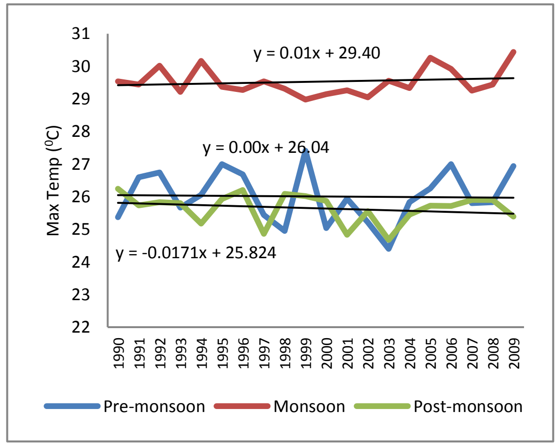



Fig. 21(b) Seasonal (1990-2009)

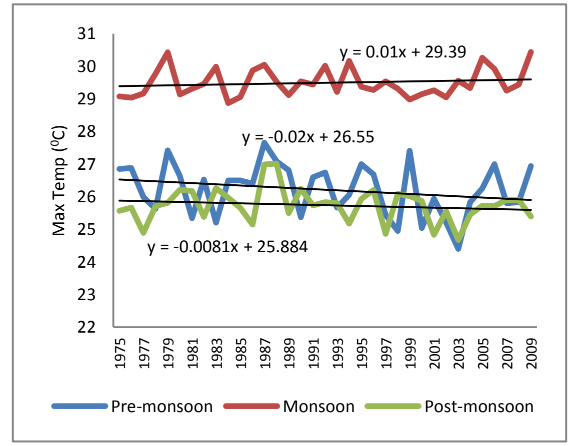



Fig. 21(c) Seasonal (1975-2009)

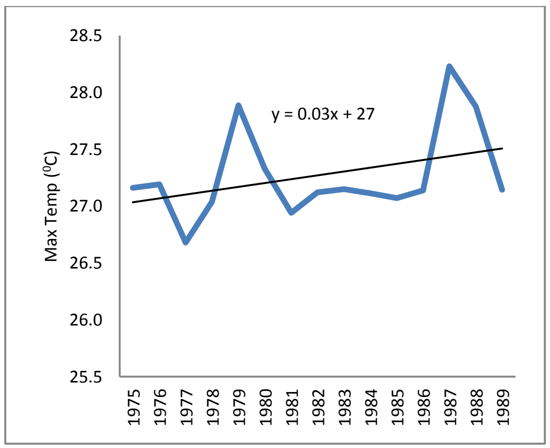



Fig. 21(d) Annual (1975-1989)

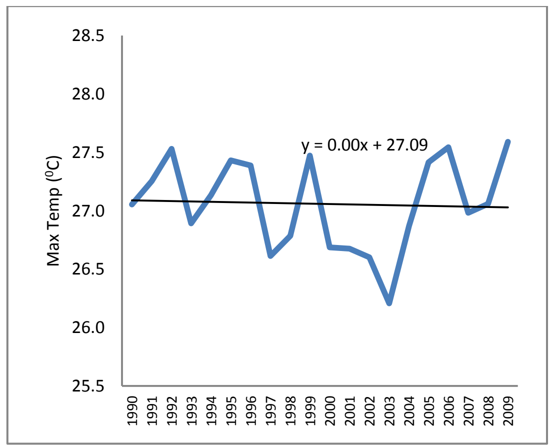



Fig. 21(e) Annual (1990-2009)

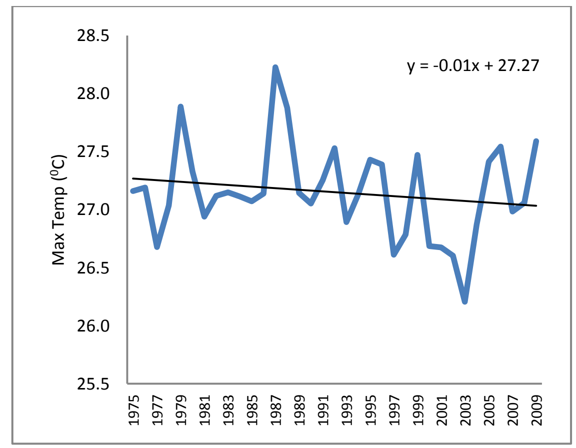



Fig.21(f) Annual (1975-2009)

Fig. 3.21. Seasonal and annual maximum temperature in Darjeeling

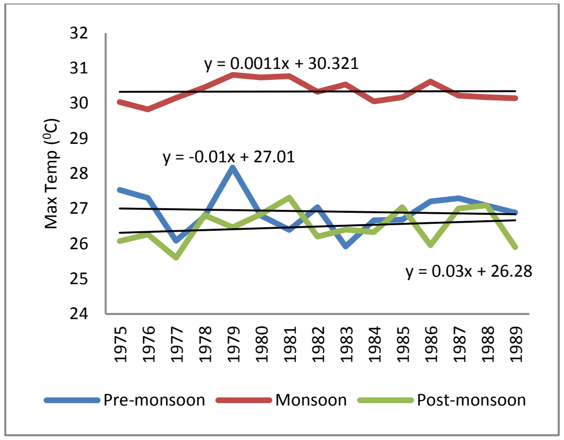



Fig. 22(a) Seasonal (1975-1989)

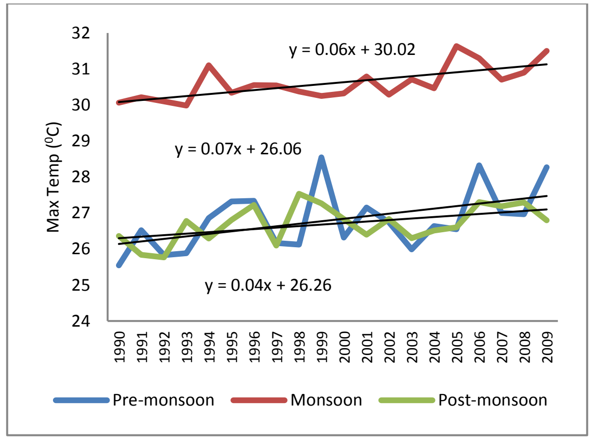



Fig. 22(b) Seasonal (1990-2009)

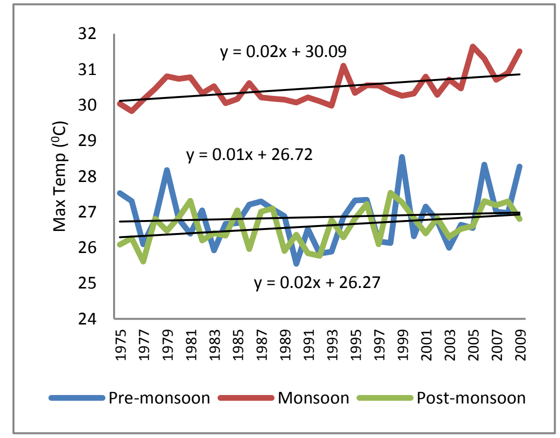



Fig. 22(c) Seasonal (1975-2009)

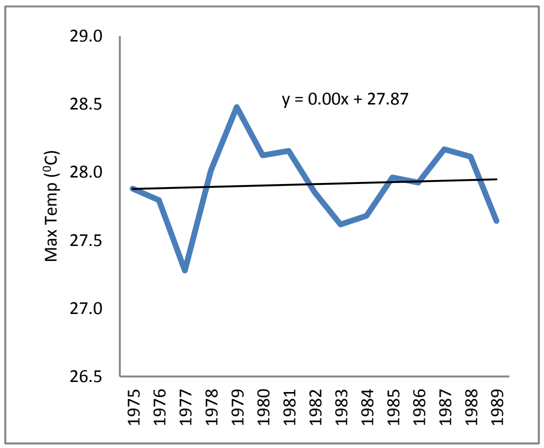



Fig. 22(d) Annual (1975-1989)

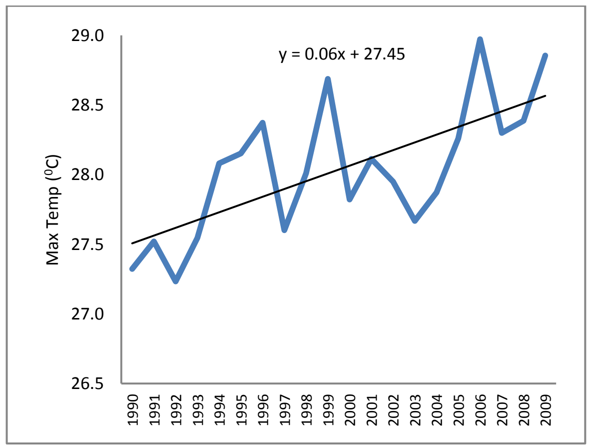



Fig. 22(e) Annual (1990-2009)

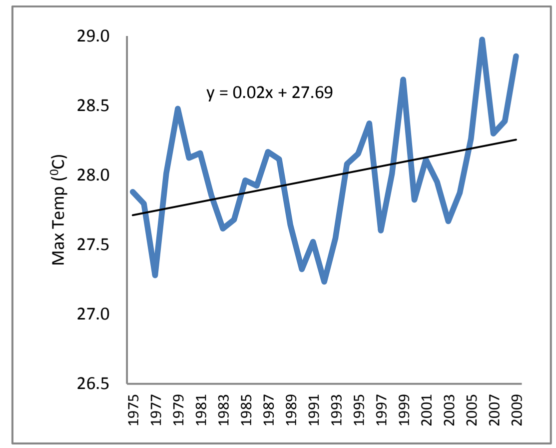



Fig.22(f) Annual (1975-2009)

Fig. 3.22. Seasonal and annual maximum temperature in Meghalaya

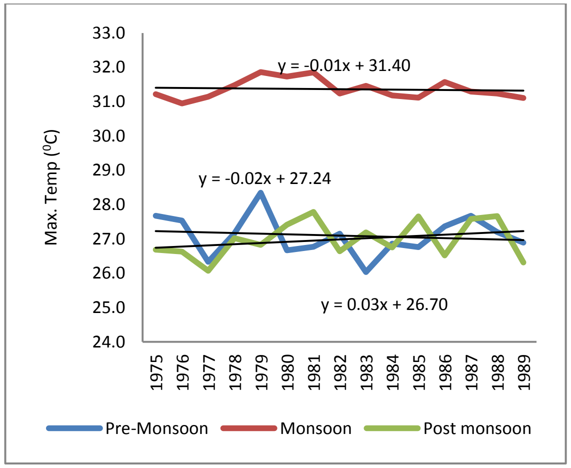



Fig. 23(a) Seasonal (1975-1989)

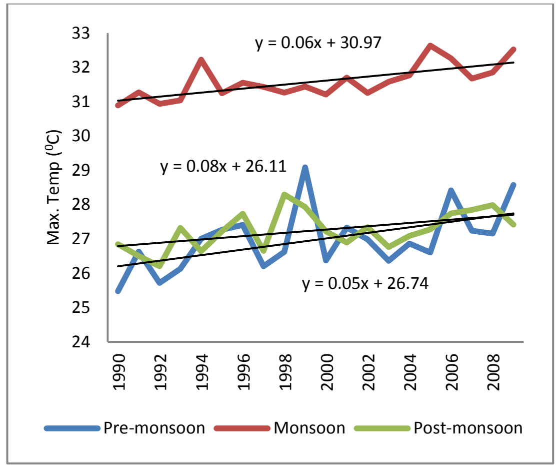



Fig. 23(b) Seasonal (1990-2009)

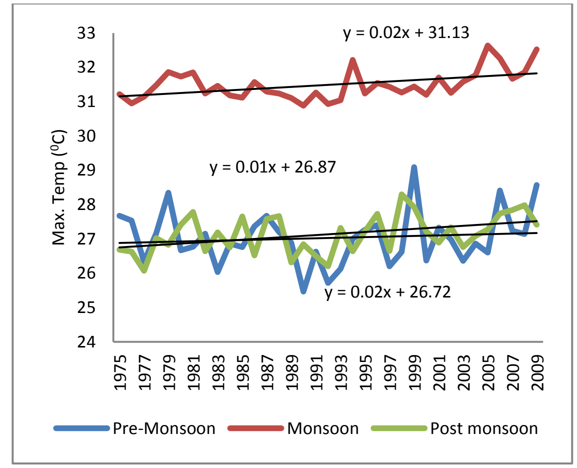



Fig. 23(c) Seasonal (1975-2009)

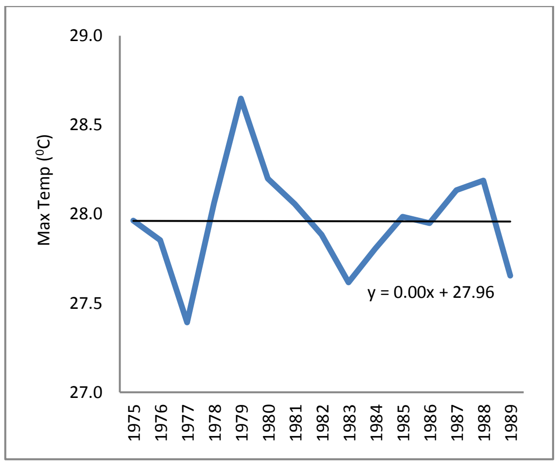



Fig. 23(d) Annual (1975-1989)

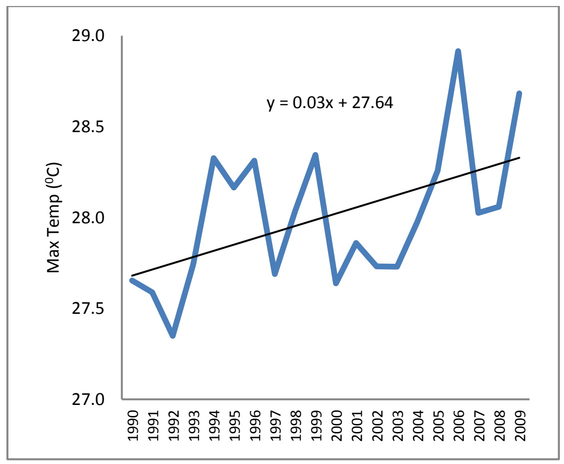



Fig. 23(e) Annual (1990-2009)

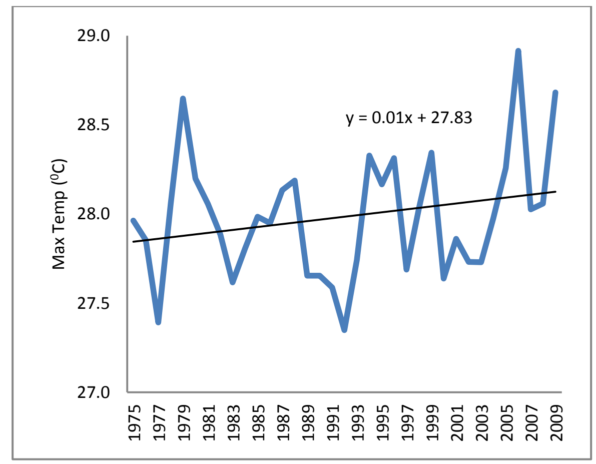



Fig. 23(f) Annual (1975-2009)

Fig. 3.23. Seasonal and annual maximum temperature in Arunachal Pradesh

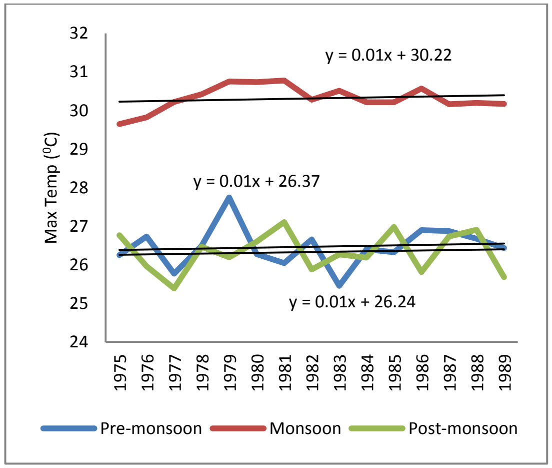



Fig. 24(a) Seasonal (1975-1989)

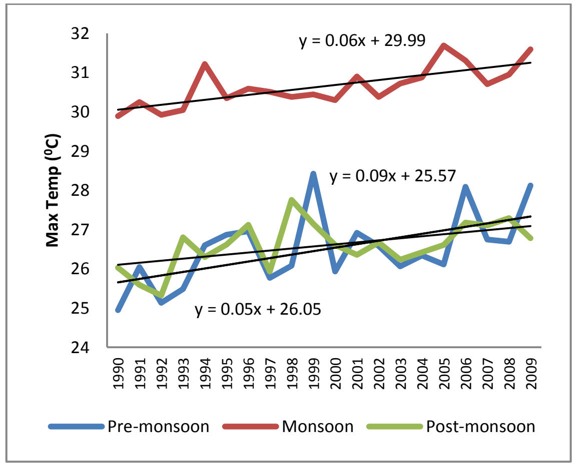



Fig. 24(b) Seasonal (1990-2009)

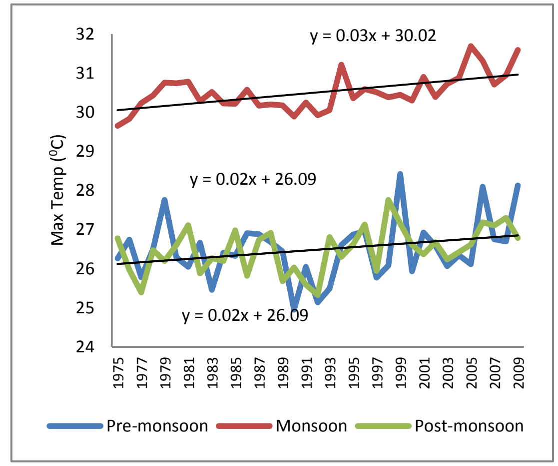



Fig. 24(c) Seasonal (1975-2009)

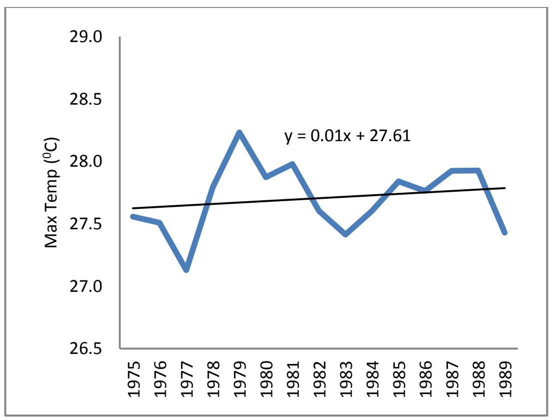



Fig. 24(d) Annual (1975-1989)

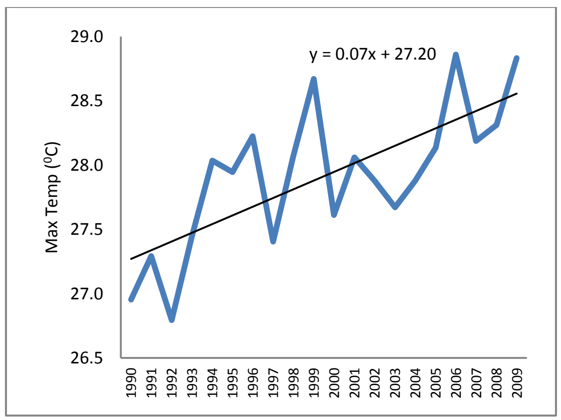



Fig. 24(e) Annual (1990-2009)

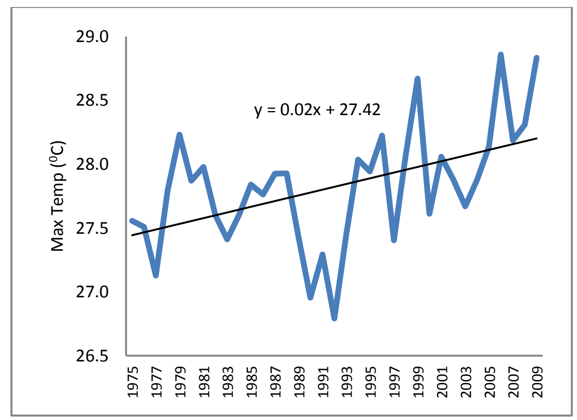



Fig.24(f) Annual (1975-2009)

Fig. 3.24. Seasonal and annual maximum temperature in Karbi Anglong

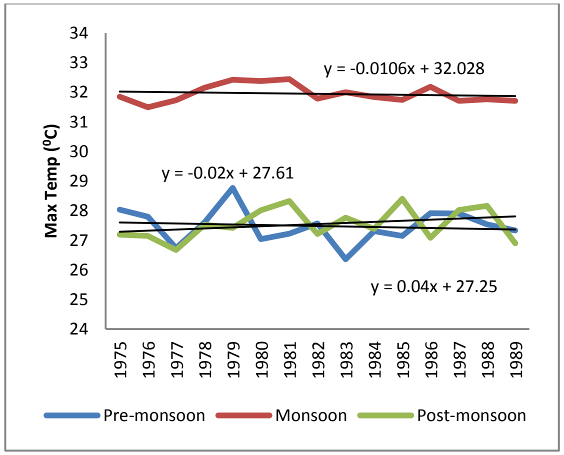



Fig. 25(a) Seasonal (1975-1989)

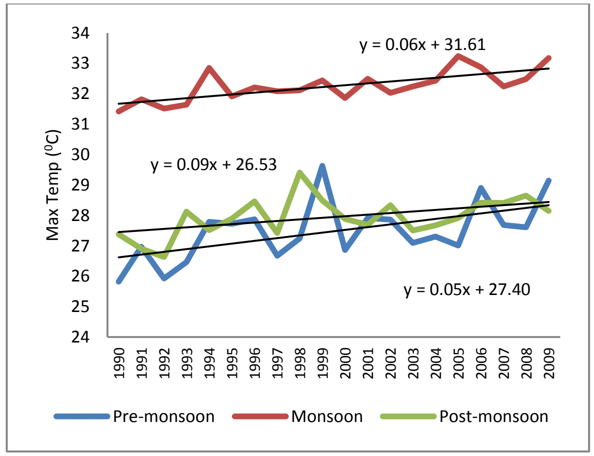



Fig. 25(b) Seasonal (1990-2009)

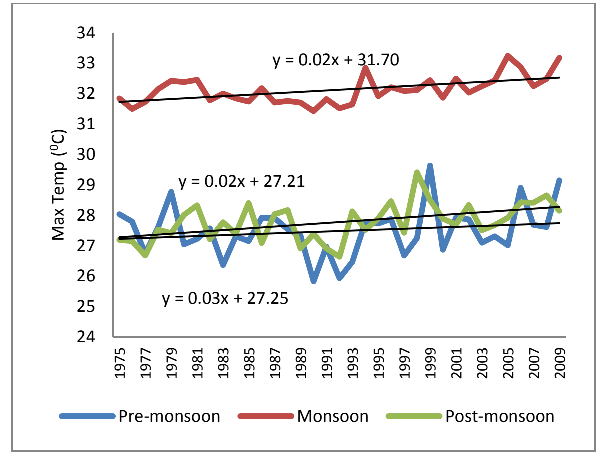



Fig. 25(c) Seasonal (1975-2009)

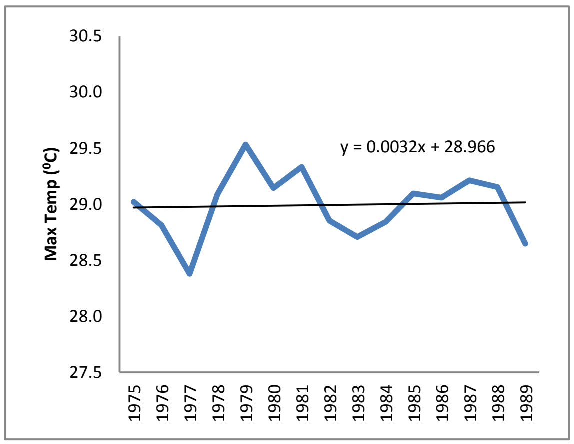



Fig. 25(d) Annual (1975-1989)

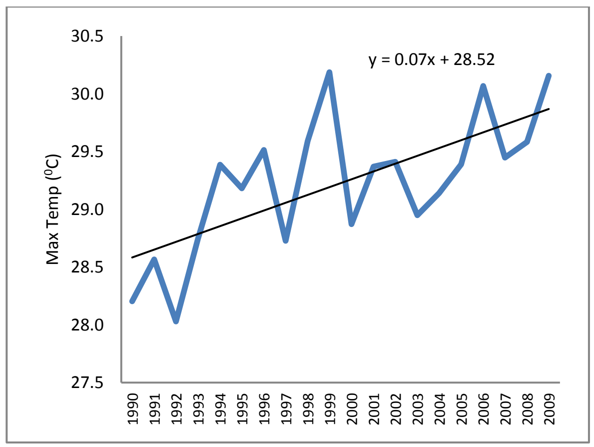



Fig. 25(e) Annual (1990-2009)

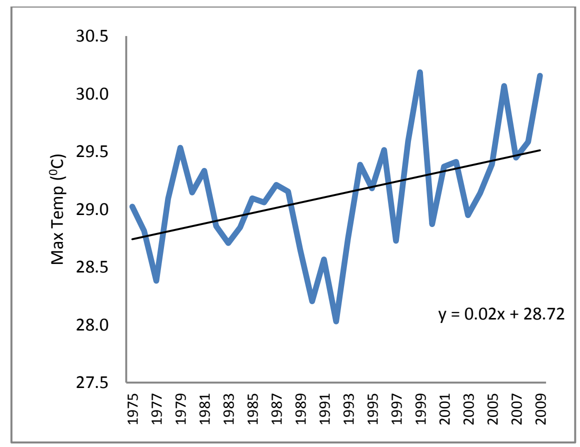



Fig.25(f) Annual (1975-2009)

Fig. 3.25. Seasonal and annual maximum temperature in Nagaland

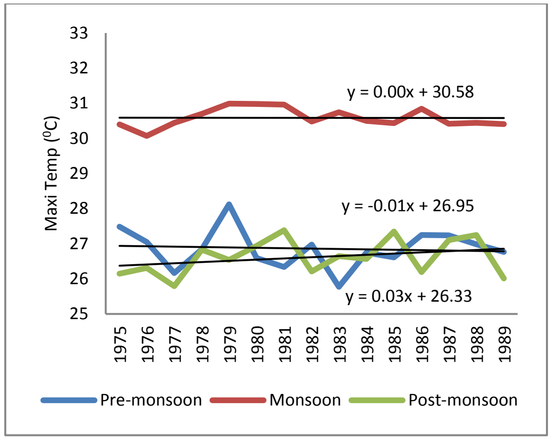



Fig. 26(a) Seasonal (1975-1989)

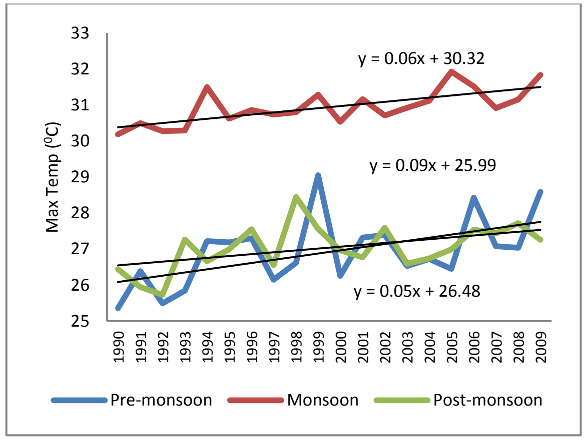
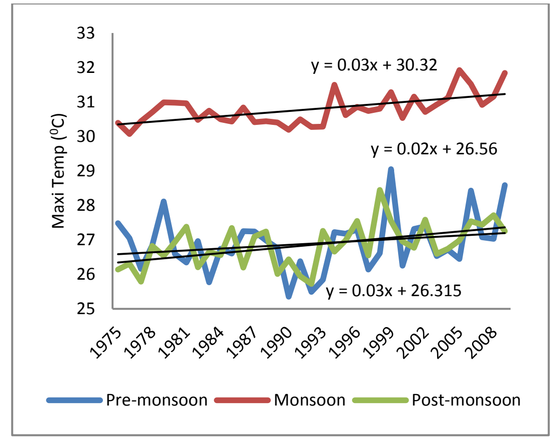



Fig. 26(b) Seasonal (1990-2009)




F ig. 26(c) Seasonal (1975-2009)

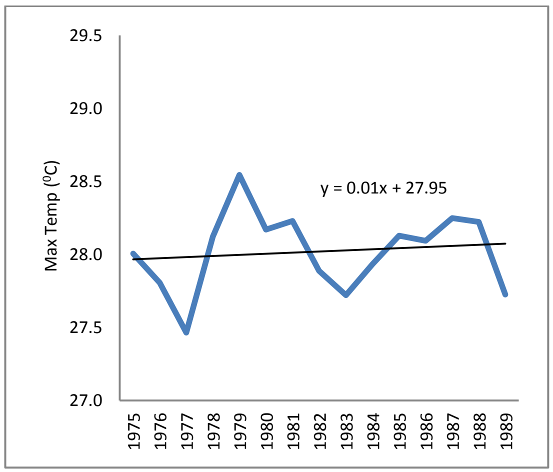



Fig. 26(d) Annual (1975-1989)

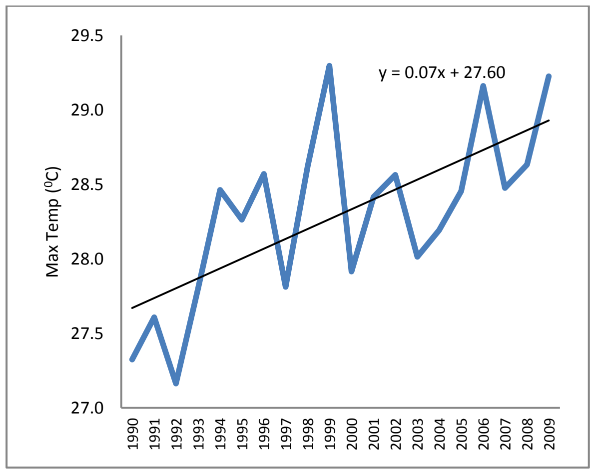



Fig. 26(e) Annual (1990-2009)

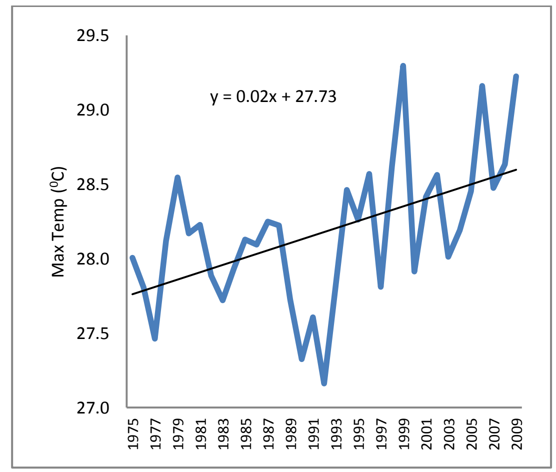



Fig.26(f) Annual (1975-2009)

Fig. 3.26. Seasonal and annual maximum temperature in Manipur

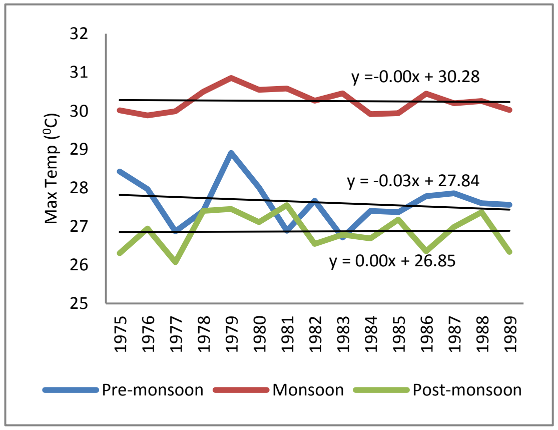



Fig. 27(a) Seasonal (1975-1989)

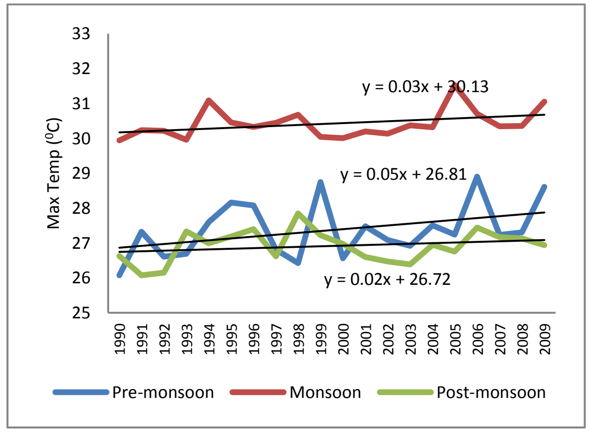



Fig. 27(b) Seasonal (1990-2009)

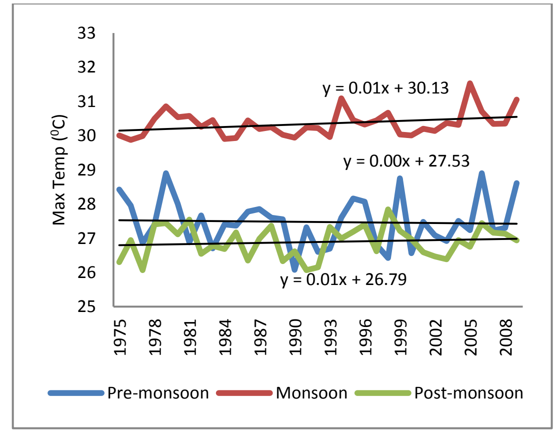



Fig. 27(c) Seasonal (1975-2009)

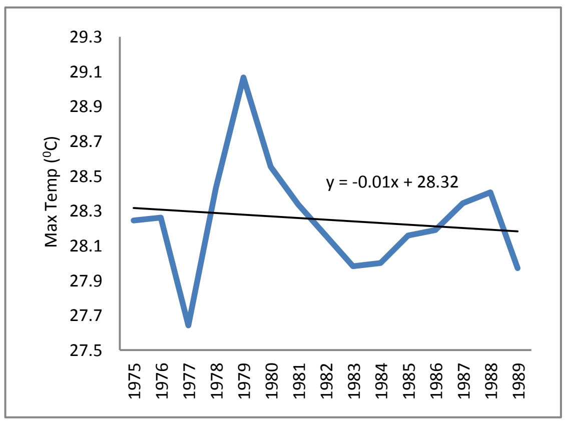



Fig. 27(d) Annual (1975-1989)

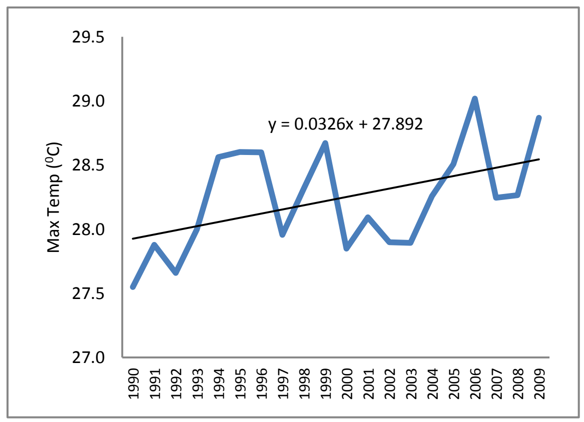



Fig. 27(e) Annual (1990-2009)

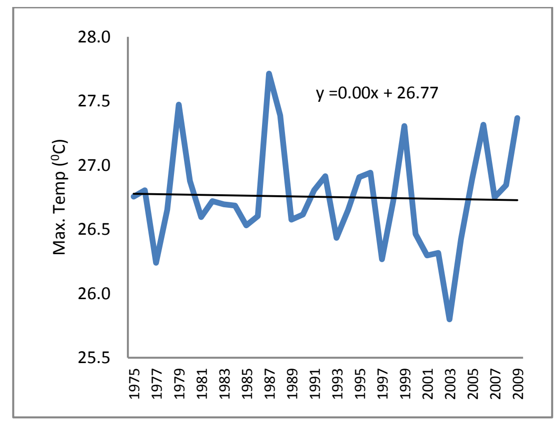



Fig.27(f) Annual (1975-2009)

Fig. 3.27. Seasonal and annual maximum temperature in Tripura

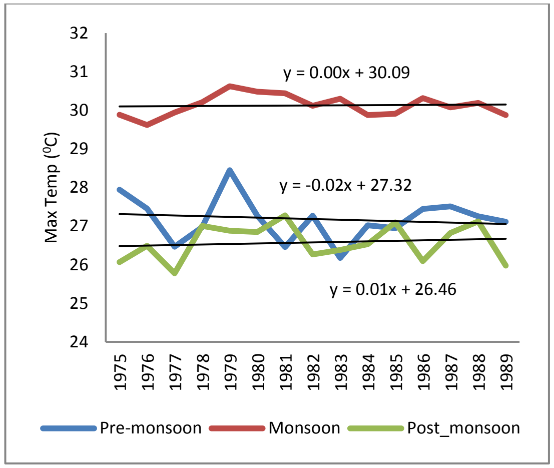



Fig. 28(a) Seasonal (1975-1989)

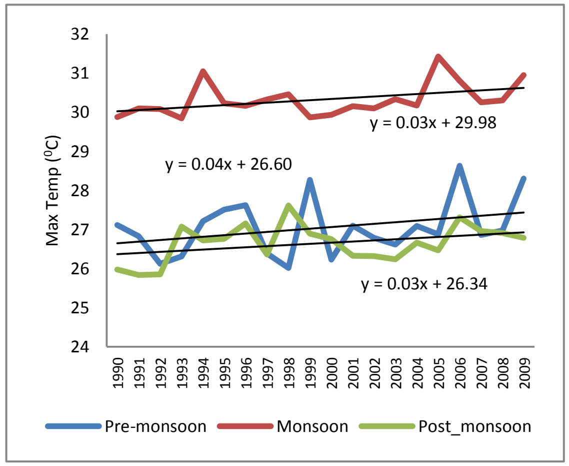



Fig. 28(b) Seasonal (1990-2009)

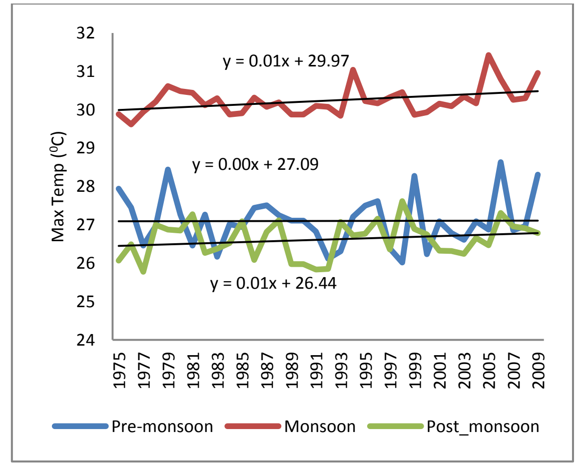



Fig. 28(c) Seasonal (1975-2009)

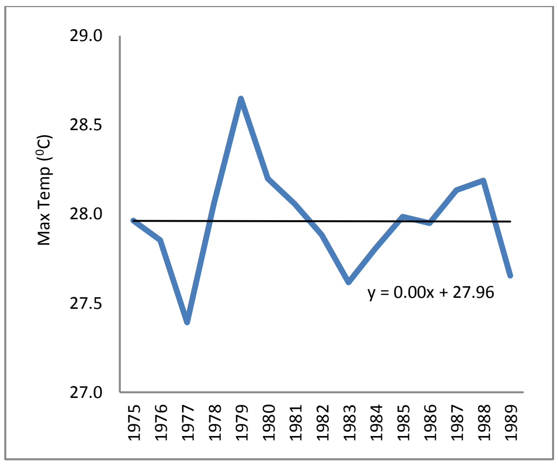



Fig. 28(d) Annual (1975-1989)

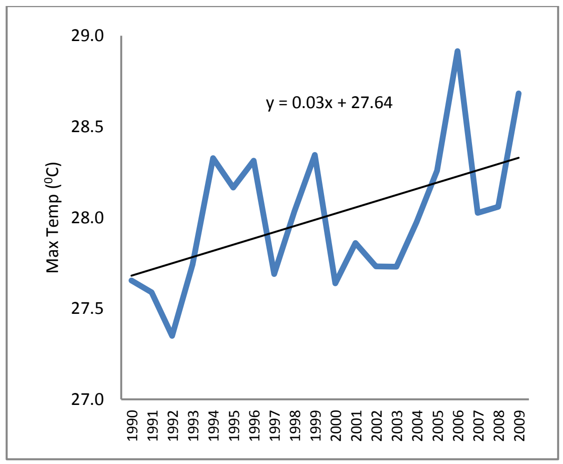



Fig. 28(e) Annual (1990-2009)

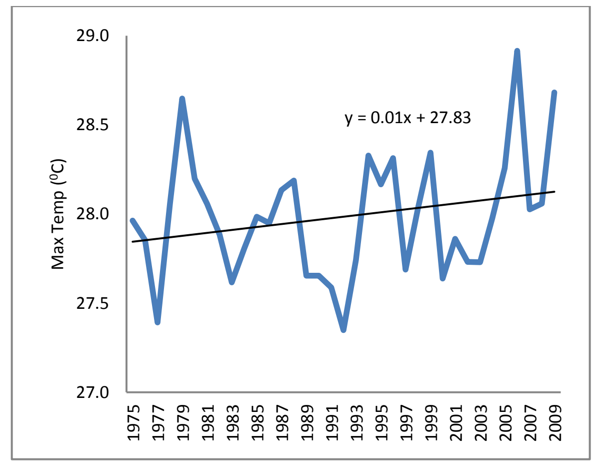



Fig.28(f) Annual (1975-2009)

Fig. 3.28. Seasonal and annual maximum temperature in Mizoram

| Table 3.2.2.4. Linear trend coefficients of maximum temperature in NEH of India | | | | | | |
|---|---|---|---|---|---|---|
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | |
| | B | P | b | p | b | p |
| Sikkim | 0.02 | 0.36 | 0.01 | 0.55 | 0.00 | 0.82 |
| Darjeeling | 0.03 | 0.17 | 0.00 | 0.84 | -0.01 | 0.32 |
| Meghalaya | 0.00 | 0.79 | 0.06*** | 0.00 | 0.02** | 0.02 |
| Arunachal | 0.00 | 0.86 | 0.06*** | 0.00 | 0.02** | 0.02 |
| Karbi-Anglong | 0.01 | 0.51 | 0.07*** | 0.00 | 0.02*** | 0.00 |
| Nagaland | 0.00 | 0.86 | 0.07*** | 0.00 | 0.02*** | 0.00 |
| Manipur | 0.01 | 0.66 | 0.07*** | 0.00 | 0.02*** | 0.00 |
| Tripura | -0.01 | 0.63 | 0.03** | 0.03 | 0.00 | 0.46 |
| Mizoram | 0.00 | 0.99 | 0.03** | 0.02 | 0.01 | 0.16 |

** & *** indicates significance at 5% and 1% level, respectively

*Pre-monsoon maximum temperature*

The pre-monsoon maximum temperatures in all the states of the NEH region have showed negative trends, except Sikkim, Darjeeling and Karbi Anglong during 1975-89 but in-significant. But interestingly, the trends turned out to be positive during 1990-2009 and are statistically significant for Meghalaya (0.07$^0$C/year), Arunachal Pradesh (0.08$^0$C/year), Karbi Anglong (0.09$^0$C/year), Nagaland (0.09$^0$C/year) and Manipur (0.09 $^0$C/year). During the whole study period *i.e.*, 1975-2009 the maximum temperatures have exhibited positive but in-significant trend, except in Sikkim and Darjeeling.

*Monsoon maximum temperature*

Monsoon temperatures in all the states of the NEH region have showed positive trends, except Arunachal Pradesh and Nagaland during 1975-89 but the trends are in-significant. The trends are positive during 1990-2009 and are statistically significant for Meghalaya, Arunachal Pradesh, Karbi Anglong, Nagaland and Manipur where the temperatures have increased by 0.06$^0$C/year during the monsoon season.

*Post-monsoon maximum temperature*

Post-monsoon temperatures in all the states of the NEH region have showed insignificant positive trends during 1975-89. But during 1990-2009, the post-monsoon temperatures in Sikkim, Darjeeling and Nagaland showed negative trend whereas, temperatures in Meghalaya, Arunachal Pradesh, Karbi Anglong, Manipur, Tripura and Mizoram have showed positive trends. The declining trend of Nagaland is significant. The increasing trends in maximum temperature were significant in case of Meghalaya (0.04$^0$C/year), Arunachal Pradesh (0.05$^0$C/year), Karbi Anglong (0.05$^0$C/year), and Manipur (0.05$^0$C/year). During the complete study period, the post monsoon maximum temperatures have exhibited positive trend, except Darjeeling.

*Annual maximum temperature*

Annual temperatures in all the states of the NEH region have showed positive trends during the study period, except in Tripura during 1975-1989. The trends are statistically significant during 1990-2009 for the states of Meghalaya (0.06$^0$C/year), Arunachal Pradesh (0.06$^0$C /year), Karbi Anglong (0.07$^0$C /year), Nagaland (0.07$^0$C/year), Manipur (0.07$^0$C/year), Tripura (0.03$^0$C/year) and Mizoram (0.03$^0$C/year) during 1990-2009.

During the complete study period (1975-2009), the trends for annual maximum temperatures are significant for Meghalaya, Manipur, Karbi Anglong, Arunachal Pradesh and Nagaland when the temperatures have increased by 0.02$^{0}$C/year.

Just and Pope Model is applied on panel data constructed from time series of seven states to assess the impact of climatic variable on mean yield and yield variability of major crops and milk in North Eastern Himalayan (NEH) states. Annual yield is used as dependent variable in the model. Annual rainfall, annual minimum and maximum temperature, time as trend and state dummy are included as explanatory variables in the model. The coefficients are estimated using Maximum Likelihood (ML) technique. The data pertain to different period for different crops based upon the availability. Various functional forms of mean function and variance function were used and the best fit is selected based upon the logical (sign and magnitude of coefficients) and econometric criteria *i.e.,* least Akaike criterion (AIC).

## 4.1. Descriptive statistics

The descriptive statistics of dependent variables used in the Just and Pope model is presented in Table 4.1.1

Table 4.1.1. Mean and SD of dependent variables across different states of NEH

| Crops | Sikkim | AP | Megh | Man | Nag | Tripura | Miz | NEH |
|---|---|---|---|---|---|---|---|---|
| **Rice (1981-2007)** | | | | | | | | |
| Mean (kg/ha) | 1316.4 | 1142.9 | 1155.1 | 2015.0 | 1249.0 | 1909.1 | 1320.6 | 1444.0 |
| SD | 311.2 | 144.0 | 108.8 | 370.8 | 315.2 | 407.3 | 486.2 | 306.2 |
| **Maize (1994-2007)** | | | | | | | | |
| Mean (kg/ha) | 1450.3 | 1385.7 | 1438.9 | 2347.6 | 1456.2 | 925.5 | 1995.4 | 1571.4 |
| SD | 92.0 | 51.0 | 90.2 | 712.1 | 344.4 | 92.9 | 181.8 | 223.5 |
| **Wheat (1991-2007)** | | | | | | | | |
| Mean (kg/ha) | 1487.4 | 1542.1 | 1622.3 | NA | 2006.6 | 1941.0 | 1856.4 | 1742.6 |
| SD | 283.49 | 211.1 | 196.18 | NA | 788.2 | 80.0 | 487.9 | 341.1 |
| **Potato (1996-2007)** | | | | | | | | |
| Mean (kg/ha) | 4461.7 | 7120.4 | 8995.2 | 5425.7 | 9031.4 | 17473.0 | 4634.1 | 8163.1 |
| SD | 209.7 | 488.5 | 873.1 | 670.3 | 1719.1 | 1682.1 | 1716.3 | 1051.3 |
| **Ginger (1996-2007)** | | | | | | | | |
| Mean (kg/ha) | 3384.5 | 7441.8 | 5670.9 | 1607.3 | 9887.6 | 2186.9 | 5845.2 | 5146.3 |
| SD | 2208.2 | 365.6 | 401.2 | 165.4 | 3570.9 | 953.9 | 798.8 | 1209.1 |
| **Milk (1988-2007)** | | | | | | | | |
| Mean ('000MT/year) | 36.48 | 37.4 | 60.6 | 72.6 | 50.2 | 59.9 | 12.8 | 47.1 |
| SD | 8.0 | 13.7 | 9.6 | 8.5 | 11.0 | 25.4 | 4.0 | 11.5 |

AP = Arunachal Pradesh, Megh = Meghalaya, Man = Manipur, Nag = Nagaland, Miz = Mizoram

The mean yield of rice is estimated to be 1444.0 kg/ha in NEH states of India. The mean rice yield was highest (2015.0 kg/ha) in Manipur, followed by mean yield of rice in Tripura (1909.1 kg/ha). The lowest rice yield was recorded in Arunachal Pradesh. The variability in rice yield was minimum in Meghalaya and maximum in Mizoram which is evident from the standard deviation (SD) values. The mean maize yield is calculated to be 1571.4 kg/ha in the NEH states with highest yield of 1995.4 kg/ha in Mizoram and lowest yield of 925.5 kg/ha in Tripura. The variability in maize was found to be maximum in Manipur whereas, it was minimum in Arunachal Pradesh. Highest yield of wheat *i.e.*, 2006.6 kg/ha was recorded in Nagaland and lowest in Sikkim (1487.4 kg/ha). The variability in wheat yield is maximum in Nagaland whereas, minimum in Tripura. In case of potato, the mean yield is 8163.1 kg/ha in NE states of India. The highest yield of potato is registered in Tripura (17473.0 kg/ha), followed by Nagaland and Meghalaya. The variability in potato yield is maximum in Nagaland and minimum in Sikkim. The mean yield of ginger is calculated to be 5146.3 kg/ha in the region. Nagaland ranks first in ginger yield (9887.6 kg/ha) and Manipur stands at the bottom with 1607.3 kg/ha. Similarly, the variability in ginger yield is also maximum in Nagaland and minimum in Manipur. The average milk yield in the NEH states is 47.1 thousand MT per year, with highest milk yield of 72.6 thousand MT per year in Manipur, followed by Meghalaya and Tripura. The variability in milk yield is maximum in Tripura and minimum in Mizoram.

### 4.2. Just and Pope Model

The coefficients, their standard errors (SE) and probability (p) values of selected best functional forms of Just and Pope Model are presented in Table 4.2.1 and Table 4.2.2.

Table 4.2.1. Estimated Just and Pope Model for major cereal crops in NEH

| Crop | Rice | | | Maize | | | Wheat | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: | Ln (Yield) | | | Ln (Yield) | | | Ln (Yield) | | |
| Variables | B | SE | P | B | SE | P | b | SE | P |
| Mean function | Ln_yield | | | LnY-LnX | | | LnY-LnX | | |
| const | 5.066 | 32.283 | 0.875 | 13.344 | 2.617 | 0.000*** | 2.421 | 5.799 | 0.676 |
| Time | 0.019 | 0.003 | 0.000*** | 0.012 | 0.003 | 0.000*** | −0.004 | 0.008 | 0.616 |
| MaxT | −0.848 | 2.329 | 0.716 | −1.574 | 0.880 | 0.074* | 2.045 | 1.877 | 0.276 |
| MinT | 1.645 | 1.047 | 0.116 | 0.083 | 0.254 | 0.745 | −0.114 | 1.362 | 0.933 |
| RainT | −0.001 | 0.002 | 0.801 | −0.112 | 0.029 | 0.000*** | −0.168 | 0.170 | 0.321 |
| MaxT2 | 0.025 | 0.046 | 0.584 | | | | | | |
| MinT 2 | −0.009 | 0.025 | 0.716 | | | | | | |
| RainT2 | 0.000 | 0.000 | 0.527 | | | | | | |
| MaxTMinT | −0.041 | 0.039 | 0.304 | | | | | | |
| MaxTRainT | 0.000 | 0.000 | 0.478 | | | | | | |
| MinTRainT | −0.000 | 0.000 | 0.333 | | | | | | |
| Sikkim | 0.018 | 0.156 | 0.911 | −0.387 | 0.053 | 0.000*** | −0.091 | 0.156 | 0.561 |
| AP | −0.015 | 0.064 | 0.817 | −0.355 | 0.039 | 0.000*** | −0.296 | 0.130 | 0.022*** |
| Meghalaya | 0.001 | 0.051 | 0.989 | −0.314 | 0.030 | 0.000*** | −0.253 | 0.124 | 0.041*** |
| Manipur | 0.420 | 0.063 | 0.000*** | −0.024 | 0.058 | 0.679 | | | |
| Nagaland | −0.017 | 0.088 | 0.848 | −0.272 | 0.052 | 0.000*** | −0.285 | 0.113 | 0.011*** |
| Tripura | 0.371 | 0.074 | 0.000*** | −0.763 | 0.032 | 0.000*** | −0.074 | 0.102 | 0.466 |
| Variance function | Linear | | | Linear | | | Ln | | |
| const | −10.562 | 5.525 | 0.056* | −21.097 | 7.194 | 0.003*** | −124.692 | 32.473 | 0.000*** |
| Time | 0.070 | 0.011 | 0.000*** | 0.063 | 0.042 | 0.134 | 0.088 | 0.019 | 0.000*** |
| MaxT | 0.459 | 0.279 | 0.100 | 1.658 | 0.413 | 0.000*** | 18.384 | 10.201 | 0.072* |
| MinT | −0.461 | 0.255 | 0.070* | −1.552 | 0.426 | 0.000*** | 10.605 | 6.975 | 0.128 |
| RainT | 0.001 | 0.000 | 0.001*** | −0.001 | 0.000 | 0.001*** | 3.787 | 0.849 | 0.000*** |
| Akaike criterion | −40.514 | | | −137.510 | | | 52.669 | | |

* & *** indicates significance at 10% and 1% level, respectively

**Impact on rice yield**

The quadratic model with dependent variable in log form and the variance function in linear form is found to be the best model. Only the trend variable is significant at 1 per cent level of significance in the mean function which implies that technological progress, in the form of improved varieties, better agronomic practices and plant protection measures, has positive influence on rice yield which is evident from increased rice yield in the region over the study period. None of the climatic factors have significant influence on the mean yield of rice in the region. The yield of rice in Manipur and Tripura are statistically different from the other states.

But in the variance function, trend and rainfall are found to be strongly significant (1% level) and positive whereas, minimum temperature is weekly significant (at 10% level) and negative which means that, time and rainfall are the variance increasing factors whereas, minimum temperature is variance decreasing factor. The variability in rice yield is increasing over the years and increase in rainfall is expected to increase the variability in rice yield.

**Impact on maize yield**

The double log linear model with the variance function in linear form has turned out to be the best model. The trend variable is significant at 1 per cent level of significance in the mean function which implies that technological progress has positive influence on maize yield. Rainfall and maximum temperature have significant (at 1% and 10%, respectively) negative influence on mean yield of maize. As the area receives high annual rainfall the increase in rainfall is expected to decrease the mean yield of maize. Similarly, the increasing temperature especially during the maturity period will hamper the grain filling in maize. The yields of maize of the different states are significantly different from the yield of maize in Manipur and Mizoram.

In variance function, minimum temperature and rainfall are found to be strongly significant (1% level) and negative whereas, maximum temperature is positive and significant at 1 per cent level of significance which means that, minimum temperature and rainfall are the variance decreasing factors whereas, maximum temperature is variance increasing factor. If the rainfall increases, the variability in maize yield will decrease. Similarly, increase in minimum temperature will decrease the yield variability of maize. The maximum temperature is risk increasing factor which implies that with increase in maximum temperature variability in yield of maize will also increase.

**Impact on wheat yield**

The double log model with the variance function in logarithmic form is found to be the best model. None of the climatic variable found to be significant in mean function. The yields of wheat of Arunachal Pradesh, Meghalaya and Nagaland are significantly different from the yield of wheat in other states of NEH.

In variance function, time and rainfall turned out to be strongly risk increasing factors and maximum temperature is marginally risk increasing factor. With each increasing year the variability in wheat yield is increasing. Increases in rainfall and maximum temperature are also expected to increase the variability in wheat yield.

**Impact on potato yield**

The log-lin model with the variance function in logarithmic form is turned out to be the best model. Only annual rainfall has negative influence on potato yield but it is significant only at 10 per cent level of significance. Similarly, rainfall is the factor which increased the variability in potato yield but the impact is marginal. The yields of potato in Arunachal Pradesh, Meghalaya, Nagaland and Tripura are significantly different from the yield of potato in Sikkim, Manipur and Mizoram.

| Table 4.2.2. Estimated Just and Pope Model for potato, ginger and milk in NEH | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Crop | Potato | | | Ginger | | | Milk | | |
| Dependent variable: | Ln (Yield) | | | Ln (Yield) | | | Ln (Yield) | | |
| Variables | b | SE | P | B | SE | P | b | SE | P |
| Mean function/Model | LnY-LinX | | | LnY-LnX | | | LnY-LnX | | |
| Const | 7.300 | 2.076 | 0.000*** | −0.834 | 10.313 | 0.936 | 6.704 | 2.881 | 0.020*** |
| Time | −0.005 | 0.010 | 0.619 | −0.003 | 0.017 | 0.850 | 0.034 | 0.004 | 0.000*** |
| MaxT | 0.056 | 0.090 | 0.532 | 2.089 | 3.801 | 0.583 | −1.488 | 0.696 | 0.033 |
| MinT | −0.008 | 0.099 | 0.936 | 1.254 | 2.752 | 0.649 | 0.114 | 0.531 | 0.830 |
| RainT | −0.000 | 0.000 | 0.063* | −0.153 | 0.284 | 0.590 | −0.019 | 0.071 | 0.790 |
| Sikkim | 0.072 | 0.206 | 0.728 | 0.015 | 0.313 | 0.961 | 0.997 | 0.071 | 0.000*** |
| Arunachal | 0.398 | 0.160 | 0.013** | 0.203 | 0.195 | 0.298 | 1.117 | 0.086 | 0.000*** |
| Meghalaya | 0.685 | 0.149 | 0.000*** | −0.001 | 0.210 | 0.995 | 1.524 | 0.091 | 0.000*** |
| Manipur | 0.046 | 0.134 | 0.729 | −1.329 | 0.140 | 0.000*** | 1.582 | 0.062 | 0.000*** |
| Nagaland | 0.535 | 0.120 | 0.000*** | 0.384 | 0.166 | 0.021** | 1.379 | 0.053 | 0.000*** |
| Tripura | 1.302 | 0.114 | 0.000*** | −1.027 | 0.186 | 0.000*** | 1.685 | 0.056 | 0.000*** |
| Variance function | Ln | | | Linear | | | Ln | | |
| Const | −20.960 | 33.624 | 0.533 | 11.305 | 7.699 | 0.142 | −75.170 | 16.376 | 0.000*** |
| Time | −0.004 | 0.077 | 0.961 | 0.035 | 0.059 | 0.560 | −0.276 | 0.018 | 0.000*** |
| MaxT | 5.141 | 12.443 | 0.680 | 0.742 | 0.428 | 0.083* | 26.937 | 5.742 | 0.000*** |
| MinT | −4.277 | 8.570 | 0.618 | −1.996 | 0.470 | 0.000*** | −4.445 | 4.507 | 0.324 |
| RainT | 1.670 | 0.947 | 0.078* | 0.001 | 0.000 | 0.097* | −0.063 | 0.687 | 0.927 |
| Akaike criterion | 59.531 | | | −25.271 | | | −65.826 | | |

*, ** & *** indicates significance at 10%, 5% and 1% level, respectively

**Impact on ginger yield**

The double log linear model with the variance function in linear form is the best model. None of the climatic variable found to be significant in mean function. The yields of ginger in Manipur, Nagaland and Tripura are significantly different from the yield of ginger in other states.

In variance function, maximum temperature and rainfall turned out to be marginally risk increasing factors. Increase in maximum temperature and rainfall is expected to increase the variability in ginger yield. Minimum temperature is found to be strong risk reducing factor which implies that if the minimum temperature increases the variability in ginger yield will decrease.

**Impact on milk yield**

The double log linear model with the variance function in logarithmic form is found to be the best model. The trend variable is significant at 1% level of significance in the mean function which implies that technological progress in the form of introduction of crossbred animal, artificial insemination programme *etc.* has positive influence on milk yield which is evident from increased milk yield over the study period. The yield of milk in different NEH states is statistically different from milk yield registered in Mizoram.

In variance function, time is risk decreasing factor which implies that over the year the variability is declining which is as per our expectation. The maximum temperature is strongly risk increasing factor. Increase in maximum temperature is expected to increase the variability in milk yield as the heat stress reduces the milk yield of dairy animals. Moreover, fodder availability reduces during the dry years and high temperature leads to curdling of milk.

To understand the impact of climate change on farm and farming community in the hill districts of North Eastern Himalaya (NEH) of India household survey was conducted in the nine hill districts of the region which were identified as vulnerable to climate change by Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. This chapter presents the results of household survey, state wise in Section I and case studies in Section II. All the tables in Section I are the outcome of the analysis of primary data collected from sample households.

## SECTION I: FINDINGS FROM HOUSEHOLD SURVEY

### 5.1 EAST SIKKIM DISTRICT OF SIKKIM

*Socio-economic status*

The socio-economic information of sample households of East Sikkim is presented in Table 5.1.1.

Table 5.1.1. Socio-economic information of sample households of East Sikkim

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 45.62 | Sex ratio | per 1000 male | 885.15 |
| Family size | no. | 5.61 | Religion | % | |
| Social Group | % | | Christian | | 8.33 |
| Schedule Tribe | | 37.50 | Hindu | | 65.83 |
| Schedule Caste | | 4.17 | Islam | | 0.00 |
| Other Backward Caste | | 29.16 | Buddhist | | 25.83 |
| Others | | 29.17 | Educational status | % | |
| | | | Illiterate | | 28.33 |
| Housing structure | % | | Literate | | 3.33 |
| *Kaccha* | | 14.17 | Literate but below primary | | 5.00 |
| Semi-*pucca* | | 52.50 | Primary | | 14.17 |
| *Pucca* | | 33.33 | Middle | | 8.33 |
| Operational land holding | ha | 0.72 | Secondary | | 25.83 |
| Upland | | 0.72 | Higher Secondary | | 11.67 |
| Lowland | | 1.00 | Graduate | | 7.50 |
| Irrigated land | % | 16.78 | Post Graduate | | 0.83 |

The average age of the respondent farmers was 45.62 years and their families were composed of on an average six members in East Sikkim district (Table 5.1.1). Majority of them were Hindu (65.83%), followed by Buddhist (25.83%) and Christians (8.33 %). Majority of the responding farmers belonged to the Schedule Tribe (ST) category (37.50%), followed by Other Backward Caste (OBC) and unreserved category (29.17%). The number of female was relatively low in the area with around 885 per 1000 male and the literacy rate was around 71 per cent. Majority of the respondents were educated up to Secondary (25.83%) level, followed by Primary (14.17%) and Higher Secondary (HS) level (11.67%).

The average operational land holding is calculated to be 0.72 ha and only 16.78 per cent of the total cultivated land was irrigated.

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in East Sikkim district is eliciated in Table 5.1.2 to Table 5.1.4.

Table 5.1.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in East Sikkim

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 100.00 | Yes | 98.33 |
| Acidity | 0.00 | Not sure | 1.67 |
| Others | 0.00 | Do not know | 0.00 |

All of the respondent farmers reported the problem of water stress or drought like situation in their respective farms. Majority of the respondents (98.33%) felt that the climate has changed over the years and only a few of them (1.67%) were unsure about any change in climate (Table 5.1.2).

Table 5.1.3. Farmers' perception (%) about change in temperature and rainfall in East Sikkim

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 3.36 | 50.00 | Late | 84.35 | 10.64 | Low | 84.11 | 41.38 |
| Increase | 94.96 | 42.11 | Early | 6.96 | 1.06 | High | 6.54 | 0.00 |
| No change | 1.68 | 7.89 | No change | 8.70 | 54.26 | No change | 6.54 | 49.43 |
| Not sure | 0.00 | 0.00 | Not sure | 0.00 | 34.04 | Not sure | 1.87 | 9.20 |

Table 5.1.4. Unexpected change encountered by the respondents in East Sikkim (in %)

| Response | Long dry spell | | Drought incidence | | Hailstorm | |
|---|---|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 66.67 | 10.00 | 23.08 | 3.85 | 0.00 | 60.00 |
| Yes | 16.67 | 80.00 | 69.23 | 88.46 | 96.88 | 30.00 |
| No change | 0.00 | 10.00 | 0.00 | 3.85 | 0.00 | 0.00 |
| Not sure | 16.67 | 0.00 | 7.69 | 3.85 | 1.56 | 10.00 |

Although majority farmers of the district perceived that the summer (94.96%) temperature has increased (Table 5.1.3), but half of them (50.00%) felt that winter temperature has decreased in last 10 years. About 84.11 per cent of the responding farmers perceived that the monsoon rainfall has declined over the years, whereas, only 41.38 per cent felt that winter rainfall declined. The monsoon rainfall has also become late in the area, as per 84.35 per cent farmers in East Sikkim district.

Most of the respondents of East Sikkim recalled about long unexpected dry spell within a rainy period during winter and unexpected drought incidence during winter season (Table 5.1.4). Unexpected hailstorms in summer (96.88%) and winter (30.00%) seasons, have damaged the standing crops and it reduced the crop productivity.

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.1.5 to Table 5.1.9.

Table 5.1.5. Effect of rainfall variability on area under rice, maize and fallow in East Sikkim (in %)

| Response | Rice area | | Maize area | | Fallow | |
|---|---|---|---|---|---|---|
| | Late | Drought/Low rainfall | Late | Drought/Low rainfall | Late | Drought/Low rainfall |
| Decrease | 24.32 | 22.97 | 14.00 | 13.86 | 0.00 | 0.00 |
| Increase | 0.00 | 0.00 | 1.00 | 0.99 | 62.50 | 58.82 |
| No change | 75.68 | 75.68 | 85.00 | 85.15 | 37.50 | 41.18 |
| Not sure | 0.00 | 1.35 | 0.00 | 0.00 | 0.00 | 0.00 |

Rice and maize cultivated in the area were primarily rainfed, hence changes in rainfall pattern has direct effect on the production and productivity of the crops. About 24.32 per cent and 22.97 per cent of the farmers have reported that they reduced the area under rice crop in case of late rainfall and drought/low rainfall situations, respectively whereas, in case of maize, only 14 per cent and 13.86 per cent reported about cultivating smaller area than normal in case of late rainfall and drought/low rainfall, respectively which resulted into increase in the fallow area (Table 5.1.5).

Table 5.1.6. Effects of rainfall variability on yield of rice and maize in East Sikkim

| Response | Direction (in %) | | | | | | Quantum (kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rice | | | Maize | | | Rice | | Maize | |
| | Low | High | Early/ late | Low | High | Early/ late | Drought /Low | Normal | Drought/ Low | Normal |
| Decrease | 100.00 | 0.00 | 100.00 | 98.06 | 0.00 | 98.20 | 762.41 | 1271.73 | 363.71 | 656.08 |
| Increase | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -40.05% | | -44.56 | |
| No change | 0.00 | 100.00 | 0.00 | 1.94 | 100.00 | 1.80 | | | | |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |

All the sample farmers informed that low rainfall and change in timing of rainfall reduced the productivity of paddy. Similarly, majority of them opined about reduction in the productivity of maize. It is calculated that the productivity of rice declined by 40.05 per cent, from 1271.73 kg/ha to 762.41 kg/ha during periods of droughts or low rainfall situations. The productivity of maize also declined by 44.56 per cent, from 656.08 kg/ha to 363.71 kg/ha in times of droughts or low rainfall situations (Table 5.1.6).

Table 5.1.7. Effect of change in climate on pest and disease infestation in East Sikkim (in %)

| Response | Rice | | Maize | | Crop damaged | |
|---|---|---|---|---|---|---|
| | Disease | Pest | Disease | Pest | Rice | Maize |
| Decrease | 0.00 | 0.00 | 0.00 | 0.00 | 24.40 | 24.28 |
| Increase | 71.11 | 68.00 | 56.52 | 63.93 | | |
| No change | 28.89 | 32.00 | 41.30 | 34.43 | | |
| Not sure | 0.00 | 0.00 | 2.17 | 1.64 | | |

Majority of the responding farmers perceived that the pests and disease infestations have increased in both, rice (71.11% and 68.00%) and maize (56.52% and 63.93%) in recent times which may be due to the change in climate. It has resulted in 24.40 per cent and 24.28 per cent crop loss/damage in case of rice and maize, respectively (Table 5.1.7).

Table 5.1.8. Effect of climate change on availability of food in East Sikkim

| Particulars | Normal | Drought/Low rainfall |
|---|---|---|
| Supply of food from own land (months) | 4.38 | 2.97 |
| Perception (%) | | |
| Insufficient/decline | 19.49 | 75.21 |
| Sufficient/improve | 33.90 | 8.55 |
| No change | 46.61 | 16.24 |
| Not sure | 0.00 | 0.00 |

Table 5.1.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in East Sikkim

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Sufficiency of money for purchase of food | 97.50 | | |
| Family members | | Grown up children | 0.00 |
| Husband | 0.00 | Elders | 0.00 |
| Wife | 0.00 | All members | 99.17 |
| Both husband & wife | 0.00 | Do not know | 0.84 |

In normal seasons, the farm produce lasted for 4.38 months for home consumption but during drought/low rainfall they could consume for 2.97 months only (Table 5.1.8). About 75.21 per cent of the farmers reported that availability of food become insufficient during droughts or low rainfall situations (Table 5.1.8) but only 2.50 per cent of the responding farmers faced difficulty to purchase food during climatic variability as they resort to alternative employment opportunities (Table 5.1.9). There was no gender discrimination about distribution of food during climatic variability as 99.17 per cent of the farmers reported all members of their families received equal distribution of food (Table 5.1.9).

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.1.10 and Table 5.1.11.

Table 5.1.10. Responses about change in water availability during low rainfall or drought situations in East Sikkim (in %)

| Type of change | Irrigation | Drinking |
|---|---|---|
| Decrease | 93.33 | 78.76 |
| Increase | 2.22 | 14.16 |
| No change | 2.22 | 7.08 |
| Not Sure | 2.22 | 0.00 |

Majority of the farmers reported about low water availability for irrigation (93.33%) as well as drinking (78.76%) purposes during the drought seasons or low rainfall situations (Table 5.1.10). Reducing drinking water facility and inadequate irrigation facility in the village was reported by 85.47 per cent and 89.74 per cent of the farmers, respectively. About 22.22 per cent of the sample farmers reported about conflicts in the village due to shortage of water in the last 5 years in East Sikkim district (Table 5.1.11).

Table 5.1.11. Response (%) on water scenario in the village in East Sikkim

| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
|---|---|---|---|
| No | 14.53 | 10.26 | 74.36 |
| Yes | 85.47 | 89.74 | 22.22 |
| Not sure | 0.00 | 0.00 | 3.42 |

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.1.12 to Table 5.1.14.

Table 5.1.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in East Sikkim

| Source of cooking fuel | | Who collects wood? | | Fire wood availability during low rainfall | |
|---|---|---|---|---|---|
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 95.83 | Husband | 2.61 | Decrease | 81.74 |
| Charcoal | 0.00 | Wife | 4.35 | Increase | 5.22 |
| Cow dung | 0.00 | Both | 8.70 | No change | 13.04 |
| LPG | 93.33 | Grown up children | 7.83 | Not sure | 0.00 |
| | | Elders | 21.74 | | |
| | | All members | 57.39 | | |
| | | Market | 1.74 | | |

Most of the respondents (95.83%) still used wood as fuel, though about 93.33 per cent of them have Liquefied Petroleum Gas (LPG) connection in East Sikkim (Table 5.1.12). The responsibility of collecting fire wood was primarily shared by all the family members in case of 57.39 per cent households and by the elders of the family in case of 21.74 per cent households. During the periods of low rainfall or drought like situations, majority of the responding farmers (81.74%) reported decline in firewood availability.

Table 5.1.13. Effect of climatic variability on time spent (hr/day) during climatic variability in East Sikkim

| Activities | Normal | Drought/Low rainfall |
|---|---|---|
| Fodder collection/grass cutting | 1.34 | 2.04 |
| Fetching drinking water | 0.40 | 0.46 |
| Wood (fuel) collection | 1.20 | 1.64 |
| Working hours in crop field | 6.13 | 6.47 |

| Table 5.1.14. Extra burden shared during climatic variability in East Sikkim (in %) | | | | |
|---|---|---|---|---|
| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
| Male | 0.00 | 0.00 | 0.00 | 0.85 |
| Female | 1.90 | 97.48 | 0.00 | 0.00 |
| Both male & female | 98.10 | 2.52 | 100.00 | 99.15 |

The respondents revealed that the time spent on regular activities increased during the periods of climatic variability (Table 5.1.13). The extra burden during ECV was shared between both male and female for most of the daily activities, except in the case of fetching drinking water. The females in the families (97.48%) has shared greater burden to fetch drinking water (Table 5.1.14).

*Adaptation and mitigation strategy*

The adaptation and mitigation strategies followed by the sample farmers in East Sikkim district are presented in Table 5.1.15 to Table 5.1.19.

| Table 5.1.15. Adaptation strategy followed in agriculture in East Sikkim (in %) | | |
|---|---|---|
| Strategy | Late rainfall | Drought/Low rainfall |
| Leave complete fallow | 2.56 | 2.61 |
| Grow dry fodder crops | 0.00 | 0.00 |
| Change in cropping sequence | 0.00 | 0.00 |
| Change in crop cultivar/ landrace | 0.00 | 0.00 |
| Change in sowing/transplanting time | 40.17 | 38.26 |
| Change in harvesting time | 37.61 | 36.52 |
| Shift from crops to livestock | 2.56 | 2.61 |
| Grow more cash crops | 5.98 | 6.09 |
| Cultivate smaller area than usual | 17.09 | 18.10 |
| No change | 51.28 | 50.00 |

About 40.17 per cent and 38.26 per cent of the farmers changed sowing time in case of late rain and drought like situation, respectively and consequently 37.61 per cent and 36.52 per cent of them have also changed their harvesting time (Table 5.1.15). Majority of the farmers (51.28% in case of late rain and 50.00% in case of drought like situation) did not take up any adaptation strategy in times of climatic variability, which reflected non-availability of options, means and intent.

| Table 5.1.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in East Sikkim | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 1.67 | Start shop keeping | 2.50 |
| Wage labour | 57.50 | Devote more time in shop keeping | 0.00 |
| Go to neighbouring villages for labour work | 2.50 | Sell assets | 0.00 |
| Loan | 0.00 | Children drop out from school | 0.00 |
| | | Others | 31.67 |

It was found that working as wage labour under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) was the best alternative source of livelihood for majority of the respondents (57.50%) in case of climatic variability (Table 5.1.16). Some of the farmers (31.67%) also depended on the alternative income from other vocations such as government job or working in the pharmaceutical factory near their village and starting their own business, other than petty shop keeping. Only 1.67 per cent of the respondent migrated to neighbouring village/town and mainly the respondents' wives and grown male members were left behind at home (Table 5.1.17).

Table 5.1.17. Migration during climatic variability in East Sikkim

| Place of migration | Frequency (%) | Family members left at home | Frequency (%) |
|---|---|---|---|
| Neighbour village | 100.00 | Wife | 50.00 |
| Neighbour town | 0.00 | Minor | 0.00 |
| Outside district | 0.00 | Male grown | 50.00 |
| State capital | 0.00 | Female grown | 100.00 |
| Outside state | 0.00 | Elders | 0.00 |

Use of stress-tolerant cultivars, health management of animals, shift to improved cropping system and pest and disease management were the measures considered as preferable mitigating options to climate change by the farmers in the study area (Table 5.1.18).

Table 5.1.18. Mitigating options preferred by respondents in East Sikkim

| Options | Frequency (%) | Options | Frequency (%) |
|---|---|---|---|
| Use of stress-tolerant crop cultivar | 50.00 | Pest and disease management techniques such as IPM | 12.50 |
| Shift to improved cropping system | 20.00 | Development and use of crop cultivar resistant to pests and diseases | 2.50 |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 0.00 | New livestock breeds | 8.33 |
| Short duration variety grow other additional crops | 3.33 | Animal health management | 21.67 |
| New land management techniques | 3.33 | Others | 0.83 |
| Changes in agricultural water-managed techniques | 0.00 | Do not know | 1.67 |

It was found that both, husband and wife together, primarily decided on any changes in cultivars (*Annex V(SK)_I)*. The respondents revealed that yield (35.83%), availability of seeds (35.00%), taste (30.00%) and tolerance to drought (22.50%) were the major decisive factors that influenced their decisions to continue with or change a rice cultivar. In case of maize, availability of seeds and water (73.63% and 61.54%), tolerance to drought (45.05%), resistance to pest (62.64%) and diseases (41.76%) were the main criteria for continuing or changing a cultivar (*Annex V(SK)_II*).

Suitable cultivars, as reported by the responding farmers, were *Addey, Tulsi, Donasy* and *Kale Poge* (Table 5.1.19). The sample farmers expressed their preferences for training on crop production management (35.83%), water management (27.50%) and management of animals (28.33%) (*Annex V(SK)_III*).

| Table 5.1.19. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in East Sikkim | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivar | Reason | Cultivar | Reason |
| Addey | Low productivity | PD10 | Low productivity |
| Basmati | Low productivity and lack of inputs (machinery, fertilizers, etc.) | Phudugki | Low productivity |
| Charaky | Low productivity, cannot withstand water stress | Sugandha | Low productivity |
| Juhari | Low productivity | Thulo Addey | Low productivity |
| Kala Ninia | Not suitable for climate | Tulsi | Low productivity |
| Krishna Bhog | Cannot withstand water stress | | |
| **Cultivars suitable in climate change scenario** | | | |
| Addey | Withstand water stress conditions | Donasy | Good production |
| Kale Poge | Drought tolerant | Tulsi | Withstand water stress conditions |

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.1.20 to Table 5.1.23.

| Table 5.1.20. Who has the access to agricultural information in East Sikkim? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Access to information | 77.50 | | |
| Member | | Elders | 2.15 |
| Men | 8.60 | Male grown children | 0.00 |
| Women | 1.08 | Female grown children | 0.00 |
| Both men and women | 84.95 | Do not know | 0.00 |

About 77.50 per cent of the respondents have accessed agricultural information and 84.95 per cent of them opined that both male and female members have access to information (Table 5.1.20).

| Table 5.1.21. Source of information on agriculture and weather in East Sikkim | | | | |
|---|---|---|---|---|
| Agriculture | | | Weather | |
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 84.95 | 52.69 | Radio | 15.83 |
| Progressive farmers | 45.16 | 43.01 | Newspaper | 14.17 |
| Fellow farmers | 62.37 | 56.99 | Television | 28.33 |
| Elders | 30.11 | 29.03 | Neighbour | 19.17 |
| Others | 0.00 | 0.00 | Family member | 10.83 |
| | | | Traditional knowledge | 68.33 |
| | | | Others | 0.83 |

Institutions like Krishi Vigyan Kendra (KVK), Indian Council of Agricultural Research (ICAR), Agriculture Department, Block Office *etc.* (84.95% and 52.69%), fellow farmers in village (62.37% and 56.99%), and progressive farmers (45.16% and 43.01%)

were the major source for agricultural information in normal periods as well as during extreme climatic variability (ECV)(Table 5.1.21). Interestingly, most of the respondents used traditional knowledge (68.33%) and watched television (28.33%) for weather information (Table 5.1.21).

| Table 5.1.22. Per cent of respondents accessed agricultural loan and heard about insurance schemes in East Sikkim | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 1.67 |
| Insurance scheme | |
| Crop | 20.83 |
| Livestock | 47.06 |
| Human | 75.00 |
| Other | 10.83 |

Only 1.67 per cent of the farmers have acquired loan for agricultural purposes in the study area. Though many of them were aware of human (75.00%) and livestock (47.06%) insurance but only 20.83 per cent have heard about crop (20.83%) insurance (Table 5.1.22).

| Table 5.1.23. Type of support received and agencies that supported the farmers in East Sikkim | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.83 | Agriculture Department | 57.50 |
| Old Age Pension | 25.00 | Horticulture Department | 8.33 |
| PDS ration | 87.50 | Animal Husbandry/ Fisheries Department | 2.50 |
| Thrift and credit through SHGs | 26.67 | Bank/ Cooperative Bank/Society | 0.00 |
| Farmers' group | 11.67 | KVK/Block Office | 19.17 |
| Health insurance | 0.00 | Meteorological Department/ Irrigation Department | 0.00 |
| Support from NGOs (specify) | 0.00 | Health Department | 0.00 |
| Training on new rice technologies | 0.00 | Agricultural Universities | 0.00 |
| MGNREGA program | 75.83 | None | 18.33 |
| None | 3.33 | Others | 23.33 |

PDS ration (87.50%) and MGNREGA (75.83%) were the major support received by the responding families in the study area (Table 5.1.23). Agricultural support to the farmers was mainly provided by the Agriculture Department (57.50%) and other sources (23.33%) such as, the local village organizations and other progressive farmers.

## 5.2 DARJEELING DISTRICT OF WEST BENGAL

*Socio-economic status*

The socio-economic information of sample households of Darjeeling is presented in Table 5.2.1. The average age of the respondents was 46.23 years and a family was composed of on an average five members in the Darjeeling district of West Bengal. Majority of the respondents were Hindu (73.33%) and remaining 11.67 per cent were Christian. The Hindus were basically Nepali and belonged to either general caste (58.33%)

or OBC (20.83%) category while the Christians were mostly ST. The number of female was 933 per 1000 male and the literacy rate was 93.50 per cent. Maximum of the respondents had education up to Secondary (30.00%) level, followed by Middle (26.67%) and Primary (20.00%) school level. The farmers were mainly staying in semi-*pucca* (56.72%) or *pucca* (43.28%) types of dwellings (Table 5.2.1). The average land holding was calculated to be 1.29 ha out of which 82.18 per cent was irrigated.

Table 5.2.1. Socio-economic information of sample households of Darjeeling

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 46.23 | Sex ratio | per 1000 male | 932.52 |
| Family size | no. | 5.15 | | | |
| Social group | % | | Religion | % | |
| Schedule Tribe | | 17.50 | Christian | | 11.67 |
| Schedule Caste | | 2.50 | Hindu | | 73.33 |
| Other Backward Caste | | 20.83 | Islam | | 0.00 |
| Others | | 58.33 | Buddhist | | 15.00 |
| Housing structure | % | | Operational land holding | ha | 1.29 |
| *Kaccha* | | 0.00 | Upland | | 1.28 |
| Semi-*pucca* | | 56.72 | Lowland | | 3.00 |
| *Pucca* | | 43.28 | Irrigated land | % | 82.18 |
| Educational status | % | | Educational status | % | |
| Illiterate | | 7.50 | Middle | | 26.67 |
| Literate | | 2.50 | Secondary | | 30.00 |
| Literate but below primary | | 5.00 | Higher Secondary | | 11.67 |
| Primary | | 20.00 | Graduate | | 5.00 |

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in Darjeeling district is eliciated in Table 5.2.2 to Table 5.2.4. All of the respondent farmers reported the problem of water stress or drought like situation in their farms and felt that the climate has been changing over the years and especially in the last ten years (Table 5.2.2).

Table 5.2.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in Darjeeling

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 100.00 | Yes | 100.00 |
| Acidity | 0.00 | Not sure | 0.00 |
| Others | 0.00 | Do not know | 0.00 |

The farmers of the district perceived that the summer (98.33%) as well as winter (45.00%) temperature has increased (Table 5.2.3). About 89.19 per cent of the responding farmers perceived that the monsoon rainfall has declined over the years, while about 68.29 per cent felt that winter rainfall has not changed. Although the monsoon rainfall has also become late (90.09%) but the timing has not changed for winter rainfall (84.17%).

| Table 5.2.3. Farmers' perception (%) about change in temperature and rainfall in Darjeeling | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.83 | 17.50 | Late | 90.09 | 3.33 | Low | 89.19 | 23.17 |
| Increase | 98.33 | 45.00 | Early | 2.70 | 0.00 | High | 4.50 | 0.00 |
| No change | 0.83 | 36.67 | No change | 5.41 | 84.17 | No change | 2.70 | 68.29 |
| Not sure | 0.00 | 0.83 | Not sure | 1.80 | 12.50 | Not sure | 3.60 | 8.54 |

| Table 5.2.4. Unexpected change encountered by the respondents in Darjeeling (in %) | | | | | | |
|---|---|---|---|---|---|---|
| Response | Long dry spell | | Drought incidence | | Hailstorm | |
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 49.21 | 46.88 | 43.40 | 51.61 | 64.29 | 44.00 |
| Yes | 15.87 | 3.13 | 35.85 | 0.00 | 0.00 | 48.00 |
| No change | 15.87 | 46.88 | 11.32 | 48.39 | 28.57 | 4.00 |
| Not sure | 19.05 | 3.13 | 7.55 | 0.00 | 7.14 | 4.00 |

Most of the respondents (49.21%) did not recall incidence of long unexpected dry spell within a rainy period but about 35.85 per cent of the respondents recalled unexpected drought incidence during monsoon and 48 per cent informed about unexpected hailstorms during winter season (Table 5.2.4).

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.2.5 to Table 5.2.9.

Any change in the rainfall pattern, affects the area under crop. About 78.57 per cent of the farmers have reported that they reduced the area under rice crop in case of drought and which resulted into increased fallow area but majority of the respondents (80.00% and 87.18%) did not change the crop area in case of early or late rainfall, respectively (Table 5.2.5). Similar trend was observed in case of maize also.

| Table 5.2.5. Effects of rainfall variability on area under rice, maize and fallow in Darjeeling (in %) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Response | Rice area | | | Maize area | | | Fallow | | |
| | Early | Late | Drought/ Low rain | Early | Late | Drought/ Low rain | Early | Late | Drought/ Low rain |
| Decrease | 20.00 | 10.26 | 78.57 | 13.33 | 25.58 | 81.61 | 0.00 | 33.33 | 0.00 |
| Increase | 0.00 | 2.56 | 0.00 | 0.00 | 2.33 | 0.00 | 0.00 | 0.00 | 100.00 |
| No change | 80.00 | 87.18 | 21.43 | 86.67 | 72.09 | 17.24 | 100.00 | 66.67 | 0.00 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.15 | 0.00 | 0.00 | 0.00 |

The sample farmers informed that low rainfall (100%) and change in timing of rainfall (98.72%) lead to reduction in the productivity of paddy (Table 5.2.6). The yield losses were more than 40 per cent for both rice and maize. More than 60 per cent of the farmers perceived that the incidences of pests and diseases on cereal crops have increased in recent times which may be due to the change in climate. The disease infestations were higher in rice than maize crop. On an average, the productivity reduced by 14.92 per cent in case of rice and 17.19 per cent in case of maize (Table 5.2.7).

Table 5.2.6. Effects of rainfall variability on yield of rice and maize in Darjeeling

| Response | Direction (in %) | | | | | | Quantum (kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rice | | | Maize | | | Rice | | Maize | |
| | Low | High | Early/ Late | Low | High | Early/ Late | Drought/Low | Normal | Drought / Low | Normal |
| Decrease | 100.00 | 0.00 | 98.72 | 100.00 | 0.00 | 97.50 | 770.38 | 1432.49 | 457.94 | 901.11 |
| Increase | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | -46.22% | | -49.18% | |
| No change | 0.00 | 100.00 | 0.00 | 0.00 | 100.00 | 0.00 | | | | |
| Not sure | 0.00 | 0.00 | 1.28 | 0.00 | 0.00 | 0.00 | | | | |

Table 5.2.7. Effect of change in climate on pest and disease infestation in Darjeeling (in %)

| Response | Rice | | Maize | | Crop damaged | |
|---|---|---|---|---|---|---|
| | Disease | Pest | Disease | Pest | Rice | Maize |
| Decrease | 17.46 | 18.31 | 12.77 | 3.77 | 14.92 | 17.19 |
| Increase | 61.90 | 60.56 | 31.91 | 64.15 | | |
| No change | 15.87 | 14.08 | 48.94 | 26.42 | | |
| Not sure | 4.76 | 5.63 | 6.38 | 5.66 | | |
| New Disease | 0.00 | 1.41 | 0.00 | 0.00 | | |

Table 5.2.8. Perception (in %) about effect of climate change on availability of food in Darjeeling

| Particulars | Normal | Drought/Low rainfall |
|---|---|---|
| Supply of food from own land (months) | 4.51 | 3.33 |
| Perception (%) | | |
| Insufficient/decline | 8.55 | 37.39 |
| Sufficient/improve | 11.97 | 5.22 |
| No change | 79.49 | 57.39 |
| Not sure | 0.00 | 0.00 |

Table 5.2.9. Sufficiency of money for purchase of food during Effects of climatic variability and who gets sufficient foodin Darjeeling

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Sufficiency of money for purchase of food | 96.61 | Family members | |
| Family members | | Grown up children | 0.83 |
| Husband | 0.83 | Elders | 0.00 |
| Wife | 0.00 | All members | 97.50 |
| Both husband & wife | 0.00 | Do not know | 1.68 |

In normal seasons the farm produce lasted for 4.51 months for family consumption but during climatic variability they could consume for 3.3 months only (Table 5.2.8). About 37.39 per cent of the farmers reported that availability of food became insufficient during drought/low rainfall situations (Table 5.2.8) but majority of the respondents replied that they could afford food (Table 5.2.9). There was no gender discrimination about distribution of food during climatic variability in Darjeeling district.

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.2.10 and Table 5.2.11.

| Table 5.2.10. Responses (in %) about change in water availability during low rainfall or drought situation in Darjeeling | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 96.46 | 78.15 |
| Increase | 0.00 | 0.00 |
| No change | 1.77 | 21.01 |
| Not sure | 0.88 | 0.93 |

| Table 5.2.11. Response (%) on water scenario in the village in Darjeeling | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 10.83 | 14.53 | 44.35 |
| Yes | 84.17 | 81.20 | 53.04 |
| Not sure | 5.00 | 4.27 | 2.61 |

Majority of the farmers reported that water availability for both, irrigation (96.46%) as well as drinking (78.15%) purposes reduced during the drought season (Table 5.2.10). Reducing drinking water facility in the village was reported by 81.20 percent of the farmers and 84.17 per cent revealed that water for irrigation has become inadequate over time. An overwhelming percentage (53.04%) of the farmers in Darjeeling district reported conflict in the village due to shortage of water in the last 5 years (Table 5.2.11).

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.2.12 to Table 5.2.14.

| Table 5.2.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Darjeeling | | | | | |
|---|---|---|---|---|---|
| Source of cooking fuel | | Who collects wood? | | Fire wood availability during drought/low rainfall | |
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 99.17 | Husband | 10.92 | Decrease | 30.77 |
| Charcoal | 0.00 | Wife | 6.72 | Increase | 3.85 |
| Cow dung | 0.00 | Both | 16.81 | No change | 64.42 |
| LPG | 49.17 | Grown up children | 9.24 | Not sure | 0.96 |
| | | Elders | 7.56 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | All members | 44.54 | | |
| | | Market | 4.20 | | |

Even though 49.17 per cent of the respondents were having LPG connection, nearly all of them used wood for fuel purpose (Table 5.2.12). Most of them were of the opinion that all the members of a family collect wood but about 16.81 per cent informed that both wife and husband in the household were responsible for collecting wood from nearby jungle. The availability of wood has remained unchanged (64.42%) in the area during low rainfall or drought like situation but 30.77 per cent opined that as most of the farmers in the villages collect wood during this time for future use, resulting in low availability of wood (Table 5.2.12), which was reflected by increase in time for wood collection (Table 5.2.13).

Table 5.2.13. Perception about effect on time spent (hr/day) during climatic variability (in %) in Darjeeling

| Activities | Normal | Drought/Low rainfall |
|---|---|---|
| Fodder collection/grass cutting | 1.41 | 1.79 |
| Fetching drinking water | 0.29 | 0.44 |
| Wood collection | 1.84 | 2.73 |
| Working hours in crop field | 6.23 | 6.43 |

Table 5.2.14. Perception (in %) about extra burden shared during climatic variabilityin Darjeeling

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 31.09 | 30.34 | 37.72 | 22.50 |
| Female | 11.76 | 22.47 | 6.14 | 3.33 |
| Both male & female | 57.14 | 47.19 | 56.14 | 74.17 |

Contrary to our expectation, in case of extra burden during climatic variability, most of it was shared by either both male and female or only the male member of the household (Table 5.2.14).

*Adaptation and mitigation strategy*

The adaptation and mitigation strategies followed by the sample farmers in Darjeeling district are presented in Table 5.2.15 to Table 5.2.19.

Table 5.2.15. Adaptation strategy followed in agriculture in Darjeeling (in %)

| Strategy | Late rainfall | Early rainfall | Drought/Low rainfall |
|---|---|---|---|
| Leave complete fallow | 0.00 | 0.00 | 0.98 |
| Grow dry fodder crops | 0.00 | 0.00 | 0.00 |
| Change in cropping sequence | 1.92 | 0.00 | 2.91 |
| Change in crop cultivar/ landrace | 1.92 | 0.00 | 1.94 |
| Change in sowing/transplanting time | 73.08 | 7.69 | 75.73 |
| Change in harvesting time | 71.15 | 7.69 | 72.82 |
| Shift from crops to livestock | 0.96 | 0.00 | 0.97 |
| Grow more cash crops | 0.00 | 0.00 | 0.97 |

| | | | |
|---|---|---|---|
| Cultivate smaller area than usual | 15.38 | 0.00 | 43.69 |
| No change | 17.65 | 14.29 | 13.73 |

Changing the time of sowing and harvesting or cultivating lesser area were the major decisions the farmers have taken in case of change in rainfall pattern or climatic variability (Table 5.2.15). About 73.08 per cent and 75.73 per cent of the farmers changed sowing time in case of late rain and drought like situation, respectively and consequently their harvesting time also has changed. It was found that some of the farmers (17.65%) in case of late rain and 13.73% in case of drought like situation) did not take up any adaptation strategy in times of climatic variability.

Table 5.2.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Darjeeling

| Strategy | Frequency (%) | Strategy | Frequency (%) |
|---|---|---|---|
| Migrate | 7.50 | Start shop keeping | 0.83 |
| Wage labour | 72.50 | Devote more time in shop keeping | 3.33 |
| Go to neighbouring villages for labour work | 0.00 | Sell assets | 0.00 |
| Loan | 0.83 | Children drop out from school | 0.00 |

It was found that working as wage labor under MGNREGA which provides 100 days of employment opportunity was the best alternative source of livelihood for majority of the respondents (72.50%) in case of climatic variability (Table 5.2.16) whereas about 7.50 per cent searched job outside their villages (Table 5.2.17). Mostly they went to neighbouring village/town and about 11.11 per cent went outside the district and mainly the wives and female members were left behind at home.

Table 5.2.17. Migration by the farmers during climatic variability in Darjeeling

| Place of migration | Frequency (%) | Family members left at home | Frequency (%) |
|---|---|---|---|
| Neighbour village | 66.67 | Wife | 55.56 |
| Neighbour town | 11.11 | Minor | 0.00 |
| Outside district | 11.11 | Male grown up | 22.22 |
| State capital | 0.00 | Female grown up | 33.33 |
| Outside state | 33.33 | Elders | 22.22 |

Health management of animals, use of stress-tolerant cultivars, shift to improved cropping system and pest and disease management were the measures considered as preferable mitigating options to climate change by the farmers of the study area (Table 5.2.18).

Table 5.2.18. Mitigating options preferred by respondents in Darjeeling

| Options | Frequency (%) | Options | Frequency (%) |
|---|---|---|---|
| Use of stress-tolerant crop cultivar | 25.83 | Pest and disease management techniques such as IPM | 20.83 |
| Shift to improved cropping system | 25.83 | Development and use of crop cultivar resistant to pests and diseases | 1.67 |
| Planting of early, medium | 5.00 | New livestock breeds | 14.17 |

| | | | |
|---|---|---|---|
| or late cultivar to avoid crop loss to variations in drought/flood occurrence | | | |
| Short duration variety grow other additional crops | 7.50 | Animal health management | 26.67 |
| New land management techniques | 2.50 | Others | 0.00 |
| Changes in agricultural water-managed techniques | 3.33 | Do not know | 5.83 |

About 43.53 per cent of the rice growers have changed the cultivars which they earlier have cultivated, whereas in case of maize, only 8.79 per cent have changed cultivars (*Annex V(D)_I*).

| Table 5.2.19. Rice cultivars which are stopped and cultivars perceived as suitable in climate change scenario in Darjeeling | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivar | Reason | Cultivar | Reason |
| Adde | More straw but low yield | Javaca | Low productivity |
| Dudhe | low productivity and less tasty | Kala rang | Low productivity |
| Machino | low productivity, not suitable for water stress situation | Khosro | Low productivity |
| Kage | Low productivity | Athe | Low productivity |
| Jasuda | Low productivity | Manchuli | Low productivity |
| Jaupaka | Low productivity | Brampul | Low productivity |
| **Cultivars suitable in climate change scenario** | | | |
| Kage | Suitable in water stress situation | Adde | Suitable in water stress situation |

In the study area, yield (63.53) and taste (49.41%) were the major decisive factors that influenced the decision to continue or change a rice cultivar (*Annex V(D)_II*).Similar trend was found for maize crop also. They reported that *Kagge* and *Adde* were the two varieties which were resistant to water stress but they have stopped cultivating them due to lower level of yields (Table 5.2.19.). The sample farmers emphasized training on crop production management (35.83%), pest management (25.00%) and management of animals (23.33%) (*Annex V(D)_III*).

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.2.20 to Table 5.2.23.

| Table 5.2.20. Who has the access to agricultural information in Darjeeling? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Access to information | 49.17 | | |
| Member | | Elders | 0.00 |
| Men | 54.24 | Male grown children | 1.69 |
| Women | 1.69 | Female grown children | 0.00 |
| Both men and women | 40.68 | Do not know | 0.00 |

About 49.17 per cent of the farmers have access to agricultural information (Table 5.2.20). About 54.24 per cent opined that the male members of the household have

access to information whereas 40.68 per cent were of the view that both, male and female members equal have access to information.

| Table 5.2.21. Source of information on agriculture and weather in Darjeeling | | | | |
|---|---|---|---|---|
| Agriculture | | | Weather | |
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 50.85 | 44.07 | Radio | 0.83 |
| Progressive farmers | 32.20 | 25.42 | Newspaper | 4.17 |
| Fellow farmers | 71.19 | 64.41 | Television | 25.00 |
| Elders | 3.39 | 1.69 | Neighbour | 1.67 |
| Others | 0.00 | 0.00 | Family member | 0.00 |
| | | | Traditional knowledge | 40.83 |
| | | | Others | 0.00 |

Table 5.2.21 reveals that other farmers in the village (71.19% and 64.41%), institutions like KVK, ICAR, Agriculture Department, Block Office *etc.* (50.85% and 44.07%) and progressive farmers (32.20% and 25.42%) were the major source for agricultural information in normal periods as well as during extreme climatic variability (ECV). Interestingly, most of the respondents in the district used traditional knowledge (40.83%) and watched television (25.00%) for weather information (Table 5.2.21).

| Table 5.2.22. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Darjeeling | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 42.86 |
| Insurance scheme | |
| Crop | 22.50 |
| Livestock | 51.67 |
| Human | 80.00 |
| Other | 9.17 |

About 42.86 per cent have acquired loan for agricultural purposes and many of them were aware of crop (22.50%) and livestock (51.67%) insurance (Table 5.2.22).MGNREGA (91.67%) and PDS ration (97.50%) were the major support they received (Table 5.2.23). About 35.83 per cent of the respondents were member of SHGs. Agricultural support for the farmers was given mainly through the Agriculture Department (14.17%) and KVK/Block office (7.50%).

| Table 5.2.23. Type of support received and agencies that supported the farmers in Darjeeling | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.83 | Agriculture Department | 14.17 |
| Old Age Pension | 11.67 | Horticulture Department | 0.00 |
| PDS ration | 97.50 | Animal Husbandry/ Fisheries Department | 0.00 |
| MGNREGA program | 91.67 | Bank/ Cooperative Bank/Society | 5.83 |
| Thrift and credit through SHGs | 35.83 | KVK/Block Office | 7.50 |

| | | | |
|---|---|---|---|
| Farmers' group | 5.83 | Meteorological department/ Irrigation Department | 0.00 |
| Health insurance | 3.33 | Health Department | 0.00 |
| Training on new rice technologies | 0.83 | Agricultural Universities | 0.00 |
| None | 0.83 | None | 57.50 |
| Support from NGOs | 0.00 | NGOs | 0.00 |

## 5.3 RI-BHOI DISTRICT OF MEGHALAYA

*Socio-economic status*

The socio-economic information of sample households of Ri-Bhoi district is presented in Table 5.3.1.

Table 5.3.1. Socio-economic information of sample households of Ri-Bhoi

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 42.08 | Sex ratio | per 1000 male | 1065.71 |
| Family size | no. | 6.04 | Religion | % | |
| Social group | % | | Christian | | 83.33 |
| Schedule Tribe | | 100.00 | Hindu | | 11.67 |
| Schedule Caste | | 0.00 | Islam | | 0.00 |
| Other Backward Caste | | 0.00 | Buddhist | | 0.00 |
| Housing structure | % | | Operational land holding | ha | 0.68 |
| *Kaccha* | | 20.83 | Upland | | 0.78 |
| Semi-*pucca* | | 55.00 | Lowland | | 0.53 |
| *Pucca* | | 24.17 | Irrigated land | % | 50.26 |
| Educational status | % | | Educational status | % | |
| Illiterate | | 26.89 | Middle | | 16.81 |
| Literate | | 6.72 | Secondary | | 12.61 |
| Literate but below Primary | | 5.00 | Higher Secondary | | 11.67 |
| Primary | | 6.72 | Graduate | | 0.84 |

The average age of the respondents was 42.08 years and a family comprised of six members (Table 5.3.1). Majority of them (83.33%) were Christian and remaining 11.67 per cent were Hindu. All of the respondents belonged to the ST category and there were about 1065 female per 1000 males. Majority of them were illiterate (26.89%), followed by respondents having Middle (16.81%), Secondary (12.61%) and Higher Secondary (11.67%) education, respectively. Most of them were residing in semi-*pucca* houses (55%), followed by *pucca* houses (24.17%) and *kaccha* houses (20.83%). The average operational landholding was 0.68 ha and 50.26 per cent of the land was irrigated.

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in Ri-Bhoi district is eliciated in Table 5.3.2 to Table 5.3.4. Low rainfall/drought (82.50%) was the major stress experienced by the farms in the study area (Table 5.3.2). All the sample farmers reported that they were aware of change in climate that has taken place over the last 10 years.

| Table 5.3.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in Ri-Bhoi | | | |
|---|---|---|---|
| Stress | Frequency (%) | Response | Frequency (%) |
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 82.50 | Yes | 100.00 |
| Acidity | 0.00 | Not sure | 0.00 |
| Others | 17.50 | Do not know | 0.00 |

| Table 5.3.3. Farmers' perception (%) about change in temperature and rainfall in Ri-Bhoi | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.83 | 7.50 | Late | 95.83 | 5.83 | Low | 99.16 | 6.67 |
| Increase | 94.17 | 80.83 | Early | 0.00 | 0.00 | High | 0.00 | 0.00 |
| No change | 3.33 | 9.17 | No change | 3.33 | 82.50 | No change | 0.00 | 80.83 |
| Not sure | 1.67 | 2.50 | Not sure | 0.83 | 11.67 | Not sure | 0.84 | 12.50 |

Majority of them perceived that the temperature has increased in the area for both, summer (94.17%) and winter (80.83%) season; the farmers also experienced both late rainfall (95.83%) and low rainfall (99.16%) during monsoon, but most of them reported no change in timing (82.50%) or amount (80.83%) of rainfall during winter season (Table 5.3.3).

| Table 5.3.4. Perception (%) about unexpected change encountered by the respondents in Ri-Bhoi | | | | | | |
|---|---|---|---|---|---|---|
| Response | Long dry spell | | Drought incidence | | Hailstorm | |
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 92.50 | 83.05 | 81.67 | 80.00 | 62.71 | 100.00 |
| Yes | 2.50 | 3.39 | 14.17 | 5.00 | 27.12 | 0.00 |
| No change | 0.00 | 10.17 | 1.67 | 12.50 | 0.00 | 0.00 |
| Not sure | 5.00 | 3.39 | 1.67 | 2.50 | 10.17 | 0.00 |

Although incidence of unexpected climatic change was low, 14.17 per cent of the respondents reported drought during monsoon (Table 5.3.4).

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.3.5 to Table 5.3.9.

| Table 5.3.5 Perception (%) about effect of climatic variability on area under rice and fallow in Ri-Bhoi | | | | | | |
|---|---|---|---|---|---|---|
| Response | Rice area | | | Fallow | | |
| | Early | Late | Drought/Low rainfall | Early rainfall | Late | Drought/ Low rainfall |
| Decrease | - | 7.02 | 40.00 | - | 0.00 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Increase | - | 0.00 | 0.00 | - | 100.00 | 100.00 |
| No change | - | 92.98 | 60.00 | - | 0.00 | 0.00 |
| Not Sure | - | 0.00 | 0.00 | - | 0.00 | 0.00 |

The decrease in area under rice during drought was reported by 40.00 per cent of the respondents who encountered low rainfall or drought like situations. But for majority of them (60.00%), the area under rice remained same in case of late rain or low rainfall (Table 5.3.5).

Table 5.3.6. Effect of rainfall variability on yield of rice in Ri-Bhoi

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low | High | Early/late | Drought/Low rainfall | Normal |
| Decrease | 99.07 | - | 100.00 | 1744.44 | 3029.23 |
| Increase | 0.00 | - | 0.00 | -42.41 % | |
| No change | 0.93 | - | 0.00 | | |
| Not Sure | 0.00 | - | 0.00 | | |

Yield of rice also decreased during periods of low rainfall and late rainfall as reported by 99.07 per cent and 100 per cent of the respondents, respectively. The average productivity of rice (3029.23 kg/ha) reduced by about42.41 per cent (1744.44 kg/ha) during drought (Table 5.3.6). Increasing incidences of pest and diseases was reported by 100 per cent and 98.94 per cent of the respondents, respectively during climatic variability which may be due to climate change (Table 5.3.7).

Table 5.3.7. Perception (%) about effect of change in climate on rice pest and disease in Ri-Bhoi

| Response | Disease | Pest | Crop damaged |
|---|---|---|---|
| Decrease | 0.00 | 0.00 | |
| Increase | 98.94 | 100.00 | |
| No change | 1.06 | 0.00 | 10.54 |
| Not sure | 0.00 | 0.00 | |
| New disease | 0.00 | 0.00 | |

The farmers could use the own farm produce for 10.47 months in normal years but during the climatic variability it lasted for 8.13 months only (Table 5.3.8). About 97.50 per cent of the respondents informed that the availability of food was insufficient during drought or low rainfall situations (Table5.3.8). Although 59.17 per cent of them did not have sufficient money to purchase food during drought like situations and 90.00 per cent of them said that they arranged food, somehow, for all the members of the family (Table 5.3.9).

Table 5.3.8 Effect of climate change on availability of food in Ri-Bhoi

| Particulars | Normal | Drought/Low rainfall |
|---|---|---|
| Supply of food from own land (months) | 10.47 | 8.13 |
| Perception (%) | | |
| Insufficient/decline | 15.83 | 97.50 |
| Sufficient/improve | 80.00 | 0.83 |
| No change | 3.33 | 1.67 |
| Not sure | 0.83 | 0.00 |

| Table 5.3.9 Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in Ri-Bhoi | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Sufficiency of money for purchase of food | 40.83 | | |
| Family members | | Grown up children | 4.17 |
| Husband | 0.00 | Elders | 0.83 |
| Wife | 0.83 | All members | 90.00 |
| Both husband and wife | 3.33 | Do not know | 0.00 |

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.3.10 and Table 5.3.11.

| Table 5.3.10. Responses (%) about change in water availability in Ri-Bhoi | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 88.57 | 75.68 |
| Increase | 2.86 | 2.70 |
| No change | 8.57 | 21.62 |
| Not sure | 0.00 | 0.00 |

| Table 5.3.11. Response (%) on water scenario in the village in Ri-Bhoi | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 2.52 | 13.33 | 97.48 |
| Yes | 93.28 | 68.33 | 2.52 |
| Not sure | 0.00 | 0.00 | 0.00 |

Though the water availability has improved in normal years in the district but majority of the farmers reported that availability of irrigation water (88.57%) and drinking water for human (75.68%) get reduced during drought periods (Table 5.3.10). Conflicts over water were rare in the last five years, even though 93.28 per cent and 68.33 per cent of them reported declining irrigation and drinking water facility in their villages (Table 5.3.11).

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.3.12 to Table 5.3.14.

| Table 5.3.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Ri-Bhoi | | | | | |
|---|---|---|---|---|---|
| Source of cooking fuel | | Who collects wood? | | Fire wood availability during drought | |
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 99.17 | Husband | 60.50 | Decrease | 6.72 |

| | | | | | |
|---|---|---|---|---|---|
| Charcoal | 0.00 | Wife | 5.88 | Increase | 39.50 |
| Cow dung | 0.00 | Both | 11.76 | No change | 46.22 |
| LPG | 6.67 | Grown up children | 10.08 | Not sure | 7.56 |
| | | Elders | 14.29 | | |
| | | All members | 0.00 | | |
| | | Market | 10.92 | | |

The major source of fuel in the area was wood (99.17%) and the husbands in the households (60.50%) primarily have performed the task of collecting wood (Table 5.3.12). About 46.22 per cent of the responding farmers said that availability of wood in the area was same, while 39.50 per cent of them reported increase in availability during drought period.

Table 5.3.13. Effect of climatic variability on time spent (hr/day) during climatic variability in Ri-Bhoi

| Activities | Normal | Drought |
|---|---|---|
| Fodder collection/grass cutting | 2.00 | 1.50 |
| Fetching drinking water | 1.54 | 2.23 |
| Wood (fuel) collection | 2.53 | 2.39 |
| Working hours in crop field | 6.53 | 6.97 |

During drought, the time spent on fetching drinking water (1.54 hr/day to 2.23 hr/day) increased significantly as they travelled far and waited in queue (Table 5.3.13). Extra burden of work during climatic variability was primarily shared by both, men and women in case of all type of activities in the study area (Table 5.3.14). About 30.43 per cent of respondents told that women shared the extra burden in case of fetching drinking water.

Table 5.3.14. Perception (%) about extra burden shared during climatic variability in Ri-Bhoi

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 0.00 | 1.74 | 18.63 | 11.67 |
| Female | 0.00 | 30.43 | 4.90 | 0.00 |
| Both male & female | 100.00 | 67.83 | 76.47 | 88.33 |

*Adaptation and mitigation strategy*

The adaptation and mitigation strategies followed by the sample farmers in Ri-Bhoi district are presented in Table 5.3.15 to Table 5.3.19. Change in sowing and consequently the harvesting time were the major adaptation strategies followed by the respondents during climatic variability; contrary to it about 20.87 per cent and 25.00 per cent of the respondents did not adapt any strategy in case of late rainfall and drought like situations, respectively which calls for attention (Table 5.3.15).

Wage labour was the best response to negative impact of climatic variability for sustaining livelihood, as revealed by majority (86.67%) of the respondents. Starting small businesses like shop keeping as an alternative source of livelihood was also reported by 6.67 per cent of them (Table 5.3.16). The mitigation options preferred by the farmers included use of stress-tolerant cultivars (93.33%), use of short duration crops (75.00%), adoption of pest and disease management techniques (69.17%) and shifting to improved cropping system (54.17%) (Table 5.3.17).

| Table 5.3.15. Adaptation strategy followed in agriculture in Ri-Bhoi | | | (in %) |
|---|---|---|---|
| Strategy | Late rainfall | Early rainfall | Drought/Low rainfall |
| Leave complete fallow | 0.96 | - | 6.98 |
| Grow dry fodder crops | 0.00 | - | 0.00 |
| Change in cropping sequence | 0.98 | - | 2.38 |
| Change in crop cultivar/ landrace | 0.00 | - | 2.38 |
| Change in sowing/transplanting time | 79.65 | - | 61.22 |
| Change in harvesting time | 77.88 | - | 61.22 |
| Shift from crops to livestock | 0.00 | - | 0.00 |
| Grow more cash crops | 4.90 | - | 2.33 |
| Cultivate smaller area than usual | 11.65 | - | 23.81 |
| No change | 20.87 | - | 25.00 |

| Table 5.3.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Ri-Bhoi | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 0.00 | Start shop keeping | 6.67 |
| Wage labour | 86.67 | Devote more time in shop keeping | 0.83 |
| Go to neighbouring villages for labour work | 0.00 | Sell assets | 0.00 |
| Loan | 0.00 | Children drop out from school | 0.00 |

Majority of the farmers (76.92%) in the area revealed that they have changed rice cultivars in the past (*Annex V(MG)_I*). The decisions what to grow was taken by husband and wife jointly (88.33%). The major factors influencing whether to continue or change a cultivar were the number of panicles (90.53%), yield (89.47%), number of shoots (74.74%), resistance to disease (66.32%) and pest (65.26%) and taste (70.09%). Market price (43.16%) and demand (41.05%) were other important factors on choosing a cultivar (*Annex V(MG)_II*). The cultivars like *Baphri, Eithati, Lai Pawa, Lahi, Lakang, Lyngkot Saw, Matiasra etc.* were considered as suitable in climate change scenario by the farmers of Ri-Bhoi district of Meghalaya (Table 5.3.18.). The farmers expressed that training should have more emphasis on pest management (65.83%), water management (42.50%) and seed health management (40.83%) technique (*Annex V(MG)_III*).

| Table 5.3.17. Mitigating options preferred by respondents in Ri-Bhoi | | | |
|---|---|---|---|
| Options | Frequency (%) | Options | Frequency (%) |
| Use of stress-tolerant crop cultivar | 93.33 | Pest and disease management techniques such as IPM | 69.17 |
| Shift to improved cropping system | 54.17 | Development and use of crop cultivar resistant to pests and diseases | 29.17 |

| | | | |
|---|---|---|---|
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 11.67 | New livestock breeds | 24.17 |
| Short duration variety grow other additional crops | 75.00 | Animal health management | 21.67 |
| New land management techniques | 7.50 | Others | 0.00 |
| Changes in agricultural water-managed techniques | 15.00 | Do not know | 0.00 |

Table 5.3.18. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in Ri-Bhoi

| **Cultivars stopped** | | | |
|---|---|---|---|
| Cultivar | Reason | Cultivar | Reason |
| Assam | Low productivity and taste not preferred | Lyngkot Saw | low productivity and higher fertilizer requirement |
| Bara | Low productivity, taste not preferred, cannot withstand water stress | Mataisara | Cannot withstand heat stress and prone to lodging due to tallness |
| Eithati, Manipur | Low productivity (but taste is good) | Mynri | Low productivity and cannot withstand stress |
| Kharhali /kharlain | Low productivity | Sohkyrlieh | Low productivity and cannot withstand stress |
| Khrahati | Low productivity and cannot withstand stress | Tihar | Taste is not preferred |
| Lahi | Low productivity | Tlangiong | Low productivity |
| Lai Pawa | Low productivity | Kbastem | Low productivity and cannot withstand stress |
| Lakang | Low productivity | | |
| **Cultivars suitable in climate change scenario** | | | |
| Assam | Withstand water stress | Lai Pawa | can withstand water and heat stress |
| Baphri | Withstand stress | Lakang | Withstand water stress |
| Barma | Withstand stress (Low rainfall) | Lyngkotsaw | Withstand water stress |
| Eithati | Withstand drought / stress | Matiasra | Withstand water and heat stress |
| Lahi | Withstand water stress (suitable for uplands) and wind | | |

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.3.19 to Table 5.3.22.

Table 5.3.19. Who has the access to agricultural information in Ri-Bhoi?

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Access to information | 23.33 | | |
| Member | | Elders | 3.57 |
| Men | 10.71 | Male grown children | 0.00 |
| Women | 3.57 | Female grown children | 0.00 |
| Both men and women | 82.14 | Do not know | 0.00 |

| Table 5.3.20. Source of information on agriculture and weather in Ri-Bhoi | | | | |
|---|---|---|---|---|
| Agriculture | | | Weather | |
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 100.00 | 26.92 | Radio | 1.67 |
| Progressive farmers | 50.00 | 0.00 | Newspaper | 31.67 |
| Fellow farmers | 0.00 | 0.00 | Television | 68.33 |
| Elders | 0.00 | 0.00 | Neighbour | 56.67 |
| Others | 0.00 | 0.00 | Family member | 0.00 |
| | | | Traditional knowledge | 18.33 |
| | | | Others | 0.00 |

| Table 5.3.21. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Ri-Bhoi | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 5.83 |
| Insurance scheme | |
| Crop | 1.67 |
| Livestock | 2.50 |
| Human | 25.21 |
| Other | 0.00 |

Only 23.33 per cent of the total respondents have accessed information on agriculture in the study area and majority of them felt that both, men and women (82.14%) have access to information (Table 5.3.19.). They have received information from institutions like ICAR, Agriculture Department, Block Office, *panchayats* and progressive farmers in the village during normal years whereas, during ECV years only 26.92 per cent of them reported that these institutions provided specific information, which implies absence of specific agricultural information during ECVs (Table 5.3.20). Television (68.33%), neighbours (56.67%) and newspaper (31.67%) were the sources of weather information.

| Table 5.3.22. Type of support received and agencies that supported the farmers in Ri-Bhoi | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 5.83 | Agricultural Department | 3.33 |
| Old age pension | 5.83 | Horticultural Department | 0.00 |
| PDS ration | 70.00 | Animal Husbandry/ Fisheries Department | 4.17 |
| MGNREGA program | 95.00 | Bank/ Cooperative bank/society | 3.33 |
| Thrift and credit through SHGs | 1.67 | KVK/Block Office | |
| Farmers' group | 0.00 | Meteorological department Irrigation Department | 2.50 |
| Health insurance | 20.00 | Health Department | 0.00 |

| | | | |
|---|---|---|---|
| Training on new rice technologies | 0.83 | Agricultural Universities | 69.17 |
| None | 1.67 | None | 0.00 |

Awareness on insurance schemes needs to be disseminated as very few respondents were aware of insurance, such as crop (1.67%), livestock (2.50%) and human (25.21%) insurances (Table 5.3.21). Major support received by the respondents was through the MGNREGA scheme (95.00%) (Table 5.3.22). Benefit of PDS ration was availed by 70 per cent of the sampled farmers. Agricultural universities and institutes like the ICAR were the main organizations that supported the farmers in Ri-Bhoi district (Table 5.3.22).

## 5.4 WEST KAMENG DISTRICT OF ARUNACHAL PRADESH

*Socio-economic status*

Table 5.4.1. Socio-economic information of sample households of West Kameng

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 35.08 | Sex ratio | per 1000 male | 921.82 |
| Family size | no. | 4.89 | | | |
| Social Group | % | | Religion | % | |
| Schedule Tribe | | 98.33 | Christian | | 0.83 |
| Schedule Caste | | 0.00 | Hindu | | 0.83 |
| Other Backward Caste | | 0.00 | Islam | | 0.00 |
| Others | | 0.83 | Buddhist | | 98.33 |
| Housing structure | % | | Operational land holding | ha | |
| *Kaccha* | | 44.17 | Upland | | 1.55 |
| Semi-*pucca* | | 55.00 | Lowland | | 1.70 |
| *Pucca* | | 0.88 | Irrigated land | % | 1.03 |
| Educational Status | % | | Educational Status | % | 19.55 |
| Illiterate | | 46.67 | Middle | | 13.33 |
| Literate | | 10.83 | Secondary | | 12.50 |
| Literate but below primary | | 5.00 | Higher Secondary | | 11.67 |
| Primary | | 6.67 | Graduate | | 1.67 |

The socio-economic information of sample households of West Kameng district of Arunachal Pradesh is presented in Table 5.4.1. The average age of the respondents was 35.08 years in West Kameng district of Arunachal Pradesh and a family was comprised of, on an average, five members. Majority of them were Buddhist (98.33%) and belonged to the ST category (98.33%). About 46.67 per cent of the respondents were illiterate. Formal education of Middle and Secondary level was attained by 13.33 per cent and 12.50 per cent of the sample farmers, respective. There were 921 female per 1000 male in the study area. The respondents were mainly living in semi-*pucca* (55.00%) and *kaccha* (44.17%) houses. Only 0.88 per cent of the respondents were residing in *pucca* houses, which shows weak socio-economic standing of the people residing in the area. On an average a household possessed 1.55 ha of agricultural land and only 1.03 per cent of land was irrigated (Table 5.4.1.).

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in West Kameng district is eliciated in Table 5.4.2 to Table 5.4.4.

Table 5.4.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in West Kameng

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 1.67 | No | 0.00 |
| Drought/Water stress | 58.33 | Yes | 100.00 |
| Acidity | 54.17 | Not sure | 0.00 |
| Others (late rainfall) | 35.00 | Do not know | 0.00 |

Water stress or drought (58.33%) and soil acidity (54.17%) were the major stress the farms encountered in the study area. About 35.00 per cent of the responding farmers (others) felt late rainfall also put stress on to their farms (Table 5.4.2). It was noted that all the respondents in the study area were aware of the change in climate in the area over the years.

Table 5.4.3. Farmers' perception (%) about change in temperature and rainfall in West Kameng

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.00 | 34.17 | Late | 96.67 | 8.33 | Low | 95.00 | 10.00 |
| Increase | 95.83 | 57.50 | Early | 0.83 | 0.00 | High | 4.17 | 0.00 |
| No change | 4.17 | 7.50 | No change | 0.83 | 36.67 | No change | 0.83 | 41.67 |
| Not sure | 0.00 | 0.83 | Not sure | 1.67 | 55.00 | Not sure | 0.00 | 48.33 |

Majority of the respondents (95.83%) expressed that the summer temperature has risen in the area over the years (Table 5.4.3). Although 57.50 per cent of the respondents reported rise in winter temperatures, about 34.17 per cent of them reported that the winter temperature has fallen over the years which clearly indicated the difference in perception about climate change by the farmers of the district. Majority of the respondents perceived that onset of monsoons have been delayed (96.67%) and quantum of rainfall have declined (95.00%) during monsoon seasons. In case of winter rainfall either they felt no change or were not sure about of any change in rainfall pattern (Table 5.4.3).

Table 5.4.4. Unexpected change encountered by the respondents in West Kameng (in %)

| Response | Long dry spell | | Drought incidence | | Hailstorm | |
|---|---|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 95.00 | 93.33 | 41.67 | 94.17 | 59.17 | 70.00 |
| Yes | 0.00 | 0.00 | 58.33 | 0.00 | 35.00 | 17.50 |
| No change | 3.33 | 1.67 | 0.00 | 0.00 | 0.00 | 4.17 |
| Not sure | 1.67 | 5.00 | 0.00 | 5.83 | 5.83 | 8.33 |

Unexpected long dry spells during summer and winter were not reported by any respondents and only 58.33 per cent reported unexpected drought incidences during summer (Table 5.4.4). Unexpected incidence of hailstorms during summer and winter was reported by 35.00 per cent and 17.50 per cent of the respondents, respectively.

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.4.5 to Table 5.4.9.

Table 5.4.5. Effect of rainfall variability on area under rice, maize and fallow in West Kameng (in %)

| Response | Rice area | | Maize area | | Fallow | |
|---|---|---|---|---|---|---|
| | Late rainfall | Drought | Late rainfall | Drought | Late rainfall | Drought |
| Decrease | 13.79 | 5.26 | 5.50 | 0.00 | 0.00 | 0.00 |
| Increase | 0.00 | 0.00 | 0.00 | 0.00 | 14.06 | 8.57 |
| No change | 86.21 | 91.23 | 94.50 | 100.00 | 85.94 | 85.71 |
| Not sure | 0.00 | 3.51 | 0.00 | 0.00 | 0.00 | 5.71 |

Table 5.4.6. Effect of rainfall variability on yield of rice and maize in West Kameng (in %)

| Response | Rice | | | Maize | | |
|---|---|---|---|---|---|---|
| | Low | High rainfall | Early/late | Low | High | Early/late |
| Decrease | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 93.88 |
| Increase | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| No change | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.12 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 5.4.7. Effect of change in climate on pest and disease infestation in West Kameng (in %)

| Response | Rice | | Maize | | Crop damaged | |
|---|---|---|---|---|---|---|
| | Disease | Pest | Disease | Pest | Rice | Maize |
| Decrease | 0.00 | 0.00 | 0.00 | 0.00 | 12.71 | 7.36 |
| Increase | 100.00 | 73.68 | 95.24 | 98.70 | | |
| No change | 0.00 | 26.32 | 0.00 | 0.00 | | |
| Not sure | 0.00 | 0.00 | 4.76 | 1.30 | | |

It was found that most of the farmers have not changed area under the cereal crops in case of late or low rainfall situations (Table 5.4.5). All of the respondents reported that productivity of cereal crops decreased during low rainfall or drought like situations (Table 5.4.6).

While increasing disease incidence was reported by all of the responding farmers, 73.68 per cent of them also reported increase in pest incidence which may be due to climate change in the area (Table 5.4.7). The damage due to pest and disease infestation in maize crop was relatively lesser in comparison to rice crop.

Table 5.4.8. Effect of climate change on availability of food in West Kameng

| Particulars | Normal | Drought |
|---|---|---|
| Supply of food from own land (months) | 6.75 | 6.47 |
| Perception (%) | | |
| Insufficient/decline | 2.65 | 58.62 |

| | | |
|---|---|---|
| Sufficient/improve | 84.07 | 41.38 |
| No change | 11.50 | 0.00 |
| Not sure | 1.77 | 0.00 |

| Table 5.4.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during in West Kameng | |
|---|---|
| Particulars | Frequency (%) |
| Sufficiency of money for purchase of food | 60.00 |
| Family members | |
| Husband | 0.00 |
| Wife | 0.83 |
| Both husband and wife | 9.17 |
| Grown up children | 4.17 |
| Elders | 1.67 |
| All members | 75.00 |
| Do not know | 9.24 |

The farmers informed no significant change about how many months the own farm produce was consumed at home (6-7 months) in normal or low rainfall situations (Table 5.4.8). Although only 2.65 per cent of the responding farmers reported decline in food availability during normal times, in case of climatic variability the almost 58.62 per cent of them were finding difficulty due to non-availability of food for their family's consumption (Table 5.4.8). About 60 per cent of the respondents reported difficulty in purchasing food during climatic variability (Table 5.4.9) but the distribution of food among the members was equitable.

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.4.10 and Table 5.4.11.

| Table 5.4.10. Responses (in%)about change in water availability in West Kameng | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 100.00 | 39.56 |
| Increase | 0.00 | 50.55 |
| No change | 0.00 | 9.89 |
| Not sure | 0.00 | 0.00 |

| Table 5.4.11. Response (%) on water scenario in the village in West Kameng | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 45.00 | 61.67 | 94.17 |
| Yes | 48.33 | 33.33 | 5.83 |
| Not sure | 6.67 | 5.00 | 0.00 |

All of them have reported that the water for irrigation become scanty during low rainfall situations but the drinking water situations has not been as bad due to proper government initiatives (Table 5.4.10). Even though, shortage of irrigation and drinking water in the village was reported by 48.83 per cent and 33.33 per cent of the respondents, respectively. Only 5.83 per cent of the farmers reported any conflict in the village in the last five years due to water shortage (Table 5.4.11).

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.4.12 to Table 5.4.14.

Table 5.4.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in West Kameng

| Source of cooking fuel | | Who collects wood? | | Fire wood availability during drought/low rainfall | |
|---|---|---|---|---|---|
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 99.17 | Husband | 24.37 | Decrease | 82.22 |
| Charcoal | 1.67 | Wife | 8.40 | Increase | 6.67 |
| Cow dung | 0.00 | Both | 46.22 | No change | 11.11 |
| LPG | 40.83 | Grown up children | 5.04 | Not sure | 0.00 |
| | | Elders | 10.92 | | |
| | | All members | 5.88 | | |
| | | Market | 1.68 | | |

Table 5.4.13. Effect of climatic variability on time spent (hr/day) during climatic variability in West Kameng

| Activities | Normal | Drought |
|---|---|---|
| Fodder collection/grass cutting | 1.88 | 1.00 |
| Fetching drinking water | 1.13 | 1.10 |
| Wood (fuel) collection | 2.90 | 2.55 |
| Working hours in crop field | 7.31 | 7.10 |

In West Kameng district nearly all of the respondents used wood as a primary source of fuel and 40.83 per cent had LPG connection (Table 5.4.12). About 46.22 per cent of the respondents reported that both, male and female members of the households collected fire wood from the jungle whereas, about 24.17 per cent and 10.92 per cent of the sample farmers informed that wood was collected by the male member and elders, respectively. About 82.22 per cent of the respondents reported decline in availability of wood in their village due to deforestation by cutting and burning of trees in the forest (Table 5.4.12).

Table 5.4.14. Farmers' perception on extra burden shared during climatic variability in West Kameng (in %)

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 0.00 | 2.15 | 35.92 | 15.38 |
| Female | 12.50 | 56.99 | 4.85 | 4.40 |
| Both male & female | 87.50 | 40.86 | 58.25 | 80.22 |

Interestingly, Table 5.4.13 reveals that time spent in daily activities reduced during climatic variability. Although most of the extra burden during climatic variability was shared between both male and female but 56.99 per cent of the farmers reported that additional burden was on females in the case of fetching drinking water (Table 5.4.14).

*Adaptation strategy*

The adaptation and mitigation strategies followed by the sample farmers in West Kameng district are presented in Table 5.4.15 to Table 5.4.19.

Table 5.4.15. Adaptation strategy followed in agriculture in West Kameng (in %)

| Strategy | Late rainfall | Early rainfall | Drought |
|---|---|---|---|
| Leave complete fallow | 3.33 | 0.00 | 0.00 |
| Grow dry fodder crops | 0.00 | 0.00 | 0.00 |
| Change in cropping sequence | 0.83 | 0.00 | 0.00 |
| Change in crop cultivar/ landrace | 1.67 | 0.00 | 0.00 |
| Change in sowing/harvesting time | 40.83 | 0.00 | 0.00 |
| Change in harvesting time | 41.67 | 0.00 | 0.00 |
| Shift from crops to livestock | 0.00 | 0.00 | 0.00 |
| Grow more cash crops | 0.00 | 0.00 | 0.00 |
| Cultivate smaller area than usual | 0.00 | 0.00 | 0.00 |
| No change | 57.63 | 0.00 | 0.00 |

During late rains, 40.83 per cent of the respondents changed sowing time and subsequently the harvesting time was changed by 41.67 per cent of the respondents. No adaptation strategy was reported in case of drought, which was a cause of concern which needs to be resolved by the authorities (Table 5.4.15).

Table 5.4.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in West Kameng

| Strategy | Frequency (%) | Strategy | Frequency (%) |
|---|---|---|---|
| Migrate | 0.00 | Start shop keeping | 4.17 |
| Wage labour | 79.17 | Devote more time in shop keeping | 1.67 |
| Go to neighbouring villages for labour work | 16.67 | Sell assets | 0.00 |
| Loan | 0.83 | Children drop out from school | 0.00 |

Wage labour was the primary response (79.17%) to negative impact of climatic variability for sustaining livelihood as reported by majority of the farmers (Table 5.4.16). About 16.67 per cent of the farmers went to neighbouring villages for labour work but returned at their home daily in the evening.

Table 5.3.17. Mitigating options preferred by respondents in West Kameng

| Options | Frequency (%) | Options | Frequency (%) |
|---|---|---|---|
| Use of stress-tolerant crop cultivar | 60.83 | Pest and disease management techniques such as IPM | 30.00 |
| Shift to improved cropping system | 43.33 | Development and use of crop cultivar resistant to | 16.67 |

| | | | |
|---|---|---|---|
| | | pests and diseases | |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 27.50 | New livestock breeds | 2.50 |
| Short duration variety grow other additional crops | 51.67 | Animal health management | 4.17 |
| New land management techniques | 25.00 | Others | 0.00 |
| Changes in agricultural water-managed techniques | 6.67 | Do not know | 10.83 |

Table 5.4.18. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in West Kameng

| | | | |
|---|---|---|---|
| **Cultivar stopped** | | | |
| Cultivar | Reason | Cultivar | Reason |
| Chungshang | Taste not preferable | Wheat | |
| Zingra | Cannot withstand water stress and low productivity | Phunk | Production is not sufficient |
| Ninachas | | | |
| **Suitable in climate change scenario** | | | |
| Pangra | Good production even low rainfall and can stand stress | Sirfur | Withstand water stress |
| Maize | | Misbhalia | Withstand water stress |
| Slang | Withstand stress | Phinang | Withstand water stress |
| Michi | It can stand stress and good production only | Masuk | Less water |

Majority of the farmers preferred use of stress-tolerant crop cultivars (60.83%), growing short duration variety along with other additional crops (51.67%) and shift to improved cropping system (43.33%) as mitigating options during the times of climatic variability (Tab1e 5.4.17).

Only 5.08 per cent of the farmers have changed the rice cultivars at some point of time (*Annex V(AP)_I*). Either the husband and wife, jointly (75.83%) or the elders (17.50%) decided which cultivar to grow.

The farmers reported that *Pangra* in rice and *Slang and Michi*in case of Maize*, Sirfur, Misbhalia, Phinang* and *Masuk in* case of wheat crop were the stress tolerant varieties which they used to grow earlier (Table 5.4.18). Taste (13.56%), yield, appearance and market demand (8.47%) were the main characteristics which influenced the decisions to stop or continue a cultivar in the study area (*Annex V(AP)_II*). Seed health management, pest management and water management were the preferred areas on which farmers would like to have trainings (*Annex V(AP)_III*).

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.4.19 to Table 5.4.22.

Only 25.83 per cent of the respondents stated that they have access to information on agriculture and 67.74 per cent of them opined that information was available to both men and women, equally (Table 5.4.19). Institutions like ICAR, State Agricultural

Department, Block Office, *Panchayats* and the progressive farmers of the area were the main sources of information for the respondents in normal times (Table 5.4.20). The flow of specialized information was not encouraging during the time of ECV in the study area. Majority of them relied upon their traditional knowledge (90.00%) and neighbours (42.50%) for information on weather. Interestingly 10.00 per cent of them contacted Buddhist religious leaders (*lama*), for forecasting weather.

Table 5.4.19. Who has the access to agricultural information in West Kameng?

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Access to information | 25.83 | | |
| Member | | Elders | 6.45 |
| Men | 16.13 | Male grown children | 0.00 |
| Women | 12.90 | Female grown children | 0.00 |
| Both men and women | 67.74 | Do not know | 0.00 |

Table 5.4.20. Source of information on agriculture and weather in West Kameng

| Agriculture | | | Weather | |
|---|---|---|---|---|
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 96.77 | 32.26 | Radio | 2.50 |
| Progressive farmers | 35.48 | 6.45 | Newspaper | 5.83 |
| Fellow farmers | 6.45 | 0.00 | Television | 31.67 |
| Elders | 3.23 | 3.23 | Neighbour | 42.50 |
| Others | 0.00 | 0.00 | Family member | 0.00 |
| | | | Traditional knowledge | 90.00 |
| | | | Others | 10.00 |

Another cause of concern was the fact that none of the respondents found aware of crop or animal insurances (Table 5.4.21). Table 5.4.22 reveals that majority of the respondents received support mainly through employment under MGNREGA programme (85.00%) and PDS (84.17%). Also, State Agriculture Department, Horticulture Department and KVK were the agencies from which they received some kind of support under different schemes.

Table 5.4.21. Per cent of respondents accessed agricultural loan and heard about insurance schemes in West Kameng

| Particulars | Frequency (%) |
|---|---|
| Accessed agricultural loan | 1.67 |
| Insurance scheme | |
| Crop | 0.00 |
| Livestock | 0.00 |
| Human | 4.17 |
| Other | 0.00 |

| Table 5.4.22. Type of support received and agencies that supported the farmers in West Kameng | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.00 | Agricultural Department | 10.00 |
| Old Age Pension | 0.00 | Horticultural Department | 6.67 |
| PDS ration | 84.17 | Animal Husbandry/ Fisheries Department | 0.83 |
| MGNREGA program | 85.00 | Bank/ Cooperative bank/society | 0.83 |
| Thrift and credit through SHGs | 0.00 | KVK/Block Office | 11.67 |
| Farmers' group | 0.00 | Meteorological Department/ Irrigation Department | 0.00 |
| Health insurance | 2.50 | Health Department | 0.00 |
| Training on new rice technologies | 1.67 | Agricultural Universities | 0.00 |
| None | 6.67 | None | 60.83 |
| Support from NGOs | 0.00 | NGOs | 0.00 |

## 5.5 KARBIANGLONG DISTRICT OF ASSAM

*Socio-economic status*

| Table 5.5.1. Socio-economic information of sample households of Karbi Anglong | | | | | |
|---|---|---|---|---|---|
| Particulars | Unit | Value | Particulars | Unit | Value |
| Average age | years | 44.39 | Sex ratio | per 1000 male | 934.25 |
| Family size | no. | 5.89 | Religion | % | |
| Social Group | % | | Christian | | 6.67 |
| Schedule Tribe | | 38.33 | Hindu | | 92.50 |
| Schedule Caste | | 0.83 | Islam | | 0.00 |
| Other Backward Caste | | 48.33 | Buddhist | | 0.83 |
| Others | | 12.51 | Educational status | % | |
| | | | Illiterate | | 12.50 |
| Housing structure | % | | Literate | | 14.17 |
| *Kaccha* | | 2.50 | Literate but below Primary | | 5.83 |
| Semi-*pucca* | | 51.67 | Primary | | 18.33 |
| *Pucca* | | 45.83 | Middle | | 20.83 |
| Operational land holding | ha | 1.91 | Secondary | | 17.50 |
| Upland | | 0.00 | Higher Secondary | | 8.33 |
| Lowland | | 1.91 | Diploma/certificate | | 2.50 |
| Irrigated land | % | 6.59 | Graduate | | 0.00 |
| | | | Post Graduate | | 12.50 |

The socio-economic information of sample households of Karbi Anglong is presented in Table 5.5.1. The average age of the respondent farmers of Karbi Anglong district was 44.39 years and a family on an average, was composed of six members. Majority of them were Hindu (92.50%), remaining being Christian and Buddhist. Most of the respondents belonged to the OBC category (48.33%) and ST category (38.33%). The number of female was 934 per 1000 male and the literacy rate was 87.50 per cent.

Majority of the respondents were educated up to middle (20.83%) level, followed by primary (18.33%) and secondary education level (17.50%). They mainly stayed in semi-*pucca* or *pucca* type of houses. The operational landholding was 1.91 ha per household but only 6.59 per cent of the land was under irrigation (Table 5.5.1).

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in Karbi Anglong district is presented in Table 5.5.2 to Table 5.5.4.

Table 5.5.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in Karbi Anglong (in %)

| Stress | Frequency | Response | Frequency |
|---|---|---|---|
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 100.00 | Yes | 100.00 |
| Acidity | 0.00 | Not sure | 0.00 |
| Others | 0.00 | Do not know | 0.00 |

All of the respondent farmers reported the problem of water stress or drought like situation in their farms and felt that the climate has been changing over the years (Table 5.5.2).

Table 5.5.3. Farmers' perception (%) about change in temperature and rainfall in Karbi Anglong

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.00 | 40.00 | Late | 98.33 | 40.83 | Low | 100.00 | 93.33 |
| Increase | 100.00 | 59.17 | Early | 0.00 | 0.00 | High | 0.00 | 0.00 |
| No change | 0.00 | 0.83 | No change | 0.83 | 27.5 | No change | 0.00 | 2.50 |
| Not sure | 0.00 | 0.00 | Not sure | 0.83 | 31.66 | Not sure | 0.00 | 4.17 |

Table 5.5.3 reveals that all the farmers of the district perceived that the summer temperature has been increasing. In case of winter temperature, the opinions were divided as about 59.17 per cent of them felt that winter temperature has increased in last 10 years and 40.00 per cent of them told it has decreased. All of the respondents reported that the amount of rainfall has declined during monsoon season and an overwhelming 93.33 per cent of them felt similarly for winter rains. Nearly all of them reported that the onset of monsoon has been delayed in recent years.

Table 5.5.4. Unexpected change encountered by the respondents in Karbi Anglong (in %)

| Response | Long dry spell | | Drought incidence | | Flood | |
|---|---|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 69.17 | 67.50 | 0.00 | 0.00 | 100.00 | 100.00 |
| Yes | 27.50 | 28.33 | 99.17 | 98.33 | 0.00 | 0.00 |
| No change | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Not sure | 3.33 | 4.17 | 0.83 | 1.67 | 0.00 | 0.00 |

Majority of the respondents did not encounter long unexpected dry spell like situations within a rainy period in the study area but almost all of the respondents reported about unexpected drought incidence during monsoon and winter season (Table 5.5.4).

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.5.5 to Table 5.5.9.

Table 5.5.5. Effect of rainfall variability on area under rice and fallow in Karbi Anglong (in %)

| Response | Rice area | | Fallow | |
|---|---|---|---|---|
| | Late rainfall | Drought/Low rainfall | Late | Drought/Low rainfall |
| Decrease | 36.67 | 53.33 | 0.00 | 0.00 |
| Increase | 0.00 | 0.00 | 31.91 | 50.00 |
| No change | 63.33 | 46.67 | 68.09 | 50.00 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 |

About 36.67 per cent and 53.33 per cent of the farmers have reduced the area under rice crop in case of late rainfall and drought/low rainfall situations, respectively. Fallow area has increased in case of 31.91 per cent and 50.00 per cent of the farms during late rainfall and drought/low rainfall, respectively. This reflects the over dependency of the farmers on the rainfall for agriculture in the area (Table 5.5.5).

Table 5.5.6. Effects of rainfall variability on yield of rice in Karbi Anglong

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low | High | Late | Drought/Low rainfall | Normal |
| Decrease | 100.00 | 00.00 | 100.00 | 1854.65 (-39.27%) | 3054.13 |
| Increase | 0.00 | 0.00 | 0.00 | | |
| No change | 0.00 | 100.00 | 0.00 | | |
| Not sure | 0.00 | 0.00 | 0.00 | | |

All the sample farmers informed that low rainfall and delayed arrival of rainfall reduce the productivity of paddy. It is calculated that the productivity of rice declined by on an average of 39.27 per cent, *i.e.,* from 3054.13 kg/ha to 1854.75 kg/ha during the periods of droughts or low rainfall situations (Table 5.5.6).

Table 5.5.7. Effect of change in climate on pest and disease infestation in rice crop in Karbi Anglong (in %)

| Response | Disease | Pest | Crop damaged |
|---|---|---|---|
| Decrease | 3.64 | 1.69 | 16.35 |
| Increase | 89.09 | 95.76 | |
| No change | 7.27 | 2.54 | |
| Not sure | 0.00 | 0.00 | |

Majority of the responding farmers (89.09% and about 95.76%) perceived that the disease and pests infestations have increased in rice in recent times which may be caused by climate change and the loss in productivity is estimated to be about 16.35 per cent in case of rice crop (Table 5.5.7). Table 5.5.8 shows that the responding farmers' farm produce for home consumption was reduced from 10.86 months to 8.91 months in times of ECV. Majority (88.24%) of the farmers reported that availability of food become insufficient during droughts or low rainfall situations (Table 5.5.8) but they did not face any difficulty as majority of them have sufficient money for purchase of food from PDS or markets (Table 5.5.9). All the family members have had sufficient food during climatic variability which indicates that there is no gender discrimination in the study area (Table 5.5.9).

| Table 5.5.8. Effect of climate change on availability of food in Karbi Anglong | | |
|---|---|---|
| Particulars | Normal | Drought/Low rainfall |
| Supply of food from own land (months) | 10.86 | 8.91 |
| Perception (%) | | |
| Insufficient/decline | 5.83 | 88.24 |
| Sufficient/improve | 0.83 | 0.00 |
| No change | 93.33 | 11.76 |
| Not sure | 0.00 | 0.00 |

| Table 5.5.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in Karbi Anglong (in %) | | | |
|---|---|---|---|
| Particulars | Frequency | Particulars | Frequency |
| Sufficiency of money for purchase of food | 95.00 | Family members | |
| Family members | | Grown up children | 0.00 |
| Husband | 3.33 | Elders | 0.00 |
| Wife | 1.67 | All members | 98.33 |
| Both husband & wife | 0.00 | Do not know | 0.00 |

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.5.10 and Table 5.5.11.

| Table 5.5.10. Responses about change in water availability during low rainfall or drought situations in Karbi Anglong (in %) | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 100.00 | 87.50 |
| Increase | 0.00 | 0.00 |
| No change | 0.00 | 12.50 |
| Not Sure | 0.00 | 0.00 |

| Table 5.5.11. Response (%) on water scenario in the village in Karbi Anglong | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 0.00 | 0.00 | 94.17 |
| Yes | 97.50 | 92.50 | 5.83 |
| Not sure | 2.50 | 2.50 | 0.00 |

All the respondents reported about decrease in water availability for the purpose of irrigation and 87.50 per cent of them reported about decrease in availability of drinking water during drought season (Table 5.5.10). Similarly, majority of them informed about inadequate irrigation facility and reducing drinking water facility in the village also but only few reported about conflicts as a result of water shortage in the last 5 years in their villages (Table 5.5.11).

Table 5.5.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Karbi Anglong

| Source of cooking fuel | | Who collects wood? | | Fire wood availability during low rainfall | |
|---|---|---|---|---|---|
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 72.50 | Husband | 8.05 | Decrease | 43.06 |
| Charcoal | 0.00 | Wife | 0.00 | Increase | 15.28 |
| Cow dung | 27.50 | Both | 2.30 | No change | 31.94 |
| LPG | 15.00 | Grown up children | 6.90 | Not sure | 9.72 |
| | | Elders | 0.00 | | |
| | | All members | 41.38 | | |
| | | Market | 41.38 | | |

Majority of the respondents (72.50%) used wood for fuel purpose. About 27.50 per cent of them used cow dung as fuel and 15.00 per cent have LPG connections (Table 5.5.12). Either the respondent villagers purchased firewood from the nearby market (41.38%) or collected from nearby forest. In majority of the families (41.38%) the responsibility of collection of wood was shared by all the family members. Low availability of firewood during drought or low rainfall situations was reported by the farmers. Bamboo was used as firewood in Karbi Anglong and they reported that the growth and availability of bamboo declines during periods of low rainfall.

Table 5.5.13. Effect of climatic variability on time spent (hr/day) during climatic variability in Karbi Anglong

| Activities | Normal | Drought/Low rainfall |
|---|---|---|
| Fodder collection/grass cutting | 1.41 | 2.27 |
| Fetching drinking water | 0.61 | 0.83 |
| Wood (fuel) collection | 2.14 | 2.39 |
| Working hours in crop field | 7.26 | 6.00 |

Table 5.5.14. Extra burden shared during climatic variability in Karbi Anglong (in %)

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 1.14 | 0.95 | 7.32 | 1.80 |
| Female | 3.41 | 30.48 | 34.15 | 1.80 |
| Both male & female | 95.45 | 68.57 | 58.54 | 96.40 |

It was observed that the farmers put extra time on regular activities, especially for fodder collection during the periods of climatic variability (Table 5.5.13). Only in the case of working hours in the field, time spent reduced during climatic variability because of reduced farming area. Either both male and female of the family or only the female of a family shared the extra burden during climatic variability (Table 5.5.14).

| Table 5.5.15. Adaptation strategy followed in agriculture in Karbi Anglong (in %) | | |
|---|---|---|
| Strategy | Late rainfall | Drought/Low rainfall |
| Leave complete fallow | 0.00 | 10.83 |
| Grow dry fodder crops | 0.00 | 0.00 |
| Change in cropping sequence | 0.00 | 0.00 |
| Change in crop cultivar/ landrace | 0.83 | 0.83 |
| Change in sowing/harvesting time | 94.17 | 46.67 |
| Change in harvesting time | 91.67 | 45.00 |
| Shift from crops to livestock | 0.83 | 0.83 |
| Grow more cash crops | 0.83 | 1.67 |
| Cultivate smaller area than usual | 32.50 | 50.00 |
| No change | 5.00 | 19.17 |

In the study area, more than 90 per cent of the farmers have changed or delayed the sowing time and harvesting time in case of late rain; similarly, many of them changed the time of sowing and harvesting in case of drought. Also many farmers (32.50% and 50.00%) cultivated smaller area than usual in periods of late rainfall and drought situations (Table 5.5.15).

| Table 5.5.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Karbi Anglong (in %) | | | |
|---|---|---|---|
| Strategy | Frequency | Strategy | Frequency |
| Migrate | 2.50 | Start shop keeping | 3.33 |
| Wage labour | 62.50 | Devote more time in shop keeping | 3.33 |
| Go to neighbouring villages for labour work | 4.17 | Sell assets | 0.00 |
| Loan | 0.00 | Children drop out from school | 0.00 |
| | | Others | 21.67 |

In case of the extreme climatic variability, the sample farmers reported that resorting to alternatives like wage labour (62.50%) was the primary mean of sustaining livelihoods. About 21.67 per cent of the respondents resorted to business activities other than shop keeping. Only 2.50 per cent of the households reported migration (2.50%) or going to neighbouring villages for labour work (4.17%) during extreme climatic variability (Table 5.5.16).

| Table 5.5.17. Mitigating options preferred by respondents in Karbi Anglong | | | |
|---|---|---|---|
| Options | Frequency (%) | Options | Frequency (%) |
| Use of stress-tolerant crop cultivar | 71.67 | Pest and disease management techniques such as IPM | 18.33 |
| Shift to improved cropping system | 18.33 | Development and use of crop cultivar resistant to pests | 0.83 |

| | | | |
|---|---|---|---|
| | | and diseases | |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 4.17 | New livestock breeds | 1.67 |
| Short duration variety grow other additional crops | 2.50 | Animal health management | 15.00 |
| New land management techniques | 0.83 | Others | 0.00 |
| Changes in agricultural water-management techniques | 31.67 | Do not know | 0.83 |

Use of stress-tolerant cultivars (71.67%), changes in agricultural water management techniques (31.67%), pest and disease management (18.33%) and shifting to improved cropping system (18.33%) were the measures considered as preferable mitigating options to climate change by the farmers in the study area (Table 5.5.17).

About 58.33 per cent of the farmers reported that they have changed the cultivars but most of them have changed the varieties in alternative one or two years to sustain the productivity of the crop and the decisions to change cultivars were mainly taken by the husband (70.00%) or by both husband and wife (23.33%) in the household (*Annex V(KA)_I*).

| Table 5.5.18. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in Karbi Anglong | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Aijong | Low production | Mansoori | Low production |
| Goya | Low Production but good taste | Dharia | Low production |
| Ranjeet | Low Production in low rainfall conditions | Rongpa | Low production |
| IR-8 | Low production | Belgudi | Low production |
| Manohar | Low Production | Bahadur | Low production |
| Agrali | Low production | Kala Bora | Low production |
| **Cultivars suitable in climate change scenario** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Goya | Withstand water stress | Bahadur | Withstand water stress |
| IR-8 | Withstand water stress | | |
| | | | |

The sample farmers have stopped cultivating the cultivars like Aijong, Goya, Mansoori, Dharia *etc.* mainly due to low productivity. Suitable cultivars, as reported by the responding farmers, were *Goya, IR-8 and Ranjeet* (Table 5.5.18).

| Table 5.5.19.Who has the access to agricultural information in Karbi Anglong (in %) | | | |
|---|---|---|---|
| Particulars | Frequency | Particulars | Frequency |
| Access to information | 63.33 | Member | |
| Member | | Elders | 0.00 |
| Men | 38.16 | Male grown children | 0.00 |
| Women | 2.63 | Female grown children | 0.00 |
| Both men and women | 59.21 | Do not know | 0.00 |

In the study area, yield (88.33%), tolerance to drought (71.67%), taste (42.50%) and availability of seeds (30.00%) were the major factors that influenced the decisions to continue with or change a rice cultivar (*Annex V(KA)_II*). Training on crop production management (39.17%), animal management (37.50%) and water management (35.00%) were the need the respondent farmers reported (*Annex VII(KA)_III*).

The study revealed that 63.33 per cent of the farmers have access to agricultural information and about 59.21 per cent of the responding farmers opined that both male and female members have access to the information (Table 5.5.19). Institutions like KVK, ICAR, Agricultural Department, Block Office *etc.* (75.00%), fellow farmers in village (25.00%) and progressive farmers (17.11%) were the major source for agricultural information in normal periods as well as during ECV (Table 5.5.20).Majority of them used their own traditional knowledge (72.50%) or discussed with neighbours (25.00%) for understanding the weather information sources of the respondents in the study area (Table 5.5.20).

Table 5.5.20. Source of information on agriculture and weather in Karbi Anglong

| Agriculture | | | Weather | |
|---|---|---|---|---|
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 75.00 | 75.00 | Radio | 0.83 |
| Progressive farmers | 17.11 | 17.11 | Newspaper | 5.00 |
| Fellow farmers | 25.00 | 25.00 | Television | 7.50 |
| Elders | 2.63 | 2.63 | Neighbour | 25.00 |
| Others | 0.00 | 0.00 | Family member | 0.00 |
| | | | Traditional knowledge | 72.50 |
| | | | Others | 0.00 |

Table 5.5.21. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Karbi Anglong

| Particulars | Frequency (%) |
|---|---|
| Accessed agricultural loan | 11.67 |
| Insurance scheme | |
| Crop | 21.67 |
| Livestock | 10.83 |
| Human | 63.33 |
| Other | 4.17 |

Loans for agricultural purposes were obtained by 11.67 per cent of the farmers in the study area. Most of the respondents were only aware of human insurances and about 21.67 per cent and 10.83 per cent of the respondents were aware of crop and livestock insurance, respectively (Table 5.5.21).

Table 5.5.22. Type of support received and agencies that supported the farmers in Karbi Anglong

| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
|---|---|---|---|
| Housing | 0.00 | Agricultural Department | 40.00 |
| Old Age Pension | 1.67 | Horticultural Department | 0.00 |
| PDS ration | 70.83 | Animal Husbandry/ Fisheries Department | 0.83 |
| Thrift and credit through SHGs | 10.00 | Bank/ Cooperative | 1.67 |

| | | | |
|---|---|---|---|
| | | Bank/Society | |
| Farmers' group | 5.00 | KVK/Block Office | 14.17 |
| Health insurance | 1.67 | Meteorological Department/ Irrigation Department | 0.00 |
| Support from NGOs | 0.00 | Health Department | 0.00 |
| Training on new rice technologies | 0.83 | Agricultural Universities | 0.83 |
| MGNREGA program | 66.67 | None | 43.33 |
| None | 11.67 | NGO | 0.00 |

The supports the respondent farmers received were mainly PDS ration (70.83%) and income opportunities through MGNREGA (66.67%) in the study area (Table 5.5.22). Agricultural support to the farmers was mainly provided by the agricultural department (40.00%) and the KVK of the district (14.17%). No support from agencies/organizations for farming activities was reported by 43.33 per cent of the responding farmers of Karbi Anglong.

## 5.6DIMAPUR DISTRICT OF NAGALAND

*Socio-economic status*

The socio-economic information of sample households of Dimapur is presented in Table 5.6.1.

Table 5.6.1. Socio-economic information of sample households of Dimapur

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 42.28 | Sex ratio | per 1000 male | 920.33 |
| Family size | no. | 5.87 | Religion | % | |
| Social Group | % | | Christian | | 13.33 |
| Schedule Tribe | | 5.00 | Hindu | | 73.33 |
| Schedule Caste | | 1.67 | Islam | | 13.33 |
| Other Backward Caste | | 20.83 | Buddhist | | 0.00 |
| Others | | 70.00 | Educational status | % | |
| | | | Illiterate | | 24.17 |
| Housing structure | % | | Literate | | 75.83 |
| *Kaccha* | | 13.33 | Literate but below Primary | | 10.83 |
| Semi-*pucca* | | 47.50 | Primary | | 15.00 |
| *Pucca* | | 39.17 | Middle | | 19.17 |
| Operational land holding | ha | 3.48 | Secondary | | 14.17 |
| Upland | | 0.00 | Higher Secondary | | 5.00 |
| Lowland | | 3.48 | Graduate | | 2.50 |
| Irrigated land | % | 9.95 | Post Graduate | | 0.00 |

The average age of the respondent farmers of Dimapur district was 42.28 years and a family on an average, was composed of six members. Majority of them were Hindu (73.33%), followed by Christian and Muslim (13.33%). Most of the respondents belonged to the unreserved category (70.00%) and OBC category (20.83%). The number of female was 920.33 per 1000 male and the literacy rate was 75.83 per cent. Majority of the respondents were educated up to middle (19.17%) level, followed by primary (15.00%) and secondary education level (14.17%). Their housing is mainly semi-*pucca* type (47.50%) or *pucca* types (39.17%). The average land holding was calculated to be 3.48 ha, out of which only 9.95 per cent was irrigated (Table 5.6.1).

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in Dimapur district is represented in Table 5.6.2 to Table 5.6.4. All of the responding farmers reported the problem of water stress or drought like situation in their farms and felt that the climate has been changing over the years (Table 5.6.2).

Table 5.6.2. Types of stress farms experience and farmers' perception about change in climate over past 10 years in Dimapur

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 100.00 | Yes | 100.00 |
| Acidity | 0.00 | Not sure | 0.00 |
| Others | 0.00 | Do not know | 0.00 |

Table 5.6.3. Farmers' perception (%) about change in temperature and rainfall in Dimapur

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.00 | 67.50 | Late | 99.17 | 57.50 | Low | 99.17 | 75.83 |
| Increase | 100.00 | 22.50 | Early | 0.83 | 2.50 | High | 0.83 | 0.00 |
| No change | 0.00 | 6.67 | No change | 0.00 | 19.17 | No change | 0.00 | 16.67 |
| Not sure | 0.00 | 3.33 | Not sure | 0.00 | 20.83 | Not sure | 0.00 | 7.50 |

Table 5.6.4. Unexpected change encountered by the respondents in Dimapur (in %)

| Response | Long dry spell | | Drought incidence | | Flood | |
|---|---|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 55.00 | 53.33 | 0.83 | 8.33 | 100.00 | 100.00 |
| Yes | 40.00 | 37.50 | 95.00 | 76.67 | 0.00 | 0.00 |
| No change | 1.67 | 4.17 | 0.83 | 10.83 | 0.00 | 0.00 |
| Not sure | 3.33 | 5.00 | 3.33 | 4.17 | 0.00 | 0.00 |

All of the farmers of the district perceived that the summer temperature has increased and 22.50 per cent of them felt that winter temperature has also increased in last 10 years whereas, majority of them (67.50%) reported lower winter temperatures in recent times. Most of respondents reported that the amount of rainfall has declined during both, summer (99.17%) and winter (75.83%) season. The advents of monsoon rains have also been delayed off late (Table 5.6.3).

Almost half of the respondents encountered long unexpected dry spell like situations within a rainy period in the study area and majority of the respondents reported about unexpected drought incidence during monsoon and winter season, respectively (Table 5.6.4).

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.6.5 to Table 5.6.9.

Table 5.6.5 indicates that about 20.83 per cent and 50.83 per cent of the farmers have reduced the area under rice crop in case of late rainfall and drought/low rainfall situations, respectively as the state lacks proper irrigation facility. Fallow area increased by about 34.25 per cent and 41.89 percent in case of late rainfall and drought/low rainfall, respectively.

Table 5.6.5. Effect of climatic variability on area under rice and fallow in Dimapur (in %)

| Response | Rice area | | Fallow | |
|---|---|---|---|---|
| | Late | Drought/Low rainfall | Late | Drought/Low rainfall |
| Decrease | 20.83 | 50.83 | 0.00 | 0.00 |
| Increase | 0.00 | 0.83 | 34.25 | 41.89 |
| No change | 79.17 | 48.33 | 65.75 | 58.11 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 |

Table 5.6.6. Effects of rainfall variability on yield of rice in Dimapur

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low | High | Late | Drought/Low rainfall | Normal |
| Decrease | 100.00 | 0.00 | 100.00 | 1384.92 (-38.94%) | 2268.17 |
| Increase | 0.00 | 0.00 | 0.00 | | |
| No change | 0.00 | 100.00 | 0.00 | | |
| Not sure | 0.00 | 0.00 | 0.00 | | |

All the sample farmers informed that low rainfall and delayed arrival of rainfall reduced the productivity of paddy. The productivity of rice is declined by 38.94 per cent, from 2268.17 kg/ha in normal years to 1384.92 kg/ha during the periods of droughts or low rainfall situations (Table 5.6.6).

Table 5.6.7. Effect of change in climate on pest and disease infestation in Dimapur (in %)

| Response | Rice | | Crop damaged |
|---|---|---|---|
| | Disease | Pest | |
| Decrease | 0.00 | 0.00 | 16.56 |
| Increase | 53.33 | 95.83 | |
| No change | 46.67 | 4.17 | |
| Not sure | 0.00 | 0.00 | |

Majority of the responding farmers (53.33% and about 95.83%) perceived that the disease and pest and infestations have increased in rice in recent times which may be due to climate change and accounted for 16.56 per cent crop loss in case of rice in the study area (Table 5.6.7).

| Table 5.6.8. Effect of climate change on availability of food in Dimapur | | |
|---|---|---|
| Particulars | Normal | Drought/Low rainfall |
| Supply of food from own land (months) | 10.53 | 8.56 |
| Perception (%) | | |
| Insufficient/decline | 5.08 | 85.34 |
| Sufficient/improve | 12.71 | 0.86 |
| No change | 82.20 | 13.79 |
| Not sure | 0.00 | 0.00 |

Table 5.6.8 shows that the responding farmers' farm produce for home consumption was reduced from 10.53 months to 8.56 months in times of ECV. Majority (86.67%) of the farmers reported that availability of food become insufficient during droughts or low rainfall situations (Table 5.6.8). Majority of them reported that they have sufficient money to purchase from market and no gender discrimination in a family was reported in relation to food.

| Table 5.6.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in Dimapur | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Sufficiency of money for purchase of food | 86.67 | | |
| Family members | | Grown up children | 0.00 |
| Husband | 0.00 | Elders | 0.00 |
| Wife | 0.00 | All members | 100.00 |
| Both husband & wife | 0.00 | Do not know | 0.00 |

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.6.10 and Table 5.6.11.

| Table 5.6.10. Responses about change in water availability during low rainfall or drought situations in Dimapur (in %) | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 100.00 | 94.17 |
| Increase | 0.00 | 0.00 |
| No change | 0.00 | 5.83 |
| Not Sure | 0.00 | 0.00 |

All the respondents reported about decrease in available water for the purpose of irrigation and about 94.17 per cent of them reported decrease in availability of drinking water during drought seasons (Table 5.6.10). Similarly, majority of them felt that water for irrigation as well as drinking purpose is reducing in their villages. About 37.70 per cent reported about conflicts due to water scarcity in their communities/ villages in the last 5 years (Table 5.6.11).

| Table 5.6.11. Response (%) on water scenario in the village in Dimapur | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 1.67 | 1.71 | 62.30 |
| Yes | 91.67 | 94.02 | 37.70 |
| Not sure | 6.67 | 4.27 | 0.00 |

Majority of the respondents (96.67%) were primarily using wood as a source of fuel; in addition, about 35.83 per cent have LPG connection and 6.67 per cent of them were using cow dung as fuel, respectively. About 41.67 per cent households purchased fire wood from nearby market. In most of the households (40.83%) all the family members shared the responsibility of collecting fire wood from the nearby forest. Low availability of firewood during drought or low rainfall situations was reported by the farmers who did not purchase firewood from the market. Bamboo was also used as fuel and the growth of the plant declined during periods of low rainfall (Table 5.6.12).

| Table 5.6.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Dimapur | | | | | |
|---|---|---|---|---|---|
| Source of cooking fuel | | Who collects wood? | | Fire wood availability during low rainfall | |
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 96.67 | Husband | 1.67 | Decrease | 41.03 |
| Charcoal | 0.00 | Wife | 0.00 | Increase | 6.84 |
| Cow dung | 6.67 | Both | 16.67 | No change | 45.30 |
| LPG | 35.83 | Grown up children | 1.67 | Not sure | 6.84 |
| | | Elders | 1.67 | | |
| | | All members | 40.83 | | |
| | | Market | 41.67 | | |

| Table 5.6.13. Effect of climatic variability on time spent (hr/day) during climatic variability in Dimapur | | |
|---|---|---|
| Activities | Normal | Drought/Low rainfall |
| Fodder collection/grass cutting | 1.70 | 2.49 |
| Fetching drinking water | 0.69 | 0.95 |
| Wood (fuel) collection | 2.59 | 2.81 |
| Working hours in crop field | 7.47 | 5.92 |

| Table 5.6.14. Extra burden shared during climatic variability in Dimapur (in %) | | | | |
|---|---|---|---|---|
| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
| Male | 4.00 | 1.54 | 20.75 | 2.56 |
| Female | 2.00 | 26.15 | 0.00 | 0.00 |
| Both male & female | 94.00 | 72.31 | 79.25 | 97.44 |

The study reveals that the farmers put extra time on regular activities (Table 5.6.13). Working hours in the field reduced during climatic variability because of smaller farming area whereas, the time spent on wood collection has increased. Though, both male and female shared the extra burden during climatic variability, the task of fetching water was primarily done by female members and fuel wood was collected by male members of the households (Table 5.6.14).

| Table 5.6.15. Adaptation strategy followed in agriculture in Dimapur | | (in %) |
|---|---|---|
| Strategy | Late rainfall | Drought/Low rainfall |
| Leave complete fallow | 0.00 | 4.17 |
| Grow dry fodder crops | 0.00 | 0.83 |
| Change in cropping sequence | 0.00 | 0.00 |
| Change in crop cultivar/ landrace | 1.67 | 2.50 |
| Change in sowing harvesting time | 83.33 | 36.67 |
| Change in harvesting time | 81.67 | 37.50 |
| Shift from crops to livestock | 2.50 | 1.67 |
| Grow more cash crops | 2.50 | 2.50 |
| Cultivate smaller area than usual | 15.83 | 40.00 |
| No change | 2.50 | 29.17 |

In the study area, most of the farmers have changed or delayed the sowing time (83.33%) and harvesting time (81.67%) in case of late rain. In case of low rainfall or drought, about 36.67 per cent and 37.50 per cent of them also have changed the time of sowing and harvesting, respectively (Table 5.6.15). Cultivating smaller area than usual in periods of late rainfall and drought was considered as adaptation strategy by 15.83 per cent and 40.00 per cent of the farmers. During the periods of drought about 29.17 per cent of the farmers had no adaptation strategy which makes the farmers more vulnerable to climate change.

| Table 5.6.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Dimapur | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 19.17 | Start shop keeping | 3.33 |
| Wage labour | 75.00 | Devote more time in shop keeping | 0.83 |
| Go to neighbouring villages for labour work | 1.67 | Sell assets | 0.00 |
| Loan | 0.00 | Children drop out from school | 0.00 |
| | | Others | 12.50 |

In case of the extreme climatic variability, resorting to alternatives like wage labour (75.00%) offered under the MGNREGA was the primary mean of sustaining livelihoods whereas, about 12.50 per cent of the respondents started business activities other than shop keeping. About 19.17 per cent of households reported that their family members migrate during climatic variability (Table 5.6.17). Neighbouring villages (60.87%) and towns (39.13%) were the major locations the farmers migrated, for earning livelihood and mainly their wives (73.91%) and minors (47.83%) were left at home.

| Table 5.6.17. Migration by the farmers during climatic variability in Dimapur | | | |
|---|---|---|---|
| Place of migration | Frequency (%) | Family members left at home | Frequency (%) |
| Neighbour village | 60.87 | Wife | 73.91 |
| Neighbour town | 39.13 | Minor | 47.83 |
| Outside district | 4.35 | Male grown up | 8.70 |
| State capital | 4.35 | Female grown up | 21.74 |
| outside state | 0.00 | Elders | 39.13 |

| Table 5.6.18. Mitigating options preferred by respondents in Dimapur | | | |
|---|---|---|---|
| Options | Frequency (%) | Options | Frequency (%) |
| Use of stress-tolerant crop cultivar | 69.17 | Pest and disease management techniques such as IPM | 5.00 |
| Shift to improved cropping system | 46.67 | Development and use of crop cultivar resistant to pests and diseases | 0.83 |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 4.17 | New livestock breeds | 1.67 |
| Short duration variety grow other additional crops | 0.00 | Animal health management | 22.50 |
| New land management techniques | 2.50 | Others | 0.00 |
| Changes in agricultural water-management techniques | 21.67 | Do not know | 0.00 |

Use of stress-tolerant cultivars (69.17%), shift to improved cropping system (46.67%), animal health management (22.50%), changes in agricultural water management techniques (21.67%) were the measures considered as preferable mitigating options to climate change by the farmers in the study area (Table 5.6.18).

| Table 5.6.19. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in Dimapur | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Arai | Higher pest attack | Raskmol | Low production |
| Goya | Low Production but good taste | Paisam | Low production |
| IR-8 | Low production | Kohima Special | Low irrigation facilities |
| Bihari | No taste | Kala Bora | Low production |
| Bahadur | Low production and no taste | Pani Dhan | Low production |
| | | | |
| **Cultivars suitable in climate change scenario** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Goya | Stress tolerant | Kohima Special | Can withstand stress |
| IR-8 | Drought Resistant | Porture | Can withstand drought |
| Ranjit | Stress tolerant | | |

About 83.33 per cent of the farmers reported that they have changed the cultivar but most of them have changed the varieties in alternative one or two years to sustain the productivity of the crop and the decisions to change cultivars were mainly taken by both husband and wife (44.17%) in the family or by husband (36.67%) in the household (Annex *V(NL)_I*).

They have stopped cultivating varieties like *Arai, Goya, IR-8, Bihari, Bahadur, Kala Bora, Pani Dhan, Paisam* and some non-descript varieties mainly due to low yield, unavailability of seed and high water requirement or pest proneness. Farmers of Dimapur considered *Goya, IR-8,* and *Kohima Special* were cultivars as suitable to climate change (Table 5.6.19).

In the study area, taste, drought tolerance and yield were the major decisive factors that influenced the decisions to continue with or change a rice cultivar (Annex V(NL)_II).Animal management, water management (39.17%) and crop production management (36.67%) were the area on which trainings were preferred by the farmers of the study area (Annex *V(NL)_III*).

| Table 5.6.20.Who has the access to agricultural information in Dimapur | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Access to information | 87.00 | | |
| Member | | Elders | 5.75 |
| Men | 47.13 | Male grown children | 0.00 |
| Women | 0.00 | Female grown children | 0.00 |
| Both men and women | 71.26 | Do not know | 0.00 |

| Table 5.6.21. Source of information on agriculture and weather in Dimapur | | | | |
|---|---|---|---|---|
| Agriculture | | | Weather | |
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 63.22 | 63.22 | Radio | 5.00 |
| Progressive farmers | 36.78 | 36.78 | Newspaper | 5.00 |
| Fellow farmers | 57.47 | 52.87 | Television | 22.50 |
| Elders | 4.60 | 4.60 | Neighbour | 29.17 |
| Others | 0.00 | 0.00 | Family member | 0.00 |
| | | | Traditional knowledge | 62.50 |
| | | | Others | 0.00 |

The study revealed that 87.00 per cent of the farmer respondents have access to agricultural information. About 71.26 per cent of the responding farmers opined that both male and female members of a family has equal access to information, whereas, 47.13 per cent of the respondents informed that only male members have access to information (Table 5.7.19). Institutions like KVK, ICAR, Agriculture Department, Block Office *etc.* (63.22%), fellow farmers in village (57.47 %) and progressive farmers (36.78%) were the major source for agricultural information in normal periods as well as during ECV (Table

5.6.21). Traditional knowledge (72.50%) and neighbours (25.00%) were the main weather information sources of the respondents in the study area (Table 5.1.21).

| Table 5.6.22. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Dimapur | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 12.50 |
| Insurance scheme | |
| Crop | 18.33 |
| Livestock | 11.67 |
| Human | 63.33 |
| Other | 6.67 |

Loans for agricultural purposes were availed by only 12.50 per cent of the farmers in the study area. Most of the respondents were only aware of human insurances and only about 18.33 per cent and 11.67 per cent of the respondents were aware of crop and livestock insurance, respectively (Table 5.6.22).

| Table 5.6.23. Type of support received and agencies that supported the farmers in Dimapur | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.00 | Agricultural Department | 45.00 |
| Old Age Pension | 9.17 | Horticultural Department | 0.00 |
| PDS ration | 35.83 | Animal Husbandry/ Fisheries Department | 0.00 |
| Thrift and credit through SHGs | 10.83 | Bank/ Cooperative Bank/Society | 0.83 |
| Farmers' group | 9.17 | KVK/Block Office | 22.50 |
| Health insurance | 0.83 | Meteorological Department/ Irrigation Department | 0.00 |
| Support from NGOs (specify) | 1.67 | Health Department | 1.67 |
| Training on new rice technologies | 0.00 | Agricultural Universities | 0.83 |
| MGNREGA program | 52.50 | None | 38.33 |
| None | 39.17 | NGO | 0.00 |
| Others | 0.83 | Others | 15.83 |

The main support the respondent farmers received was mainly income opportunities through MGNREGA (52.50%) in the study area (Table 5.6.23). strikingly, only 35.83 per cent of the farmers received support through PDS ration. Agricultural support to the farmers was mainly provided by the agricultural department (45.00%) and the KVK/ Block office of the district (22.50%) and fellow farmers and friends (15.83%). No support from agencies/organizations for farming activities was reported by 38.33 per cent of the responding farmers of Dimapur.

## 5.7 SENAPATI DISTRICT OF MANIPUR

*Socio-economic status*

The socio-economic information of sample households of Senapati is presented in Table 5.7.1. The table depicts that the average age of the respondent farmers was 43.98 years and a family was composed of, on an average, seven members. Majority of them were Christian (75.83%), followed by Hindu (24.17%). About 75 per cent of the respondents belonged to the Schedule Tribe, followed by the unreserved category (23.33%). The number of female was 992 per 1000 male and the literacy rate was 75.83 per cent. Majority of the respondents were educated up to middle (31.66%) level, followed by Secondary (13.33%) and Higher Secondary (HS) level (11.67%). The average operational land holding is calculated to be 0.69 and only 29.10 per cent of the total cultivated land was irrigated.

Table 5.7.1. Socio-economic information of sample households of Senapati

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 43.98 | Sex ratio | per 1000 male | 992 |
| Family size | no. | 6.39 | Religion | % | |
| Social Group | % | | Christian | | 75.83 |
| Schedule Tribe | | 75.00 | Hindu | | 24.17 |
| Schedule Caste | | 0.83 | Islam | | 0.00 |
| Other Backward Caste | | 0.83 | Buddhist | | 0.00 |
| Others | | 23.33 | Educational status | % | |
| | | | Illiterate | | 24.17 |
| Housing structure | % | | Literate | | 2.50 |
| *Kaccha* | | 53.33 | Literate but below primary | | 2.50 |
| Semi-*pucca* | | 42.50 | Primary | | 6.67 |
| *Pucca* | | 4.17 | Middle | | 31.66 |
| Operational land holding | ha | 0.69 | Secondary | | 13.33 |
| Upland | | 0.67 | Higher Secondary | | 11.67 |
| Lowland | | 0.71 | Diploma/certificate | | 1.67 |
| Irrigated land | % | 29.10 | Graduate | | 5.00 |
| | | | Post Graduate | | 0.83 |

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in Senapati district is represented in Table 5.7.2 to Table 5.7.4.

All of the respondent farmers reported the problem of water stress or drought like situation in their farms and 24.17 per cent reported the problem of acidity. Majority of the respondents (97.50%) felt that the climate has changed over the years, 1.67 per cent of them reported that that there was no climate change it remains the same as before and 0.83 per cent were not sure of the change (Table 5.7.2).

Table 5.7.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in Senapati

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 0.00 | No | 1.67 |
| Drought/Water stress | 100.00 | Yes | 97.50 |
| Acidity | 24.17 | Not sure | 0.83 |
| Others | 0.00 | Do not know | 0.00 |

From Table 5.7.3 it is revealed that majority of the farmers of the district (86.67%) perceived that the summer temperature has increased, but more than two-third of them (65.00%) felt that winter temperature has decreased in last 10 years. Majority of respondents (more than 90%) reported that the amount of rainfall has declined during both, summer and winter seasons and the advent of monsoon rain has been delayed in Senapati district of Manipur.

Table 5.7.3. Farmers' perception (%) about change in temperature and rainfall in Senapati

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 4.17 | 65.00 | Late | 97.50 | 89.17 | Low | 95.83 | 91.67 |
| Increase | 86.67 | 20.83 | Early | 0.83 | 0.83 | High | 0.83 | 2.50 |
| No change | 5.00 | 10.00 | No change | 1.67 | 2.50 | No change | 2.50 | 2.50 |
| Not sure | 4.17 | 4.17 | Not sure | 0.00 | 7.50 | Not sure | 0.83 | 3.33 |

Table 5.7.4. Unexpected change encountered by the respondents in Senapati (in %)

| Response | Long dry spell | | Drought incidence | | Hailstorm | |
|---|---|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 92.50 | 91.67 | 58.33 | 64.17 | 97.50 | 96.67 |
| Yes | 6.67 | 7.50 | 41.67 | 35.83 | 1.67 | 2.50 |
| No change | 0.00 | 0.00 | 0.00 | 0.00 | 0.83 | 0.83 |
| Not sure | 0.83 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 |

Majority of the respondents did not encounter long unexpected dry spell like situations within a rainy period in the study area but about 41.67 per cent and 35.83 per cent of the respondents reported about unexpected drought incidence during monsoon and winter season, respectively (Table 5.7.4). Unexpected hailstorm was reported by only 1.67 per cent and 2.50 per cent of the respondents in monsoon and winter, respectively, indicating that it has relatively lesser impact on crop productivity in the district.

*Impact of climate change*

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.7.5 to Table 5.7.9.

Table 5.7.5. Effect of rainfall variability on area under rice and fallow in Senapati (in %)

| Response | Rice area | | Fallow | |
|---|---|---|---|---|
| | Late | Drought/Low rainfall | Late | Drought/Low rainfall |
| Decrease | 9.17 | 8.33 | 0.00 | 0.00 |
| Increase | 0.00 | 0.00 | 5.00 | 4.17 |
| No change | 90.83 | 91.67 | 95.00 | 95.83 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 |

Rice cultivation in the area depends entirely on the timely arrival and amount of rainfall received. Only 9.17 per cent and 8.33 per cent of the farmers have reported that they reduced the area under rice crop in case of late rainfall and drought/low rainfall situations, respectively and about 5 per cent and 4.17 per cent of them were reported to leave the area fallow in case of late rainfall and drought/low rainfall, respectively (Table 5.1.5). Majority of the sample farmers (95.83%) informed that low rainfall and delayed arrival of rainfall reduced the productivity of paddy. It is calculated that the productivity of rice declined by 23.78 per cent, from 2374.42 kg/ha to 1809.75 kg/ha during periods of droughts or low rainfall situations (Table 5.7.6).

Table 5.7.6. Effects of climatic variability on yield of rice in Senapati

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low rainfall | High rainfall | Late rainfall | Drought/Low rainfall | Normal |
| Decrease | 95.83 | 100.00 | 95.83 | 1809.75 (-23.78%) | 2374.42 |
| Increase | 0.00 | 0.00 | 0.00 | | |
| No change | 2.50 | 0.00 | 2.50 | | |
| Not sure | 1.67 | 0.00 | 1.67 | | |

Table 5.7.7. Effect of change in climate on pest and disease infestation in Senapati (in %)

| Response | Rice | | Crop damaged |
|---|---|---|---|
| | Disease | Pest | |
| Decrease | 0.00 | 0.00 | 4.78 |
| Increase | 19.17 | 80.83 | |
| No change | 80.00 | 18.33 | |
| Not sure | 0.83 | 0.83 | |

Majority of the responding farmers (80.83%) and about 19.17 per cent perceived that the pests and disease infestations have increased in rice in recent times which may be due to the change in climate which contributed to 4.78 per cent crop loss in case of rice in the area (Table 5.7.7).

Table 5.7.8. Effect of climate change on availability of food in Senapati

| Particulars | Normal | Drought/Low rainfall |
|---|---|---|
| Supply of food from own land (months) | 10.37 | 8.13 |
| Perception (%) | | |
| Insufficient/decline | 36.67 | 78.99 |
| Sufficient/improve | 45.00 | 19.33 |
| No change | 18.33 | 1.68 |
| Not sure | 0.00 | 0.00 |

In normal seasons, the farm produce lasted on an average of 10.37 months for home consumption, but during drought/low rainfall, home consumption of farm produce reduced to 8.13 months (Table 5.7.8). Majority (78.99%) of the farmers reported that availability of food become insufficient during droughts or low rainfall situations (Table 5.7.8) but they did not face any difficulty as purchased food during climatic variability income generated through petty business (Table 5.7.9). No gender disparity was observed in case of food consumption in the study area (Table 5.7.9).

| Table 5.7.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in Senapati | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Sufficiency of money for purchase of food | 100.00 | | |
| Family members | | Grown up children | 0.00 |
| Husband | 0.00 | Elders | 0.00 |
| Wife | 0.00 | All members | 100.00 |
| Both husband & wife | 0.00 | Do not know | 0.00 |

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.7.10 and Table 5.7.11.

| Table 5.7.10. Responses about change in water availability during low rainfall or drought situations in Senapati (in %) | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 86.67 | 65.00 |
| Increase | 0.00 | 3.33 |
| No change | 10.83 | 30.83 |
| Not Sure | 2.50 | 0.93 |

| Table 5.7.11. Response (%) on water scenario in the village in Senapati | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 15.00 | 37.82 | 92.50 |
| Yes | 82.50 | 61.34 | 7.50 |
| Not sure | 2.50 | 0.84 | 0.00 |

| Table 5.7.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Senapati | | | | | |
|---|---|---|---|---|---|
| Source of cooking fuel | | Who collects wood? | | Fire wood availability during low rainfall | |
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 98.33 | Husband | 3.33 | Decrease | 9.32 |
| Charcoal | 0.00 | Wife | 2.50 | Increase | 3.39 |
| Cow dung | 0.00 | Both | 18.33 | No change | 78.81 |
| LPG | 67.50 | Grown up children | 8.33 | Not sure | 8.47 |
| | | Elders | 3.33 | | |
| | | All members | 20.83 | | |
| | | Market | 42.50 | | |

Decrease in water availability for the purpose of irrigation and drinking during drought season was reported by 86.67 per cent and 65.00 per cent, respectively (Table 5.7.10). Similarly, inadequate irrigation facility and reducing drinking water facility was reported by 82.50 per cent and 61.34 per cent of the farmers, respectively. Only few cases (7.5%) of conflict were reported as a result of water shortage in the last 5 years in Senapati district (Table 5.7.11).

Almost all of the respondents (98.33%) still used wood as fuel, in addition, about 67.50 per cent of them have LPG connection (Table 5.7.12). About 42.50 per cent of the respondents reported that they mainly purchase firewood from the market on yearly basis and 20.83 per cent shared the responsibility of collecting fire wood from nearby forest area. There was not much change in availability of firewood during drought or low rainfall situations in Senapati.

Table 5.7.13. Effect of climatic variability on time spent (hr/day) during climatic variability in Senapati

| Activities | Normal | Drought/Low rainfall |
|---|---|---|
| Fodder collection/grass cutting | 2.57 | 3.39 |
| Fetching drinking water | 0.44 | 0.65 |
| Wood (fuel) collection | 0.58 | 0.64 |
| Working hours in crop field | 6.76 | 6.89 |

Table 5.7.14. Extra burden shared during climatic variability in Senapati (in %)

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 66.00 | 0.00 | 47.76 | 0.83 |
| Female | 4.00 | 100.00 | 0.00 | 1.67 |
| Both male & female | 30.00 | 0.00 | 52.24 | 97.50 |

From the study, it was observed that the farmers put extra time on regular activities, especially for fodder collection during the periods of climatic variability (Table 5.7.13). The extra burden for collection of fodder during climatic variability was on male members whereas, for fetching drinking water the burden was on female (Table 5.7.14).

Table 5.7.15. Adaptation strategy followed in agriculture in Senapati (in %)

| Strategy | Late rainfall | Drought/Low rainfall |
|---|---|---|
| Leave complete fallow | 3.33 | 0.83 |
| Grow dry fodder crops | 0.00 | 0.00 |
| Change in cropping sequence | 0.00 | 0.00 |
| Change in crop cultivar/ landrace | 1.67 | 0.00 |
| Change in sowing/harvesting time | 93.33 | 0.83 |
| Change in harvesting time | 41.67 | 0.00 |
| Shift from crops to livestock | 0.00 | 0.00 |
| Grow more cash crops | 0.00 | 0.00 |
| Cultivate smaller area than usual | 0.83 | 1.67 |
| No change | 5.83 | 95.00 |

Adaptation is a mean that farmer can safeguard the losses as a result of climatic variability. Importantly, 93.33 per cent of the farmers have changed or delayed the sowing time in case of late rain and drought like situation, respectively and consequently 41.67 per cent of them have also changed their harvesting time (Table 5.7.15). Majority of the farmers (95%) did not take up any adaptation strategy in case of drought like situation which reflects the vulnerability of the farmers of the area to climatic variability due to poor or absence of irrigation facilities.

| Table 5.7.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Senapati | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 0.00 | Start shop keeping | 1.67 |
| Wage labour | 70.00 | Devote more time in shop keeping | 5.00 |
| Go to neighbouring villages for labour work | 5.00 | Sell assets | 0.00 |
| Loan | 0.00 | Children drop out from school | 0.00 |
| | | Others | 24.17 |

| Table 5.7.17. Mitigating options preferred by respondents in Senapati | | | |
|---|---|---|---|
| Options | Frequency (%) | Options | Frequency (%) |
| Use of stress-tolerant crop cultivar | 75.83 | Pest and disease management techniques such as IPM | 46.67 |
| Shift to improved cropping system | 0.83 | Development and use of crop cultivar resistant to pests and diseases | 6.67 |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 9.17 | New livestock breeds | 10.83 |
| Short duration variety grow other additional crops | 0.00 | Animal health management | 29.17 |
| New land management techniques | 0.83 | Others | 0.00 |
| Changes in agricultural water-managed techniques | 6.67 | Do not know | 5.83 |

In case of the extreme climatic variability, the responding farmers reported that resorting to alternatives like wage labour (70%) offered under the MGNREGA was the main coping strategy. About 24.17 per cent of the respondents have government job. The women members were found to be engaged in handloom activities as a mean of earning income in the family. Equal percentages (5%) of the respondents opined that going to neighbouring villages for labour work and devote more time in shop keeping were also the options to buffer the effect that climatic variability could bring to their income. Migrating during climatic variability was not the option as yet reported (Table 5.7.16).

Use of stress-tolerant cultivars (75.83%), pest and disease management (46.67%) health management of animals and keeping new livestock breeds (10.83%) were the measures considered as preferable mitigating options to climate change by the farmers in the study area (Table 5.7.17).

About 45.83 per cent of the farmers reported that they have changed the rice cultivar (Annex *V (MN)_I*) but most of them have changed the varieties in alternative one or two years to sustain the productivity of the crop. In most of the cases, either both husband and wife (55.00%) together or the elders (26.67%) decided what cultivar is to be grown in the field.

Table 5.7.18. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in Senapati

| | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Addey | Production decrease<br>No longer suit the area | RCM 9 | Not suitable in the area |
| Moirang | Taste decrease<br>Cause lodging | KD | Production decrease |
| Phouren | Late variety<br>Less production<br>Production decrease | Dhrum | Production decrease |
| CAU R1 | Dwarf and difficult to harvest<br>No taste | Raina | Taste decrease |
| Desha | Threshing problem<br>Production decrease | RCM 5 | Not suitable in the area |
| | | Ching phou | Taste decrease |
| **Cultivars suitable in climate change scenario** | | | |
| Cultivars | Reasons | Cultivars | Reasons |
| Tampha phou | High production<br>Less insect attack | Addey | Can withstand drought |
| Daran phou | Dwarf variety | RCM 9 | High production |
| RCM 5 | Dwarf and high production | RCM 10 | High production |
| KD | High production<br>Less pest attack | Sona phou | High production<br>Short variety |

Suitable cultivars, as reported by the responding farmers, were *Tampha phou, Daran phou, Sona phou, RCM- 5, 9* and *10*, *Addey* and *KD* (Table 5.7.18). Training on pest and disease management (62.50%), crop production management (42.50%), animal management (26.67%) and water management (23.33%) were the need the respondent farmers reported (*Annex VII(MN)_III*).

Table 5.7.19.Who has the access to agricultural information in Senapati?

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Access to information | 44.17 | | |
| Member | | Elders | 0.00 |
| Men | 9.43 | Male grown children | 5.66 |
| Women | 18.87 | Female grown children | 11.32 |
| Both men and women | 66.04 | Do not know | 0.00 |

Table 5.7.20. Source of information on agriculture and weather in Senapati

| Agriculture | | | Weather | |
|---|---|---|---|---|
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 92.45 | 86.79 | Radio | 45.00 |
| Progressive farmers | 16.98 | 18.87 | Newspaper | 7.50 |
| Fellow farmers | 30.19 | 30.19 | Television | 30.00 |
| Elders | 1.89 | 1.89 | Neighbour | 2.50 |
| Others | 0.00 | 0.00 | Family member | 0.00 |

| | | | | |
|---|---|---|---|---|
| | | | Traditional knowledge | 73.33 |
| | | | Others | 0.00 |

In the study area, taste (77.50%), yield (62.50%) and tolerance to drought (35.00%) were the major decisive factors that influenced the decisions to continue with or change a rice cultivar (*Annex V(MN)_II*).

| Table 5.7.21. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Senapati | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 2.52 |
| Insurance scheme | |
| Crop | 7.50 |
| Livestock | 15.00 |
| Human | 74.17 |
| Other | 0.00 |

| Table 5.7.22. Type of support received and agencies that supported the farmers in Senapati | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.00 | Agricultural Department | 9.17 |
| Old Age Pension | 20.83 | Bank | 1.67 |
| PDS ration | 74.17 | Animal Husbandry/ Fisheries Department | 0.00 |
| Thrift and credit through SHGs | 39.17 | Bank/ Cooperative Bank/Society | 0.00 |
| Farmers' group | 0.00 | KVK/Block Office | 35.83 |
| Health insurance | 1.67 | Meteorological Department/ Irrigation Department | 0.00 |
| Support from NGOs (specify) | 1.67 | Health Department | 0.00 |
| Training on new rice technologies | 3.33 | Agricultural Universities | 0.00 |
| MGNREGA program | 74.17 | None | 12.50 |
| None | 0.83 | NGO | 4.17 |
| | | Others | 56.67 |

The study revealed that not even half of the farmer respondents (44.17%) have accessed agricultural information and 66.04 per cent of them opined that both male and female members have access to information, followed by women only (18.87%) (Table 5.7.19). Institutions like KVK, ICAR, Agriculture Department, Block Office *etc.* (92.45% and 86.79%), fellow farmers in village (30.19%) and progressive farmers (16.98% and 18.87%) were the major source for agricultural information in normal periods as well as during extreme climatic variability (Table 5.7.20). Traditional knowledge (73.33%) and radio (45%) and television (30%) were the main weather information sources in the study area (Table 5.7.20).

Loans for agricultural purposes were acquired by only 2.52 per cent of the farmers in the study area. Only about 15.00 per cent and 7.50 per cent of the respondents were aware of livestock and crop insurance, respectively (Table 5.7.21).

The supports the respondent farmers received were mainly PDS ration (74.17%) and income through MGNREGA (74.17%) in the study area (Table 5.7.22). Agricultural support to the farmers was mainly provided by the fellow farmers and the religious institutions like church in the villages (56.67%), followed by the KVK in Hengbung village (35.83%).

## 5.8 WEST TRIPURA DISTRICT OF TRIPURA

*Socio-economic status*

The socio-economic information of sample households of West Tripura is presented in Table 5.8.1.

Table 5.8.1. Socio-economic information of sample households of West Tripura

| Particulars | Unit | Value | Particulars | Unit | Value |
|---|---|---|---|---|---|
| Average age | years | 46.98 | Sex ratio | per 1000 male | 847.03 |
| Family size | no. | 5.43 | | | |
| Social group | % | | Religion | % | |
| Schedule Tribe | | 10.00 | Christian | | 11.67 |
| Schedule Caste | | 15.83 | Hindu | | 87.50 |
| Other Backward Caste | | 7.50 | Islam | | 0.83 |
| Others | | 66.67 | Buddhist | | 0.00 |
| Housing structure | % | | Operational land holding | ha | 1.24 |
| *Kaccha* | | 54.17 | Upland | | 1.26 |
| Semi-*pucca* | | 26.67 | Lowland | | 1.22 |
| *Pucca* | | 19.17 | Irrigated land | % | 38.67 |
| Educational status | % | | Educational status | % | |
| Illiterate | | 8.33 | Middle | | 32.50 |
| Literate | | 2.50 | Secondary | | 25.83 |
| Literate but below primary | | 5.00 | Higher Secondary | | 11.67 |
| Primary | | 7.50 | Graduate | | 0.00 |

The average age of the respondents was 47 years in the West Tripura district of Tripura. Most of the family members (54.17%) of the sample households were in the category of 25 to 60 years. About 66.67 per cent of the sample farmers belonged to unreserved category, remaining was in SC (15.83%), ST (10.00%) and OBC category. About87.50 per cent of the respondents were Hindu, and remaining were Christian (11.67%) and Muslim (0.83%). The number of female was 847 per 1000 male and the literacy rate was 91.67 per cent. Maximum of the respondents had education up to Middle (32.50%) and Secondary (25.83%) level. The houses in which the farmers stay were mainly *kaccha* (54.17%) type; followed by semi-*pucca* (26.67%) and *pucca* (19.17%) types. The average land holding was calculated to be 1.24 ha, out of which 38.67 per cent was irrigated (Table 5.8.1).

*Perception about climate change*

The sample farmers' perception about different aspects of climate change in West Tripura district is eliciated in Table 5.8.2 to Table 5.8.4.

| Table 5.8.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in West Tripura | | | |
|---|---|---|---|
| Stress | Frequency (%) | Response | Frequency (%) |
| Submergence | 5.83 | No | 0.00 |
| Drought/Water stress | 83.33 | Yes | 99.17 |
| Acidity | 1.67 | Not sure | 0.00 |
| Others | 12.50 | Do not know | 0.83 |

| Table 5.8.3. Farmers' perception (%) about change in temperature and rainfall in West Tripura | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 6.67 | 48.33 | Late | 63.03 | 4.20 | Low | 84.03 | 19.33 |
| Increase | 85.83 | 44.17 | Early | 10.08 | 0.00 | High | 5.88 | 0.84 |
| No change | 6.67 | 4.17 | No change | 17.65 | 66.39 | No change | 4.20 | 56.30 |
| Not sure | 0.83 | 3.33 | Not sure | 9.24 | 29.41 | Not sure | 5.88 | 23.53 |

| Table 5.8.4. Unexpected change encountered by the respondents in West Tripura (in %) | | | | | | |
|---|---|---|---|---|---|---|
| Response | Long dry spell | | Drought incidence | | Flood incidence | |
| | Monsoon | Winter | Monsoon | Winter | Monsoon | Winter |
| No | 77.97 | 67.80 | 45.00 | 62.18 | 94.07 | 95.76 |
| Yes | 13.56 | 11.86 | 51.67 | 18.49 | 4.24 | 0.00 |
| No change | 7.63 | 10.17 | 3.33 | 13.45 | 0.85 | 0.85 |
| Not sure | 0.85 | 10.17 | 0.00 | 0.07 | 0.85 | 3.39 |

Majority of the farms (83.33%) were water stressed or drought affected in the study area (Table 5.8.2) and nearly all of them (99.17%) felt climate has changed over the years. About 85.83 per cent farmers perceived that the summer temperature has increased over in last 10 years whereas in case of winter temperature the views were mixed, some reported that temperature has increased and according to some, temperature has decreased over the years (Table 5.8.3). It may be due to some years becoming colder and some becoming warmer over the years. About 84.03 per cent of the farmers perceived that the monsoon rainfall has declined over the years but winter rainfall has not seen much change. The monsoon rainfall has also become late (63.03%). There was no change in winter rainfall pattern (Table 5.8.3).

Most of the respondents did not recall incidence of long unexpected dry spell within a rainy period. Only about 13.56 per cent of the respondents said that they have encountered long dry spell during monsoon and only 4.24 per cent of the respondent have encountered flood problem, which implied that flood was not a problem in case of West Tripura district of Tripura (Table 5.8.4).

***Impact of climate change***

Impact on crops and food

The effect of climate change on crop area, productivity and food availability are presented in Table 5.8.5 to Table 5.8.9.

Table 5.8.5. Effect of rainfall variability on area under rice and fallow in West Tripura (in %)

| Response | Rice area | | | Fallow | | |
|---|---|---|---|---|---|---|
| | Early | Late | Drought/Low rainfall | Early | Late | Drought/Low rainfall |
| Decrease | 58.33 | 36.49 | 56.52 | 0.00 | 0.00 | 0.00 |
| Increase | 0.00 | 0.00 | 0.00 | 100 | 100 | 100 |
| No change | 41.67 | 60.81 | 42.39 | 0.00 | 0.00 | 0.00 |
| Not sure | 0.00 | 2.70 | 1.09 | 0.00 | 0.00 | 0.00 |

Table 5.8.6. Effect of rainfall variability on yield of rice in West Tripura

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low | High | Early/Late | Drought/Low | Normal |
| Decrease | 94.44 | 100.00 | 83.54 | 2731.79 | 4280.31 |
| Increase | 0.00 | 0.00 | 0.00 | -36.18% | |
| No change | 2.78 | 0.00 | 6.33 | | |
| Not sure | 1.39 | 0.00 | 0.00 | | |

Table 5.8.7. Effect of change in climate on rice pest and disease in West Tripura (in %)

| Response | Disease | Pest | Crop damaged |
|---|---|---|---|
| Decrease | 1.22 | 2.61 | 9.99 |
| Increase | 90.24 | 90.43 | |
| No change | 1.22 | 0.87 | |
| Not sure | 6.10 | 5.22 | |
| New disease | 0.00 | 0.00 | |

Any change in rainfall pattern, affects the area under crop. About 56.52 per cent of the farmers told that they have reduced the area under rice crop in case of drought (Table 5.8.5). Similar pattern of response was recorded for early rainfall and flood. But a considerable percentage of farmers did not change the crop area during low rainfall or drought like situations (42.39%) and late rainfall (60.81%).

Table 5.8.8. Effect of climate change on availability of food in West Tripura (in %)

| Particulars | Normal | Drought/Low rainfall |
|---|---|---|
| Supply of food from own land (months) | 7.63 (N=116) | 5.46 (N=110) |
| Perception (%) | | |
| Insufficient/decline | 28.33 | 76.72 |
| Sufficient/improve | 69.17 | 18.97 |
| No change | 2.50 | 3.45 |
| Not sure | 0.00 | 0.86 |

Paddy productivity got severely affected during droughts. It is calculated that the productivity declined by 36.18 per cent of the normal productivity during drought (Table

5.8.6). About 90.24 per cent of the farmers perceived that the incidences of pest and disease attacks have increased in recent days due to change in climate (Table 5.8.7). In normal seasons the farm produce lasted for 7.63 months for family consumption but during flood and drought the produce lasted for 3.33 months and 5.46 months, respectively (Table 5.8.8). Majority of the farmers reported that availability of food has become insufficient during drought (76.72%). About 31.09 per cent of them found it difficult to purchase food from market due to insufficiency of money (Table 5.8.9).

Table 5.8.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in West Tripura

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Sufficiency of money for purchase of food | 68.91 | | |
| Family members | | Grown up children | 11.67 |
| Husband | 0.83 | Elders | 0.83 |
| Wife | 2.50 | All members | 82.50 |
| Both husband and wife | 0.00 | Do not know | 4.20 |

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.8.10 and Table 5.8.11.

Table 5.8.10. Farmers' response (%)about change in water availability in West Tripura

| Type of change | Irrigation | Drinking |
|---|---|---|
| Decrease | 80.88 | 53.27 |
| Increase | 2.94 | 2.80 |
| No change | 14.71 | 41.12 |
| Not sure | 1.47 | 2.80 |

Table 5.8.11. Farmers' response (%) on water scenario in the village in West Tripura

| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
|---|---|---|---|
| No | 34.75 | 63.03 | 84.03 |
| Yes | 61.02 | 35.29 | 9.24 |
| Not sure | 0.00 | 0.00 | 0.00 |

The farmers reported that water availability for both, irrigation (80.88%) as well as drinking (53.27%) purpose reduced during the drought season (Table 5.8.10) but only 9.24 per cent of the farmers told that there were conflicts in the village for water in the last 5 years (Table 5.8.11).

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.8.12 to Table 5.8.14. Majority of respondents (92.50%) used wood as fuel. About 28.33 per cent respondents have LPG connection but they also used wood. About 30.00 per cent of flood affected farmers said that fuel availability decline during flood, whereas about 30.19 per cent drought affected people said that wood availability increased during drought whereas, 21.70 per cent felt that wood availability used to decline during drought years (Table 5.8.12).

Table 5.8.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in West Tripura

| Source of cooking fuel | | Who collects wood? | | Fire wood availability during drought/low rainfall | |
|---|---|---|---|---|---|
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 92.50 | Husband | 37.84 | Decrease | 21.70 |
| Charcoal | 0.00 | Wife | 0.00 | Increase | 30.19 |
| Cow dung | 13.33 | Both | 10.81 | No change | 33.02 |
| LPG | 28.33 | Grown up children | 7.21 | Not sure | 14.15 |
| | | Elders | 27.03 | | |
| | | All members | 3.60 | | |
| | | Market | 20.72 | | |

Table 5.8.13. Effect of climatic variability on time spent (hr/day) during climatic variability in West Tripura

| Activities | Normal | Drought/Low rainfall |
|---|---|---|
| Fodder collection/grass cutting | 1.11 | 1.34 |
| Fetching drinking water | 0.62 | 0.71 |
| Wood (fuel) collection | 1.84 | 2.19 |
| Working hours in crop field | 5.38 | 5.96 |

Table 5.8.14. Farmers' perception on extra burden shared during climatic variability in West Tripura (in %)

| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
|---|---|---|---|---|
| Male | 59.02 | 5.13 | 66.67 | 77.78 |
| Female | 18.03 | 10.26 | 5.38 | 2.56 |
| Both male & female | 22.95 | 10.26 | 27.96 | 18.80 |

There was only marginal difference in time spent in different activities during drought and flood in comparison to normal years (Table 5.8.13). During climatic variability, most of the cases the extra burden, was on male members, except in case of fetching of water which is contrary to expectation (Table 5.8.14).

*Adaptation and mitigation strategy*

The adaptation and mitigation strategies followed by the sample farmers in West Tripura district are presented in Table 5.8.15 to Table 5.8.19. Changing the time of sowing and harvesting were the two major decisions the farmers took in case of late rainfalls. Some of them have changed the cultivars or cropping sequence due to change in climate (Table 5.8.15). During drought, most of the farmers cultivated in smaller area of land as compared to normal years. It was found that quite large number of farmers did not change anything, and that is the issue on which interventions are required.

| Table 5.8.15. Adaptation strategy followed in agriculture in West Tripura (in %) | | | | |
|---|---|---|---|---|
| Strategy | Late rainfall | Early rainfall | Drought/Low rainfall | Flood |
| Leave complete fallow | 0.00 | 0.00 | 13.33 | 0.00 |
| Grow dry fodder crops | 1.49 | 0.00 | 1.09 | 0.00 |
| Change in cropping sequence | 7.69 | 0.00 | 5.62 | 12.50 |
| Change in crop cultivar/ landrace | 4.69 | 12.50 | 2.20 | 0.00 |
| Change in sowing/harvesting time | 54.55 | 25.00 | 12.77 | 0.00 |
| Change in harvesting time | 50.00 | 25.00 | 11.70 | 0.00 |
| Shift from crops to livestock | 1.52 | 0.00 | 1.10 | 0.00 |
| Grow more cash crops | 0.00 | 0.00 | 1.10 | 0.00 |
| Cultivate smaller area than usual | 9.09 | 0.00 | 32.97 | 16.67 |
| No change | 41.79 | 85.71 | 47.00 | 83.33 |

| Table 5.8.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in West Tripura | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 11.67 | Start shop keeping | 9.17 |
| Wage labour | 74.17 | Devote more time in shop keeping | 4.17 |
| Go to neighbouring villages for labour work | 3.33 | Sell assets | 0.83 |
| Loan | 0.00 | Children drop out from school | 0.83 |

| Table 5.8.17. Migration by the farmers during climatic variability in West Tripura | | | |
|---|---|---|---|
| Place of migration | Frequency (%) | Family members left at home | Frequency (%) |
| Neighbour village | 35.71 | Wife | 57.14 |
| Neighbour town | 64.29 | Minor | 7.14 |
| Outside district | 0.00 | Male grown up | 21.43 |
| State capital | 0.00 | Female grown up | 85.71 |
| outside state | 0.00 | Elders | 14.29 |

| Table 5.8.18. Mitigating options preferred by respondents in West Tripura | | | |
|---|---|---|---|
| Options | Frequency (%) | Options | Frequency (%) |
| Use of stress-tolerant crop cultivar | 59.17 | Pest and disease management techniques such as IPM | 69.17 |
| Shift to improved cropping system | 25.00 | Development and use of crop cultivar resistant to pests and diseases | 31.67 |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood | 36.67 | New livestock breeds | 8.33 |

| | | | |
|---|---|---|---|
| occurrence | | | |
| Short duration variety grow other additional crops | 59.17 | Animal health management | 11.67 |
| New land management techniques | 35.83 | Others | 0.83 |
| Changes in agricultural water-managed techniques | 17.50 | Do not know | 0.83 |

Table 5.8.19. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in West Tripura

| | | | |
|---|---|---|---|
| **Cultivars stopped** | | | |
| Cultivar | Reason | Cultivar | Reason |
| MR | Low productivity, higher water requirement, disease prone, low market price and unavailability of seeds, suitable for *rabi* season | Krishna Chamsa | Low productivity |
| Mulasala | Low productivity | Kalihati | Low productivity |
| Malati | Low productivity, taste is not preferred, disease prone, threshing is difficult as straw is hardy, unavailability of seeds | Jaya | Low productivity, high water requirement and unavailability of seed |
| Mahinau dan | Low productivity and disease prone | Jolly | High water requirement |
| Lathisail | Low productivity | GR-16 | Low productivity |
| Chingri | low productivity | GR-11 | Low productivity and unavailability of seeds |
| 1014 | low productivity | Eri | Low productivity |
| Thaisong | low productivity | | |
| **Cultivars suitable in climate change scenario** | | | |
| Swarna Mahsuri | Can withstand drought | Malati | Drought resistant |
| Paijam | Drought resistant | Ranjit | Less attack of pests in floods |
| Satabdi | Drought resistant | | |

Working as wage labour (74.17%) was the best alternative they had in case of climatic variability, as 100 days of employment opportunity was available in the village under MGNREGA (Table 5.8.16). About 11.67 per cent of the farmers migrated during climatic variability and majority of them (64.29%) migrated to neighbouring village and mostly the wives were left at home (Table 5.8.17).

Farmers expressed their preferences for pest and disease management technique (69.17%), stress-tolerant cultivators (59.17%), short duration variety to grow additional crop (59.17%) *etc.*as measures to reduce the vulnerability to climate variability (Table 5.8.18).

About 79.49 per cent of the farmers reported that they have changed the cultivar but most of them have changed the varieties in alternative one or two years to sustain the productivity of the crop and the decisions to change cultivars were mainly taken by the husband (75.00%) in the household (*Annex V(TR)_I*).

They have stopped cultivating varieties like *MR, Mulasala, Malati, Mahinuaudan, Lathisail, Krishna Chamsa, Kalihati etc.* mainly due to low yield, unavailability of seed and high water requirement or disease proneness. The respondent farmers reported that

*Swarna Mahsuri, Paijam, Malati, Ranjit* and *Satabdi* were the varieties resistant to water stress (Table 5.8.19).

In the study area, market price, taste and drought tolerance were the major decisive factors that influenced the decisions to continue with or change a rice cultivar (*Annex V(TR)_II*). They also expressed interest for training in pest management (52.50%), water management (45.00%) and nutrient management (39.17%) (*Annex V(TR)_III*).

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.8.20 to Table 5.8.23.

Table 5.8.20. Who has the access to agricultural information in West Tripura?

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Access to information | 37.50 | | |
| Member | | Elders | 17.78 |
| Men | 62.22 | Male grown children | 8.89 |
| Women | 4.44 | Female grown children | 4.44 |
| Both men and women | 17.78 | Do not know | 0.00 |

Table 5.8.21. Source of information on agriculture and weather in West Tripura

| Agriculture | | | Weather | |
|---|---|---|---|---|
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 84.44 | 51.11 | Radio | 5.83 |
| Progressive farmers | 6.67 | 0.00 | Newspaper | 40.83 |
| Fellow farmers | 4.44 | 2.22 | Television | 76.67 |
| Elders | 0.00 | 0.00 | Neighbour | 30.83 |
| Others | 0.00 | 0.00 | Family member | 5.83 |
| | | | Traditional knowledge | 16.67 |
| | | | Others | 5.00 |

About 37.50 per cent of the farmers have accessed agricultural information (Table 5.8.20). About 62.22 per cent opined that the male members of the household have access to information whereas 17.78 per cent were of the view that both, male and female members have access to information.

Mainly the government organizations like KVK, ICAR, Agriculture Department, Block Office *etc.* were the sources of information in normal periods as well as during ECVs (Table 5.8.21). For weather information, they were dependent on television (76.67%), newspaper (40.83%), neighbour (30.83%) and traditional knowledge (16.67%).

Only 12.50 per cent of the respondents have availed loan for agricultural purpose. Though about 35.83 per cent of them heard about human insurance but only 6.67 per cent were aware of crop insurance and 11.02 per cent about livestock insurance (Table 5.8.22).

MGNREGA scheme (80.00%), PDS ration (79.17%) and old age pension (20.83%) were the major supports the respondents have received (Table 5.8.22). Agriculture Department (66.67%), KVK/Block office (41.67%) were the major agencies which were engaged with the farmers.

| Table 5.8.22. Per cent of respondents accessed agricultural loan and heard about insurance schemes in West Tripura | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 12.50 |
| Insurance scheme | |
| Crop | 6.67 |
| Livestock | 11.02 |
| Human | 35.83 |
| Other | 1.06 |

| Table 5.8.23. Type of support received and agencies that supported the farmers in West Tripura | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 5.83 | Agricultural Department | 66.67 |
| Old Age Pension | 20.83 | Horticulture Department | 0.00 |
| PDS ration | 79.17 | Animal Husbandry/ Fisheries Department | 1.67 |
| MGNREGA program | 80.00 | Bank/ Cooperative Bank/Society | 2.50 |
| Thrift and credit through SHGs | 0.00 | KVK/Block Office | 41.67 |
| Farmers' group | 0.00 | Meteorological Department/ Irrigation Department | 3.30 |
| Health insurance | 0.83 | Health Department | 0.00 |
| Training on new rice technologies | 5.00 | Agricultural Universities | 0.00 |
| None | 0.00 | None | 20.83 |
| Support from NGOs | 0.00 | NGOs | 0.00 |

## 5.9 LUNGLEI DISTRICT OF MIZORAM

### *Socio-economic status*

The socio-economic information of sample households of Lunglei is presented in Table 5.9.1.

| Table 5.9.1. Socio-economic information of sample households of Lunglei | | | | | |
|---|---|---|---|---|---|
| Particulars | Unit | Value | Particulars | Unit | Value |
| Average age | years | 51.85 | Sex ratio | per 1000 male | 846.38 |
| Family size | no. | 5.33 | | | |
| Social group | % | | Religion | % | |
| Schedule Tribe | | 100.00 | Christian | | 100.00 |
| Schedule Caste | | 0.00 | Hindu | | 0.00 |
| Other Backward Caste | | 0.00 | Islam | | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| Others | | 0.00 | Buddhist | | 0.00 |
| Housing structure | % | | Operational land holding | ha | 2.25 |
| *Kaccha* | | 0.83 | Upland | | 2.36 |
| Semi-*pucca* | | 91.67 | Lowland | | 1.64 |
| *Pucca* | | 7.50 | Irrigated land | % | 36.64 |
| Educational status | % | | Educational status | % | |
| Illiterate | | 5.83 | Middle | | 27.50 |
| Literate | | 1.67 | Secondary | | 22.50 |
| Literate but below Primary | | 5.00 | Higher Secondary | | 11.67 |
| Primary | | 25.83 | Graduate | | 1.67 |

The average age of the respondents was 52 years and a family was composed of on an average five members in the Lunglei district of Mizoram (Table 5.9.1). Cent per cent of the respondents were Christian and ST. The number of female was 846 per 1000 male and the literacy rate was 94.17 per cent. Maximum of the respondents had education up to Middle (27.50%) and Primary (25.83%) school level. The houses in which the farmers stay were mainly semi-*pucca* (91.67%) or *pucca* (7.50%) types (Table 5.9.1). The average land holding was calculated to be 2.25 ha, out of which 36.64 per cent was irrigated.

***Perception about climate change***

The sample farmers' perception about different aspects of climate change in Lunglei district is eliciated in Table 5.9.2 to Table 5.9.4.

Table 5.9.2. Type of stress farms experience and farmers' perception about change in climate over past 10 years in Lunglei

| Stress | Frequency (%) | Response | Frequency (%) |
|---|---|---|---|
| Submergence | 0.00 | No | 0.00 |
| Drought/Water stress | 83.33 | Yes | 100.00 |
| Acidity | 85.83 | Not sure | 0.00 |
| Others | 13.33 | Do not know | 0.00 |

Majority of the farmers (85.83%) reported about the problem of soil acidity and stress of drought (83.33%) in the study area (Table 5.9.2). All of the respondents felt climate has changed over the years.

Table 5.9.3. Farmers' perception (%) about change in temperature and rainfall in Lunglei

| Temperature | | | Timing of rainfall | | | Amount of rainfall | | |
|---|---|---|---|---|---|---|---|---|
| Change | Summer | Winter | Change | Monsoon | Winter | Change | Monsoon | Winter |
| Decrease | 0.00 | 0.00 | Late | 87.50 | 34.17 | Low | 83.33 | 45.00 |
| Increase | 100.00 | 90.83 | Early | 2.50 | 2.50 | High | 0.83 | 0.00 |
| No change | 0.00 | 9.17 | No change | 1.67 | 29.17 | No change | 6.72 | 28.57 |
| Not sure | 0.00 | 0.00 | Not sure | 8.33 | 34.17 | Not sure | 9.11 | 26.43 |

The farmers of Lunglei perceived that the summer (100%) as well winter (90.83%) temperature have increased (Table 5.9.3).About 83.33 per cent and 45.00 per cent of them perceived that the monsoon and winter rainfall has declined in last 10 years, respectively. The monsoon rainfall has also become late (87.50%) by 7-10 days over the years. Most of the respondents (48.33%) did not recall incidence of long unexpected dry spell within a rainy period but about 34.17 per cent and 10.08 per cent of the respondents recalled unexpected long dry spell and drought incidence, respectively during monsoon season (Table 5.9.4).

Table 5.9.4. Unexpected change encountered by the respondents in Lunglei (in %)

| Response | Long dry spell | | Drought incidence | |
|---|---|---|---|---|
| | Monsoon | Winter | Monsoon | Winter |
| No | 48.33 | 40.83 | 73.95 | 62.18 |
| Yes | 34.17 | 17.50 | 10.08 | 4.20 |
| No change | 16.67 | 34.17 | 15.13 | 28.57 |
| Not sure | 0.00 | 6.67 | 0.00 | 0.05 |

***Impact of climate change***

*Impact on crops and food*

The effect of climate change on crop area, productivity and food availability are presented in Table 5.9.5 to Table 5.9.9.

Table 5.9.5 Effect of rainfall variability on area under rice and fallow in Lunglei (in %)

| Response | Rice area | | | Fallow | | |
|---|---|---|---|---|---|---|
| | Early | Late | Low | Early | Late | Low |
| Decrease | 0.00 | 42.99 | 100.00 | 0.00 | 0.00 | 0.00 |
| Increase | 11.11 | 0.00 | 0.00 | 0.00 | 42.99 | 92.86 |
| No change | 88.89 | 57.01 | 0.00 | 0.00 | 57.01 | 0.00 |
| Not sure | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Any change in rainfall pattern, affects the area under crop. Majority of the respondents reported that they reduce the area under rice crop in case of drought (Table 5.9.5) and about 42.99 per cent of the farmers have reduced the area under rice cultivation in case of late rainfall which resulted into increased fallow area but majority of the respondents (88.89% and 57.01%) did not change the crop area in case of early or late rainfall, respectively.

They informed that low rainfall (93.07%) and change in timing of rainfall (86.36%) negatively affect paddy productivity. It is estimated that the productivity declined by 48.01 per cent during drought in comparison to normal year (Table 5.9.6). More than 98 per cent of the farmers perceived that the pest and disease attack has increased in recent times which may be due to the change in climate (Table 5.9.7). The crop damage due to pest and disease was on average was about 12.05 per cent.

Table 5.9.6 Effect of rainfall variability on yield of rice in Lunglei

| Response | Direction (in %) | | | Quantum (kg/ha) | |
|---|---|---|---|---|---|
| | Low | High | Early/Late | Drought/Low rainfall | Normal |
| Decrease | 93.07 | 11.11 | 86.36 | 599.24 | 1152.71 |
| Increase | 0.00 | 72.22 | 0.00 | -48.01% | |
| No change | 0.99 | 5.56 | 3.41 | | |
| Not sure | 2.97 | 5.56 | 6.82 | | |

| Table 5.9.7. Effect of change in climate on rice pest and disease in Lunglei | | | (in %) |
|---|---|---|---|
| Response | Disease | Pest | Crop damaged |
| Decrease | 1.41 | 0.00 | 12.05 |
| Increase | 98.59 | 100.00 | |
| No change | 0.00 | 0.00 | |
| Not sure | 0.00 | 0.00 | |
| New disease | 0.00 | 0.00 | |

| Table 5.9.8. Effect of climate change on availability of food in Lunglei | | |
|---|---|---|
| Particulars | Normal | Drought/Low rainfall |
| Supply of food from own land (months) | 8.83 | 6.16 |
| Perception (%) | | |
| Insufficient/decline | 22.50 | 94.52 |
| Sufficient/improve | 75.83 | 2.74 |
| No change | 0.00 | 0.00 |
| Not sure | 1.67 | 2.74 |

| Table 5.9.9. Sufficiency of money for purchase of food during climatic variability and who gets sufficient food during climatic variability in Lunglei | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Sufficiency of money for purchase of food | 54.05 | | |
| Family members | | Grown up children | 0.83 |
| Husband | 1.67 | Elders | 2.50 |
| Wife | 0.00 | All members | 61.67 |
| Both husband & wife | 2.50 | Do not know | 29.41 |

In normal season the own farm produce lasted for 8.83 months for family consumption but during low rainfall/drought the produce lasted for on an average 6.16 months (Table 5.9.8). Also, 94.52 per cent of the farmers reported that availability of food become insufficient during drought (Table 5.9.8) and 45.95 per cent of them found it difficult to purchase food from market due to insufficiency of money (Table 5.9.9). There was no gender discrimination in case of distribution of food during climatic variability.

*Effect on water situation*

The effect of climate change on water availability is presented in Table 5.9.10 and Table 5.9.11. Majority of the farmers reported that water availability for both, irrigation (89.29%) as well as drinking (62.50%) purpose reduce during the drought period (Table 5.9.10). Reducing drinking water facility in the village was reported by 92.50 percent of the farmers and 76.67 per cent revealed that water for irrigation has become inadequate over time but only 4.17 per cent of the farmers reported conflict in the village due to water shortage in the last 5 years (Table 5.9.11).

| Table 5.9.10. Responses about change in water availability during low rainfall or drought situations in Lunglei (in %) | | |
|---|---|---|
| Type of change | Irrigation | Drinking |
| Decrease | 89.29 | 62.50 |
| Increase | 0.00 | 0.00 |
| No change | 0.00 | 0.00 |
| Not sure | 10.71 | 42.06 |

| Table 5.9.11. Response (%) on water scenario in the village in Lunglei | | | |
|---|---|---|---|
| Response | Do you think your village's irrigation facility is becoming more and more inadequate? | Do you think your village's drinking water facility is reducing? | During the past 5 years any conflicts over water in your community/village? |
| No | 10.00 | 2.50 | 77.50 |
| Yes | 76.67 | 92.50 | 4.17 |
| Not sure | 13.33 | 5.00 | 18.33 |

*Impact on fuel availability and time spent on different activities*

The effect of climate change on fuel availability and time spent on different activities are presented in Table 5.9.12 to Table 5.9.14.

| Table 5.9.12. Sources of fuel, members engaged in fire wood collection and perception about effect on wood availability during climatic variability in Lunglei | | | | | |
|---|---|---|---|---|---|
| Source of cooking fuel | | Who collects wood? | | Fire wood availability during low rainfall | |
| Source | Frequency (%) | Member | Frequency (%) | Responses | Frequency (%) |
| Wood | 47.50 | Husband | 13.33 | Decrease | 3.70 |
| Charcoal | 0.83 | Wife | 15.00 | Increase | 81.48 |
| Cow dung | 0.00 | Both | 6.67 | No change | 14.81 |
| LPG | 70.83 | Grown up children | 5.83 | Not sure | 0.00 |
| | | Elders | 5.00 | | |
| | | All members | 18.33 | | |
| | | Market | 0.00 | | |

Even though majority of respondents (70.83%) were having LPG connection, about 47.50 per cent of the respondents still used wood as fuel (Table 5.9.12). About 18.33 per cent opined that all the members of a family used to collect fire wood but about 15.00 per cent and 13.33 percent informed that wife and husband in the household were doing the job of fire wood collection.

| Table 5.9.13. Effect of climatic variability on time spent (hr/day) during climatic variability in Lunglei | | |
|---|---|---|
| Activities | Normal | Low rainfall |
| Fodder collection/grass cutting | 1.25 | 2.00 |
| Fetching drinking water | 1.22 | 1.92 |
| Wood (fuel) collection | 1.84 | 1.65 |
| Working hours in crop field | 6.63 | 5.75 |

Availability of fire wood has increased (81.48%) during low rainfall/drought seasons, which is reflected by increase in time for wood collection (Table 5.9.13).Contrary to our expectation, in case of extra burden during climatic variability, most of it was carried by both male and female and least of the burden was taken by the women in the family, alone (Table 5.9.14).

| Table 5.9.14. Extra burden shared during climatic variability in Lunglei | | | | (in %) |
|---|---|---|---|---|
| Member | Fodder collection/grass cutting | Fetching drinking water | Wood (fuel) collection | Working hours in crop field |
| Male | 0.00 | 8.33 | 2.22 | 20.00 |
| Female | 0.00 | 2.50 | 0.00 | 0.83 |
| Both male & female | 100.00 | 89.17 | 97.78 | 79.17 |

***Adaptation and mitigation strategy***

The adaptation and mitigation strategies followed by the sample farmers in Lunglei district are presented in Table 5.9.15 to Table 5.9.19.

| Table 5.9.15. Adaptation strategy followed in agriculture in Lunglei | | | (in %) |
|---|---|---|---|
| Strategy | Late rainfall | Early rainfall | Low rainfall |
| Leave complete fallow | 3.17 | 0.00 | 0.00 |
| Grow dry fodder crops | 0.00 | 0.00 | 0.00 |
| Change in cropping sequence | 1.61 | 0.00 | 11.11 |
| Change in crop cultivar/ landrace | 1.67 | 0.00 | 11.11 |
| Change in sowing/harvesting time | 78.41 | 28.00 | 82.14 |
| Change in harvesting time | 78.41 | 28.00 | 82.14 |
| Shift from crops to livestock | 0.00 | 0.00 | 0.00 |
| Grow more cash crops | 1.56 | 0.00 | 0.00 |
| Cultivate smaller area than usual | 1.64 | 0.00 | 0.00 |
| No change | 26.53 | 57.14 | 20.83 |

Changing the time of sowing and harvesting were the two major mitigating strategies adopted by the farmers in case of change in rainfall pattern or climatic variability. Some of them have changed the cultivars or cropping sequence due to change in climate (Table 5.9.15). About 78.41 per cent and 82.14 per cent of the farmers changed sowing time in case of late rain and drought, respectively and consequently their harvesting time also has changed. It was found that quite a large number of farmers did not take up any adaptation strategy in times of climatic variability and that is the point where intervention is required by the concerned authorities.

| Table 5.9.16. Farmers' response to negative impact of climatic variability for sustaining livelihood in Lunglei | | | |
|---|---|---|---|
| Strategy | Frequency (%) | Strategy | Frequency (%) |
| Migrate | 0.00 | Start shop keeping | 25.00 |
| Wage labour | 50.00 | Devote more time in shop keeping | 0.83 |
| Go to neighbouring villages for labour work | 0.83 | Sell assets | 2.50 |
| Loan | 0.00 | Children drop out from school | 0.00 |

It was found that working as wage labor under MGNREGA was the best alternative source of livelihood for majority of the respondents (50.00%) in case of climatic variability (Table 5.9.16) whereas about 25 per cent the preferred to start business like shop keeping. About 2.50 per cent of them resorted to selling of assets for sustaining their livelihood. No migration was reported by the respondents in the district.

Table 5.9.17. Mitigating options preferred by respondents in Lunglei

| Options | Frequency (%) | Options | Frequency (%) |
|---|---|---|---|
| Use of stress-tolerant crop cultivar | 59.17 | Pest and disease management techniques such as IPM | 80.00 |
| Shift to improved cropping system | 32.50 | Development and use of crop cultivar resistant to pests and diseases | 15.83 |
| Planting of early, medium or late cultivar to avoid crop loss to variations in drought/flood occurrence | 9.17 | New livestock breeds | 15.83 |
| Short duration variety grow other additional crops | 51.67 | Animal health management | 22.50 |
| New land management techniques | 30.00 | Others | 0.00 |
| Changes in agricultural water-managed techniques | 36.67 | Do not know | 0.00 |

Measures for mitigation for reducing vulnerability to climate variability, preferred by farmers were pest and disease management technique (80.00%), stress-tolerant cultivars (59.17%) and short duration variety to grow additional crop (51.67%) (Table 5.9.17).

Table 5.9.18. Rice cultivars which are stopped and which are perceived as suitable in climate change scenario in Lunglei

| **Cultivar stopped** | | **Suitable in climate change scenario** | |
|---|---|---|---|
| Cultivar | Reason | Cultivar | Reason |
| Bhuban | Very sticky and low productivity | Aizong | Withstand drought |
| Bhupui | Sticky, loss market demand, low productivity and susceptible to pest infestation | Buhban | Withstand water and heat stress |
| Bhusaiki | Taste not preferred and low productivity | Buhpui | Can withstand stress (Heat) |
| Buhttai | Less production | Burmabuh | Withstand stress |
| Burma buh | Taste and low productivity | Fangsin | Withstand stress |
| Fangsen | Low productivity and taste is not preferred | Ido | Withstand drought/low rainfall |
| Ido | Low productivity | IR – 64 | withstand stress |
| IR-64 | Taste and yield is not good | Tampha Tamphapo | Withstand water stress |
| Manipur | Cannot withstand water stress and low productivity | Zobuh | Can withstand climatic change and easy to manage in dry/rainy season |
| Zobuh | Low productivity | | |

About 35.29 per cent of the farmers reported that they have changed the rice cultivar (*Annex V (MZ)_I*) but most of them have changed the varieties in alternative one or

two years to sustain the productivity of the crop. In most of the cases, either both husband and wife (60.00%) together or the husband alone decided (23.33%) what cultivar is to be grown in the field.

*Aizong, Buhban, Buhpui, Burmabuh, Fangsin, Ido,* IR–64, *TamphaTamphapo, Zobuh*were the varieties those were perceived to be resistant to water stress by the farmers of Lunglei district (Table 5.9.18). In the study area, taste (74.58%) and yield (69.49%) were the major decisive factors that influenced the decisions to continue with or change a rice cultivar (*Annex V(MZ)_II*). The factors like number of panicle and shoots which are related to yield and drought tolerance were other determining factors.

They expressed that training programs should give more emphasis on pest management (69.17%), water management (41.67%), crop production management (25.83%), management of animals (29.17%) and seed health management (17.50%) (*Annex V(MZ)_III*).

*Agricultural information and Institutional support*

The source and access to agricultural information and institutional support available in the district is presented in Table 5.9.19 to Table 5.9.22.

Table 5.9.19.Who has the access to agricultural information in Lunglei?

| Particulars | Frequency (%) | Particulars | Frequency (%) |
|---|---|---|---|
| Access to information | 52.50 | | |
| Member | | Elders | 1.59 |
| Men | 12.70 | Male grown children | 0.00 |
| Women | 3.17 | Female grown children | 0.00 |
| Both men and women | 84.13 | Do not know | 0.00 |

About 52.50 per cent of the farmers have accessed agricultural information (Table 5.9.19) and the source of information was mainly institutions like KVK, ICAR, Agriculture Department, Block Office *etc.* and progressive farmers during normal years but interestingly, very few of them reported about receiving any information on agriculture from them during ECV (Table 5.9.20). About of 84.13 per cent of the respondents, felt that both men and women have access to information on agriculture (Table 5.9.19). Interestingly, most of the respondents (57.50%) used traditional knowledge for understanding the weather (Table 5.9.20). Television (55.00%), neighbour (35.00%) and radio (31.67%) turned out to be the other major source of weather information for the farmers of the Lunglei district.

Table 5.9.20. Source of information on agriculture and weather in Lunglei

| Agriculture | | | Weather | |
|---|---|---|---|---|
| Source | Frequency (%) | | Source | Frequency (%) |
| | Normal year | ECV year | | |
| Government Institutions | 100.00 | 1.59 | Radio | 31.67 |
| Progressive farmers | 9.52 | 1.59 | Newspaper | 27.50 |
| Fellow farmers | 0.00 | 0.00 | Television | 55.00 |
| Elders | 0.00 | 0.00 | Neighbour | 35.00 |
| Others | 0.00 | 0.00 | Family member | 0.83 |

| | | | | |
|---|---|---|---|---|
| | | | Traditional knowledge | 57.50 |
| | | | Others | 0.00 |

| Table 5.9.21. Per cent of respondents accessed agricultural loan and heard about insurance schemes in Lunglei | |
|---|---|
| Particulars | Frequency (%) |
| Accessed agricultural loan | 0.00 |
| Insurance scheme | |
| Crop | 0.00 |
| Livestock | 0.00 |
| Human | 40.83 |
| Other | 6.72 |

Serious attention of the concerned organizations is required as none of the sample farmers in the district were aware of crop and livestock insurance and only 40.83 per cent of them knew about human insurance (Table 5.9.21).

| Table 5.9.22. Type of support received and agencies that supported the farmers in Lunglei | | | |
|---|---|---|---|
| Type of support | Frequency (%) | Agency/Organization | Frequency (%) |
| Housing | 0.83 | Agricultural Department | 37.50 |
| Old Age Pension | 15.83 | Horticultural Department | 8.33 |
| PDS ration | 89.17 | Animal Husbandry/ Fisheries Department | 0.00 |
| MGNREGA program | 96.67 | Bank/ Cooperative Bank/Society | 0.00 |
| Thrift and credit through SHGs | 6.67 | KVK/Block Office | 44.17 |
| Farmers' group | 0.00 | Meteorological Department/ Irrigation Department | 0.83 |
| Health insurance | 0.00 | Health Department | 0.83 |
| Training on new rice technologies | 1.67 | Agricultural Universities | 0.00 |
| None | 0.83 | None | 18.33 |
| Support from NGOs | 0.00 | NGOs | 0.00 |

Support through PDS ration was received by an overwhelming 89.17 per cent of farmers (Table 5.9.22). About 15.83 per cent of the respondents were also receiving old age pension and 6.67 per cent were part of SHGs. Agricultural support for the farmers was given mainly through the KVK/Block office (44.17%) and Agricultural Department (37.50%).

**Impact of Climate Change on Agriculture in West Jaintia Hills District of Meghalaya: Farmers' Perception**

To understand the impact of climate change on agriculture in West Jaintia Hills district, a FGD was conducted at Nongkhroh village ($25^0$36'N latitude and $92^0$07'E longitude), located in Thadlaskein Block around 30 km from Jowai. West Jaintia Hills district is located between $25^0$02'N and $25^0$45'N latitude and $91^0$58'E and $92^0$50'E longitude and the district headquarter is located in Jowai. The population of the district is 2.7 lakh and the literacy rate is 63.23 per cent (Census, 2011). The district covers an area of around 1693 sq. km. and the altitude of the district ranges from 76 m to 1627 m above msl. The average annual rainfall is around 2900 mm and the temperature in the district ranges between $10^0$C to $25^0$C.

The gross cropped area in the district is around 36.5 thousand ha with cropping intensity of 101.1 per cent. The major cereal crops cultivated in the district are rice and maize. Rice covers an area of 12.44 thousand ha with annual production and productivity of 21.35 thousand MT and 1.71 MT/ha. Maize covers an area of 3.07 thousand ha with annual production and productivity of 3.66 thousand MT and 1.19 MT/ha (GoMa, 2014). Other in important crops includes turmeric, soybean, ginger, areca nut, mustard, orange and banana (GoMb, 2014).

The Nongkhroh village has a population of 1296 and sex ratio of 1006 females per 1000 males. The literacy rate in the village is very low at 41.59 per cent, compared to the state literacy rate of 74.43 per cent. About 98.5 per cent of the total population belongs to the ST category (Census, 2011). The average maximum temperature and minimum temperature were around $24.8^0$C and $8.5^0$C, respectively in the block. The annual rainfall in the area ranges from 2500 to 3000 mm.

Total 22 farmers, comprising of 12 male and 10 female, of Nongkhroh village participated in the focus group discussion (FGD). The average age of the participants was 38 years for female farmers and 37 years for the male farmers. Only, one of the farmers has graduated and others have less than primary level of education. The people of Nongkhroh village are mainly dependent on agriculture and rice, maize, ginger, turmeric, mustard, soybean, tomato, broomstick *etc.* are grown in rainfed condition.

They revealed that water stress was the major problem that the farms in the village experience. The farmers have perceived that rainfall is reducing year by year and the arrivals of the monsoons now have been late as compared to previous decades. They were also in agreement about the rise in temperatures both, in summer and winter seasons. The increasing incidences of droughts and hail storms have adversely affected the agriculture in the village. Non-availability of irrigation facility added to the problem. Most of them said that they manually irrigate their crops with buckets during the periods of low rainfall. The famers mainly cultivated hybrid rice, available at the block office at 50 per cent subsidy. The productivity of hybrid rice was higher than the local cultivars *viz., Kbabhoi*, *Laispah* and *Khyriem*, but they were of the opinion that the local rice cultivars perform better in low rainfall/drought situations. The productivity of the hybrid rice dropped from 1400 kg/ha during normal conditions to 700-800 kg/ha during drought conditions, which was around 50 per cent reduction in productivity.

Pests and diseases have also increased in the village that may be due to climate change, but they were sure of it. In rice, shoot borer was the major pest infecting the crop and in the case of ginger, soft rot was widely reported. The increasing incidence of late blight and wilt in case of tomato was also widely reported but they informed that they have limited access to chemical measures.

Pigs, cattle and poultry were the major animals reared by the inhabitants of the village. Rearing goat was not permitted in the area because the animals tend to graze over and could destroy the crops in the fields. Low availability of green fodder during the periods of drought was the major hindrance in case of livestock rearing.

The stream which is flowing around 0.25 km from the village is the major source of drinking water in the village. Drinking water has become scarce during low rainfall periods and the respondents also reported about the deteriorating water quality during drought. Supply of water to the village through pipes was almost non-existent. Working as wage labourers in the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and searching jobs as labourers in the surrounding villages and towns were the major mitigation strategies adopted by them during periods of low rainfall/drought for sustaining their livelihoods.

Although majority of the farmers were aware of climate change in their village, apart from changing the sowing and harvesting dates, no adaptation strategy was taken up. Concerned authorities should take up measures to help reduce vulnerability to climate change by providing better irrigation facilities, arranging training programmes supported by appropriate input delivery.

## Climate Change Effect on Agriculture: A Case Study of Ukhrul in Manipur

Ukhrul is located at $25.15^0$N latitude and $94.36^0$E longitude at altitude of 2020 m msl. The average rainfall is about 1763.7 mm and the temperature ranges from 3 to 33. We have conducted a case study with the farmers of Greenland Mayourum dang (village), which is home for about 400 villagers. Ten farmers (six female and four male) farmers participated in the FGD. The average age of the participants was 57 years. Majority of them studied up to class VIII and two persons passed class X.

They informed that both summer and winter temperature has increased over the years. They also reported that monsoon rainfall has been delayed by 15 days which delay the transplanting of rice. Sowing time same-transplanting delayed and the cloudy days has reduced leading to longer drier spell. Snowfall has stopped long back in the area, they can recall 30 years back about incidence of snowfall.

Rice is the main crop in the area and pulses are grown in the bunds. The rice varieties cultivated are Uteibi, Changuima (yield is higher but not tasty), Machong (late variety), Taroima (cultivated in terrace – drought resistant and tasty), Veinagara, Paoreima, Masira and RCM-10. They used to cultivate chocho, cabbage, mustard, pea, and now they have started cultivating onion, garlic, cauliflower, laddies finger, carrot and they felt this new vegetable cultivation is possible due to increase in temperature in the area. The pest (wahik) attack is been higher in last 3-4 years. They also informed that leach and mosquito population in rise in the village. They reported that yield declines approximately by 20 per cent. Pig and poultry are reared by all the households. The river known as lungdang gong becomes narrow and less deep during winter season. Wood in the forest has declined due to heavy logging and cutting. They also informed that paralysis has become very common in the area.

## Climate Change and Vegetable Cultivation in Dhalai District of Tripura

A study was conducted in Ambassa and Kamalpur sub-division of Dhalai district in Tripura to understand farmers' perception about climate change, its impact on crop productivity and how farmers make necessary adaptation to cope up with climate change. The villages covered were Ruposhpur, Chotorsurma and Rangicherra from Kamalpur and Nalicherra from Ambassa. Three farmers from each of the villages *i.e.,* total twelve farmers and two village level worker and one Subject Mater Specialist (SMS) of KVK were interviewed. These beautiful villages were endowed with favourable condition to grow rice and wide range of vegetables. Only a few farmers grow maize and mustard. These villages have emerged as important hub for vegetable production as many farmers grow potato, tomato, cabbage, cauliflower, ladies finger, chilli *etc*. Farmers prefer to grow field pea over gram due to pea's marketability. Most of the farmers of these villages earn their livelihood through vegetable cultivation in addition to rice crop.

They now grow rice High Yielding Varieties (HYVs)/Improved Varieties (IVs) such as *Swarna, Sohobhagi, Ranjit, IR-8* but a number of traditional varieties such as *Vonboli*, *Ramaish* and *Jenger* are now abandoned by the farmers. Some varieties *viz.*, *Susumbi*, *Araid* and *Jaya* which were grown during *Aus* season are also no more in the area. Due to low productivity, farmers in the area also have stopped growing some varieties *viz. Lathichail, Balam, Binni, Khasa*. The farmers in these villages were not much interested in System of Rice Intensification (SRI) as the farmers found the method difficult to follow. The rice crop in the district was often affected by *khaira* disease.

The farmers in the villages have area for cultivating crops ranging from 0.32 ha to 4.00 ha. True Potato Seed (TPS) is popular in Tripura. Farmers in Dhalai district also cultivated potato during *rabi* season using TPS. The major problems faced by the farmers were curling of leaf and rotting of mid rib of leaf and roots. They informed that the disease attack on potato increases if the number of foggy days increase which reduces the productivity of potato. Some farmers can access the irrigation facilities from the river Dhalai and Surma. They irrigated their land using the small streaks of Dhalai and Surma rivers and those who have irrigation facility they focussed on cultivating vegetables. The drinking water facility has improved in these villages due to Governmental effort. They use ring well, tube well and depends on Government water supply. But in a few villages during summer both male and females have to take higher burden (time and drudgery) to fetch water from distance.

Most of the farmers felt that off-late temperature has risen. During their childhood they could not think of wearing half sleeve during February alike in the year 2014. They felt advent of monsoon has become late by about 10 days but in 2013 it was early by 7 days. The amount of rainfall has decreased over the years.

During normal seasons they reaped about 4-4.5 MT/ha of paddy but in case of untimely or low rainfall the productivity reduced even up to half also. The production of vegetables were not much affected as the farmers who have assured irrigation cultivated vegetables but the farmers were of the view that vegetables are sensitive to environmental extremes like high temperature and limited soil moisture which reduces the productivity. They informed that pest and disease attacks are lower during normal weather condition in comparisons to abnormal weather condition.

Lentil has been introduced as a new crop in these villages by the Krishi Vigyan Kendra (KVK) and the varieties grown by the farmers were *HUL-57, WBL-58, WBL-77* and *Ranjan*. The villages have no soil testing facility so far but they are collect information about weather from Television.

Varieties grown by the farmers

| Crop | Variety | Crop | Variety | Crop | Variety |
|---|---|---|---|---|---|
| Chilli | NS-1701 | Sweet corn | sweet 16 | Banana | Sabri |
| Tomato | Jessica, NS-501 | Mustard | sakata-555 | Mango | Amrapalli |
| Pencil bean | Katrina | Garlic | VL Garlic-2 | Guava | L 49 |
| Garden pea | Vivek Matar | Onion | VL Piyaz-3, Nasik Red | | |

## Impact of Climate Change on Potato Cultivation in Mawlynrei Village of East Khasi Hills, Meghalaya

Potato is one of the staple diets of the people of Meghalaya and the crop has been cultivated for generations by the farmers of the state. This crop covered an area of 18.13 thousand ha in the state and the annual production and yield of the crop was 172.9 thousand MT and 9.53 MT/ha, respectively in 2012-13. East Khasi Hills District is the highest producer of potato with annual production and productivity of 115.8 thousand MT and 10 MT/ha, respectively.

An FGD was conducted at Mawlynrei village to understand the impact of climate change on potato cultivation. The village is located at $25^{0}34'33''$N latitude and $91^{0}56'47''$E longitude, in East Khasi Hills district at the elevation of 1536 m. Mawlynrei has a population of around 3437 with a sex ratio of 1032 females per 1000 males. The literacy rate in the village is relatively higher at 82.29 per cent than the State's average of 74.43 per cent. Vegetables like potato, tomato, peas, beans, maize, ginger, *etc*. are the major crops cultivated by the farmers of Mawlynrei. The temperature in Mawlynrei varies from $24^{0}$C in summer to a low $4^{0}$C in winter and the annual rainfall in the area ranges from 2500 mm to 3000 mm.

Ten potato cultivators, comprising of six male and four female farmers, of Mawlynrei village participated in the FGD. The average age of male and female farmers was 52.8 and 37.0 years, respectively. Four of the respondents were illiterate; three had education up to middle level and two up to primary level. They cultivated potato on an average 0.49 ha of land. The planting season for potato was during February and March as *zaid* crop and during August and September as *rabi* crop. Most of them were cultivating potato as *jhum* cultivation under rainfed conditions. The local cultivars such as *Phan Saw Khasi* and *Phan Smit* were the popular. They harvested about 10 to 14 MT potato from one hectare of land and majority of the farmers sold their harvest in Rynjah market, after keeping some for home consumption and seeds for the next season. They stored the potato when the price dropped and sold their produce when the price rose.

All the farmers were aware of climate change in their area and reported that the temperature has been rising in the area. The amount of rainfall has decreased and the arrival of rain has also become late. All the participating farmers have opined that potato cultivation was affected in the village due to change in climate. They informed that during low rainfall or long dry spell the tubers shrivelled and the productivity reduced by 50 per cent. Some of the farmers even said that low rainfall could lead to situations when farmers may not even recover seeds for the next season. The varieties they used were suited to low temperature and increase in temperature lead to reduced production as the size of potato gets smaller.

The farmers reported that pests and disease infestations on potato crop have increased in the village in recent years which may be due to climate change. Some of them were not able to cultivate potatoes this season because almost all of their seed tubers were infected by tuber moths in storage. Incidences of late blight and brown rot has also increased in the area which resulted in use of chemical pesticides by some of the farmers. Lack of proper training on management of pests and disease left the farmers vulnerable to such situations.

They have also informed that the productivity of the land has drastically reduced over the years. To elicit this they told that the present level of yield with application of fertilizers is same as the yield they used to get without application of fertilizers, 10 years back. They opined that now potato cultivation is not possible without application of fertilizers such as urea and Di-ammonium Phosphate (DAP).

The respondents reported that due to negative impacts of climate change, many farmers in the village have reduced the area under potato cultivation and diversified towards growing vegetable crops like tomato, peas, beans, cole crops, *etc*. Among the vegetables, tomato was most favoured by the farmers in this village as they grow it mainly as *kharif* crop and they were able to harvest the crop multiple times which augmented their income levels.

The potato production has been negatively affected by the growing temperature and low rainfall. Pest and disease infestation was another constraint in case of potato cultivation. Hence, proper irrigation, pest and disease management, seed treatment and proper storage techniques are the areas where they may be trained to minimize their vulnerability to the climate change.

### Climate Change and High Altitude Agriculture and Horticulture: A Case Study of Mukto Village, Tawang in Arunachal Pradesh

To understand the impact of climate change on agriculture in high altitudes of Arunachal Pradesh five farmers of Mukto village were interviewed and discussion was held with Agricultural Development Officer and Horticultural Development Officer of the Mukto Bongkhar block. Mukto village ($27^0 33' 28''$N latitude and $91^0 56' 52''$E longitude) is located at the altitude of 2649 m above mean seas level and falls under Tawang district, situated in the western part of Arunachal Pradesh bordering with Tibet. The place experiences a cool temperate climate. The district receives an annual normal rainfall of more than 1500mm which favors the growth of vegetation. The ethnic tribe of the district is mainly *monpa* tribe (96% of the district population) who inhabit in 162 villages out of 163 villages and most of the inhabitants are scattered at lower altitudes which is less than 2500 m.

The economic life of the people in the village revolves around agriculture. Some of the major cereal crops grown in the area are maize and millet. Earlier, finger millet was common cereal crop in the village but nowadays the crop is grown by very few villagers. Normally the cultivation of finger millet starts from last week of April and harvested during last week of October or first week of November. But in the last decade the sowing is done during the month of March and harvesting during month of October/September, which they perceive due to change in climate.

But interestingly, farmers of the area reported about the positive impacts of climate change. They perceived that the temperature has increased which leads to change in cropping pattern. For example, vegetables *viz.,* cabbage, cauliflower, carrot, radish which earlier was not possible to cultivate during winter season can now be cultivated due to low temperature. Several efforts were made by the Horticulture Department to introduce new fruit crops like kiwi, apple and walnuts in the district and Mukto village is no exception to this effort made by the Department. Farmers in the area adopted the new fruit crops but there were only 6-7 farmers who grow on commercial scale. Walnuts and kiwi have been widely cultivated by the farmers in the area since the productivity is high for these two crops but recently some farmers have stopped or reduced the area under kiwi as the cost of growing and maintaining kiwi orchards is high. They reported that scab disease of apple are occurring frequently nowadays in the area which may be due to change in the climate.

The increase in temperature has helped in cultivation of vegetables and new fruit crops but course cereals are no more grown in the village and pest and disease infestation has increased in the area. Hence, research effort should be directed to make agriculture suitable to the changing climate regime.

## Climate Change Impacts on Agriculture in Mizoram: A Case Study of a Rice Farmer from Champhai Valley

Champhai (23°45'6''N and 93.32'9''E) district is located in eastern part of Mizoram. It has an area of about 3185 sq. km. The average maximum and minimum temperature of the district is 35.0$^{0}$C and 5.3$^{0}$C, respectively. On an average July and August was recorded to be the warmest months with mean maximum temperature of 27.5$^{0}$C and mean minimum temperature of 20.4$^{0}$C. The temperature starts falling from November. January was recorded to be the coldest month of the year with mean maximum temperature of 27.0$^{0}$C and minimum temperature of 6.1$^{0}$C. The average annual rainfall is about 2558 mm in the district.

The main occupation of the people of the district is agriculture with rice, pulse, passion fruit and grapes being the major crops grown in the area. The district is the major producer of rice in the state with around 13000 ha of land is under rice production. Champhai is also the largest producer of Passion Fruit (Sapthei in local language) in

Mizoram. Champhai produces around 800 MT of passion fruit annually which is about 90 per cent of the total production of the state**.**

Most of the farmers in Champhai practice rice cum fish farming in order to attain a better income from their limited land. Mr. Ramluahsanga Patea is a 62 year old farmer from Champhai valley and cultivates rice and vegetables in his land. Mr. Patea is considered as one of the progressive farmers in the area since he successfully changed the system of farming in his farm and has achieved higher farm productivity. He previously cultivated a local variety (*Butoisang*) which was popular in the area due to its taste and scent and was favoured by the tribal farmers of the area. He cultivated the rice variety in his 8 acre land and had a productivity of around 500 kg/acre. This local variety also suited low rainfall and the productivity was comparatively good even in areas where the fertility of the soil was poor. On the recommendation of the State Agriculture Department, the farmer later changed the variety in his field in 2011-12. The Department supplied the *Manipho* variety of rice seeds through the Krishi Vigyan Kendra (KVK) but the farmer did not like its taste and scent. The productivity was also low may be due to non-suitability to the local climate. In 2014 the farmer again changed to a *Burma* variety (variety came from Burma). He expressed that he was happy with the new variety because of its high productivity (800 kg/acre) and also because the taste and scent of the rice was similar to *Butoisang*. Another reason for the increase in productivity was the adoption of SRI system of rice cultivation which was introduced by the KVK of Champhai district. Despite higher productivity, the SRI method was not much adopted because the farmers were not able to carry out the rice cum fish production in the case of SRI system of rice production and the management practice was difficult in case of SRI. Although Mr. Patea followed SRI, he still continues the traditional method of rice cum fish culture in a small area of his field which yields fish about 6 q/year. Apart from rice, he also cultivates vegetables such as mustard, cabbage, cauliflower and plans to cultivate strawberry in the future with the assistance of the State Agriculture Department.

Mr. Patea informed that the rainfall in the area has decreased relative to the previous decades. The monsoon has been more erratic in nature. The rain is scheduled to arrive in June-July now get delayed till September or October. In the last year incidence of rainfall during harvesting of the *kharif* rice was detrimental to the productivity of the crop. In winter, the incidence of rainfall was minimal as compared to earlier years. The temperature in the valley has increased both in summer and winter in comparison to the previous decades and the incidences of frost in the area have been less now a days. When asked to comment upon the cause for the climate change, he said that deforestation that occurs in the system of *jhum* cultivation may be one of the factors for the change in climate in the area.

Mr. Patea being a farmer for a long period has a clear knowledge and experience on the impacts of climate change on his farm. He explained that the erratic rainfall lowers the productivity of his rice field to the extent 40 per cent in some years. The late arrival of monsoons delays the sowing of rice and lowers its production. The incidence of rains during harvesting also leads to lower production because the rice grains fall on the ground before it is harvested. The production fell from 4000 MT to 3000 MT in his 8 acre field during times of extreme climatic variability. In recent years farmers have to depend on tube wells as an additional source of irrigation.

The effect of rising temperature in the area has led to lower productivity of the local variety of rice as the local variety suited a cooler climate as compared to the other varieties. The change in temperature has also resulted in the emergence of new pest and diseases in rice such as rice grassy stunt, leaf rust, *khaira* disease *etc.* The farmer explained that there was an increase in the incidence of these pest and diseases in recent years. Although he was not certain on the actual cause of the phenomenon, he assumes that it may be due to climate change. Mitigation measures should be provided by government institutions so that the farmers are not adversely affected by climate change.

## Climate Change and its Effect on Agriculture in Jakhama Village of Kohima District, Nagaland

A case study was conducted at Jakhama village to comprehend the impact of climate change on agriculture in Nagaland. Jakhama is a picturesque village, 16 km away from Kohima in Nagaland, located at 25035'N and 94008'E at an altitude of 1550 m above msl. The village covers an area of 33 sq. km. of area out of which, 26.42 per cent is under forest area. This village has 1477 households with a total population of around 7315. On an average a household comprises of about 5 persons and the female population is higher than the male population. More than 85 per cent of the population of the village is literate. The village produced the first IAS officer from Nagaland way back in 1970's. The village has four primary schools, three secondary schools and one college.

Data were collected from 10 farmers of Jakhama village through FGD. The average age of the farmer participants was 58 years and all of them had below middle level of schooling. Majority of the inhabitants were dependent on agriculture. Rice, potato and maize are mainly cultivated in terraces. The village is famous for pani-kheti (rice-cum-fish culture) which is in practice since the generation of their forefathers. Some of the major varieties of rice grown in the village are Teviirii for plain area, Wosho for hotter area, Ngoba for area near the river and Khemenyo for the fields near the locality. Kemenyo is a scented rice variety and it fetches higher price (Rs 60/kg) in the village. Teviirii rice variety can withstand low rainfall and Ngoba variety has the ability to withstand strong wind. The villagers exchanged rice varieties with other villages in order to maintain the productivity of the crop.

The farmers perceived that the summer temperature has increased over the years, at the same time the severity of winter has also increased. The arrival of monsoon rain has been late but the amount of rainfall received is same as before. Nowadays in winter, the villagers faced shortage of rainfall and they informed that the incidence of hailstorm has also been reduced in the area.

As per the participants of FGD, late rainfall has not been a big issue as the streams nearby have enough water and they have seldom changed the sowing time of rice crop. When there was heavy rainfall during July and August, the field nearby the river and forest were mainly affected. They opined that nearly 50 per cent of production gets reduced due to immature grain filling. In the last five year stem borer infestations in rice fields has also increased. The area under rice-cum-fish culture in the village nowadays has reduced because of less water availability which may be due to deforestation. One of the villagers remarked that "earlier forests were dense but nowadays we cannot see big tress in the forest". For this special type of culture they used to fragment their large field in small plots with proper bunds to hold the water in the field. They make a special type of pool within the field so that the fish can be collected during the harvesting of rice.

Mainly they harvest and thresh on same day except Kemenyo variety of rice because threshing of this variety is difficult if it is not properly dried. Earlier they used to culture indigenous small fish varieties but now they have introduced new fish varieties, bigger in size, which were brought from china.

Potato, garlic, spring onion etc. were the other crops cultivated in the village. Due to change in timing of rainfall the production of potato has increased. They planted two types of potato varieties; locally they are differentiated by their colours, red (kufri) and white. The sizes and their prices are almost same. Earlier the farmers used to plant potato in January but now it is drifted to February in case of valley and terrace cultivation which is beneficial for the potato production in terms of size, quality and pest resistance. In case of forest fields, potato is planted in the month of March. They apply cow dung and pig manure in the fields located in the valley which is completely rainfed. The potato fields faced the problem of ants which was more in terraces as ants hide under the stones.

In this village, drinking water was plentiful as the villages is surrounded by high altitude mountains and streams and have sufficient underground water and even water is supplied to the capital city of Kohima from this village.

The climate has been changing in the village. The production of rice has not been affected due to available water resources in the village. Potato production has a got boost in the changing climate scenario. But the villagers fear about the future of pani-kheti in the village due to dwindling rainfall.

## Climate Change and *Jhum* Cultivation: Learning from Reang Tribe of North Tripura

The project team visited Damcherra Block under Kanchanpur Sub-division of North Tripura district of Tripura to understand the impact of climate change on *Jhum* cultivation. We met Darlong Babu, Agricultural Officer of Damcherra Block who gave us an insight about the agricultural scenario of the block and specially *Jhum* cultivation. He helped us in conducting a FGD at Purnoram Para under the *panchayat* Thumsaram Para in Damcherra Block. We conducted the FGD at the village school with a group of 27 *jhumias* whose average age was 33.59 years. Five of them were illiterate and most of them had education up to either primary or at the maximum secondary level.

The alleviation of the block is about 70 m above msl and at the border of Mizoram. The village is inhabited by the Reang tribe and they are the second most numerous sub-tribes of Tripuris next to old Tripura Clan, scattered all over the state. The shifting cultivation in Reang tribe is known by the term '*Huk'*. Shifting cultivation is often blamed for deforestation on hills but these indigenous tribes have cultivated crops deep inside the tropical forests for thousands of years and it is intrinsic part of their culture and identity. Though the Government has taken up program to start modern practices or settled cultivation, the Reang *jhumias* are still practising it, since it is the only source of food for them and provides stable income from mixed farming. The only investments in this practice are on labour and seed.

The tiny remote village is located on the top of the hill. The nearest market for the village is at Joyshree. The village is connected with pucca road to the nearest town Dharmanagar. The village have institutions like *panchayat*, school, anganwadi, Krishi Vigyan Kendra (KVK) at Panisagar (30 km), Agriculture Sector Office. The villagers have livelihood opportunities schemes like Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), Self Help Groups (SHGs), Old Age Pensions, *agarbati* making, Public Distribution System (PDS) *etc.* to supplement a portion of their earning. The village have 64 households but only two persons are in government job. The economic life of Purnoram Para mainly revolves round *jhum* cultivation and every family irrespective of economic status has a few patches of swiddens in the hill slopes growing mainly paddy, pulses and vegetables. It is supplemented by minor forest produce and to some extent by piggery and fishery. It is interesting to know that there is no one to distribute the land for cultivation, any one is free to cultivate anywhere in the hills even in the Mizoram hills also. After cultivating a patch for three years, the fallow period is observed for five to seven years for recuperation. The reduction in recuperative cycle is mainly on account of increase in population and shortage of land. The *jhum* cultivation starts by felling the trees and clearing of bushes in the month of January which is done mostly by males. After the trees are cut, those are allowed to dry up *in situ* for three months. In the month of March, they are set on fire. After first shower, a mixture of seeds such as rice, micro, maize, vegetables (pumpkin, brinjal, pea) are sown by dropping the seeds in the dibbled holes made in rows. As soon as the seeds are sown they do the hoeing so that the soil gets mixed up with ash covering the seeds. In case of dibbling, both male and female are engaged in the farm operation. Weeding is done in the month of June- July thrice. On the second weeding, vegetables are collected and after harvesting of paddy, again they continue to grow vegetables. Harvesting and cultivation of vegetables are mainly done by females. Farmers in the village reported that they grow a crop like millet, locally called as 'micro' which they consume similar to maize. The height of the crop is about 4 ft and when grown together with paddy it suffers retarded growth and less production. The crop is best when grown as sole crop. Recently, moong has been introduced as a new crop by the Agriculture Department to grow as a *paira* crop. When we asked about the initiative to grow other new crops, farmer Rajshekhar replied "We have to live first" indicating less potential to adopt new crop on hills as they are already exacerbated by the poverty and climate change.

Plantation crops like sugarcane and arecanut are also grown in the village. Among the fruits, local banana and citrus are cultivated by the farmers of the village. In the village, every household used to rear pigs. About 8 ponds are there in the village, out of these two big ponds were managed by SHG's. The area of pond size is about 0.56 ha each in which they used to rear rohu, mrigel and catla. Every year, they purchased fingerlings of Rs. 4000-Rs. 5000 and got yearly production of about 4 q. Farmers in the village know that fish rearing is remunerative, but due to insufficiency of money, they can't purchase fish seeds and do not feed any antibiotics to fish. Peoples in the village don't want to rear cattle in view of protecting or saving the crops and orchards from these cattle. The source of fuel for the villagers was wood from the jungle. Every household kept stock of wood for four months and females mainly collected wood from jungle.

About 10 years ago, farmers in the village used to cultivate chilli but now they are purchasing from Mizoram since they have stopped cultivating chilli. As per the villagers, chilli requires dense bamboo but now area under chilli has drastically reduced due to decline in bamboo population in the forest which they attribute to bamboo flowering. And moreover, they don't follow the scientific recommended package of practices also for cultivating chilli. The farmers in the area stopped growing some varieties of paddy *viz. Bhaidaya, Maisanyha* and *Maibrain*. *Bhaidaya* cultivar requires fertile and dense forests which are high in organic carbon content. About 20 years back, they have stopped growing this cultivar though it has good taste. Cultivation of *Maisanyha* and *Maibrain* were stopped due to decline production over the years. They still continue cultivating *Galong Beeti* since, it can withheld stress and the productivity is higher.

The hindrance for *jhum* cultivation is from climate change which affect mostly to the poor rural/hilly farmers. Farmers in the village have perceived that earlier the advent of winters were during Durga puja, now winter has shifted from October to November along with rainfall. Duration of rainfall in the area has reduced and ceased to about 6 months. Dry period is slowly increasing its spread and hot period has increased by over a month resulting in shifting trends of medium intensity towards high intensity which was totally absent earlier. Late rainfall and reduction in soil moisture during the cropping season is an issue of concern for crop production in *jhum*, affecting food and income security. Almost all the water sources (Juri river, two ring wells) dry up during dry season whereas earlier, the river was full of water for the whole year. Now, State Government supplies water but still tensions on water prevail since dry period has extended. Vegetable crops which grown in *rabi* season fails or its production decline. The production from *jhum* cultivation lasted for 3-4 months but during severe drought it lasts for only one-two month. Intermittent rain and hot temperature leads to increased incidence of pest and disease in crops under *jhum* and their incomes from crops are heavily affected during drought period. The *jhumias* remarked that during such extreme situation even pig (Rs 40/day) can't be fed properly; narrating such kind of situation one farmer named Shri. Rachindra Reang asked "How to secure a livelihood?" People in the area are really worried about the change in climate, since they derive their livelihood primarily from *jhum* cultivation. While asked about the way out they expect that the government will support them by building infrastructure, providing input facilities, technical know-how to cultivate pineapple and rice in midland and lowland area.

## Climate Change Impacts on Agriculture in Sikkim: Interview of a Key Informant

Mr. I. P. Shivakoti, Deputy Programme Director (ATMA), West Sikkim, gave a detail on the agricultural scenario in Sikkim and the impacts of climate change on the cropping pattern and productivity of the crops in the state. Although the production in the state is slowly growing, productivity in some areas is falling due to mismanagement, emergence of new pest and disease and the effects of changing rainfall patterns and temperature. He has expressed that there has been a change in the climate in the state. The temperature is rising and there is also relatively lower rainfall as compared to previous decades. The erratic nature of rainfall has also been a concern in the area, affecting agriculture in the areas and state as well.

Low rainfalls negatively impact the farmers of the state as majority of them practice rainfed agriculture. Buck wheat, millet and wheat are some of the food grains which are decreasing in the area due to low rainfall and substituted with more economically profitable cash crop such as cardamom.

Traditional crop like paddy has also reduced in terms of acreage due to low and erratic rainfall during summer. In the past rainfall in winter was common which made the cultivation of mustard and other oil seeds possible. In recent times the area under mustard is also slowly declining. Mustard was previously popular in the Timborbong Dodok area of Soreng Sub-division, West Sikkim. Chungbung area in West Sikkim was also popular for its safflower. Today very few farmers are cultivating these *rabi* crops, due to the lean rainfall situation during winter. Low winter rainfall has also caused decline in orange cultivation. High pest incidence along with poor management practices has led to poor productivity of orange orchards.

There have been reports of farmers changing varieties and even crops due to rise in temperature in the area. For example, many cardamom farmers have started growing improved variety of cardamom (*Bharleng* and *Seremna*) in areas where it was previously not possible to grow those varieties due to the cold climate in the area.

As per the records of the Spices Board and Horticulture and Cash Crop Development Department of Sikkim, the total area under large cardamom production between 1999 and 2001 was 23484 ha and the actual production area was 19912 ha. In 2003, this area increased to 26734 ha, as a result of the area expansion mission initiated by the Food Security and Agriculture Department and the Horticulture and Cash Crop Development Department, Government of Sikkim. Accordingly, the actual cardamom yielding area increased to 22714 ha in 2003. In the following years, as a consequence of long dry spells and disease infestations, the area under large cardamom decreased, and by 2007/08 it was 12500 ha, which showed a decline of 45 per cent (Pratap *et al.,* 2014).

Incidences of pests and diseases have also increased in the state which may be due to change in temperature, rainfall patterns and the introduction of new cultivars in the state. In cardamom, diseases like *chirpi* and other viral diseases have increase, which turns the plant yellow and reduced the number of pods in the plant, thereby decreasing the production of the farms. In response to growing incidence of pest and diseases the farmers have started to adopt disease resistant varieties like the *Saremna*. In oranges, incidence of die back and trunk borer are becoming more common. Production of ginger has also declined due to soft rot disease and lack of proper management techniques. These are some examples of the increasing pest and disease incidence, and further studies need to be taken up in order to identify the degree of correlation between the growing incidence and the change in climate.

The incidence of water shortage has become more frequent and acute in the area. Increased number of irrigated farm lands has also contributed to the decrease in the quantity and quality of water in the state. These constraints have resulted in some farmers abandoning agriculture and adopting other vocations such as working as wage labour and starting business.

## Climate Change and Cardamom Cultivation: A Case Study of Sikkim and Darjeeling

The case studies on cardamom were conducted in two villages, one in Darjeeling and another Sikkim. Gumbadara village (latitude 27$^{0}$3'53"N, longitude 88$^{0}$37'17"E) is located in Gorubathan Block (1521 m), 60 km from Kalimpong in Darjeeling district in West Bengal. The altitude of the village is approximately 1950 m above msl and most of the inhabitants are farmers, cultivating crops like cardamom, maize, potato and vegetables.

Darapdara Gaon (Latitude 27$^{0}$18'34"N,Longitude 88$^{0}$11'14"E) is located in West Sikkim district around 8km from Pelling at an altitude of approximately 1710 m above msl. Main inhabitants of the area are the Limboo tribe which accounts for more than 90 per cent of the population of the village. The major crops grown in the village are cardamom, maize, millet, paddy and buck wheat.

Five farmers of Gumbadara village and seven farmers of Darapdara gaon were interviewed to understand the changes occurring in cardamom cultivation due to change in climate in the region.

In the hills of Sikkim and Darjeeling cardamom is cultivated for many generations by the farmers, as under storey vegetation below the tree canopy. The crop is favoured by the locals due to its high price and many agricultural crops for cereal crops are being replaced by cardamom plantations.

Traditionally they cultivate local cultivars of cardamom in forest area on the hill slopes with minimal management and the farmers collect the cardamom after three years when they are ripe. Some farmers have also started to grow improved varieties of cardamom known as *Bharleng* and *Seremna*, which gives yield (400-500g/plant) higher than the local variety. These varieties require scientific cultural practices such as proper land preparation, nutrient management and irrigation. The *Bharleng* variety of cardamom was introduced by the Spice Board of India in the region and is popular in both the areas, whereas the *Seremna*, variety is not common in the Kalimpong. The pod size of the improved varieties is larger as compared to the local variety, hence making them more desirable in the markets. The local variety of cardamom is usually grown by this traditional method. Though the productivity of this cultivar is low (100-200g per plant), they can tolerate relatively colder temperatures and many farmers continue to grow this cultivar. The local variety of cardamom favours a relatively cooler climate as compared to the other two improved varieties.

Although cardamom plantation is a lucrative enterprise, there also exist many challenges and constraints faced by the farmers in the region due to climate change. The cardamom farmers of these regions have a perception that there had been a marginal change in climate in the last two decades. They are aware of the rising temperature and also commented on the erratic nature of the rainfall in the area which is becoming more unpredictable. They expressed their concerns over the negative impacts of climate change on the productivity of their crops as the irrigation infrastructure is not in place.

The farmers reported that pest and disease were hardly found twenty five years back. In higher altitude pest and disease attack is still not common but in lower altitudes now, pest incidence in cardamom is observable in the local varieties which are more susceptible to *chirke* disease (white spots). This may be due to the changing climate condition that suits the lifecycle of the organism. The farmers reported that temperature rise in the area have suited the cultivation of the improved cultivars over the local varieties. Most of the lands are losing productivity due to soil erosion and lack of proper nutrient management.

In response to the various constraints faced by the cardamom growers, the Government of Sikkim and the Spice Board of India has provided incentives and inputs in the form of subsidized cultures, irrigation and also diagnostic services for identification of pest and diseases infecting the crop.

**Success Story**

Cardamom plantation has been a source of livelihood for the people of Sikkim and Darjeeling and farmers have benefitted in many ways through cultivation of the crop.

In Gumbadara Village, cardamom farming is a way of life for majority of the farmers. Shree Lakpa Temba Sherpa is a resident of Gumbadara village and a cardamom farmer. Though he went to school up to middle level, he is the pioneer in the cultivation of cardamom in his village. He has received the *Elettaria Cardomomum Maton* (Cardamom Award) in the 1995 from the Spice Board of India for his success in the cultivation of cardamom and was awarded a Rs. 25000 cash prize along with a certificate for excellence for his contribution towards the development of cardamom in his area. Even at his present age of 67, he is still very enthusiastic when it comes to learning new cultivation practices for increasing productivity of the crop. Mr. Sherpa started to cultivate the *Bharleng* variety in 1990's in his 3 acre land and during peak productivity he obtains more than 600g of cardamom seeds per plant. He reported that the productivity of his farm was declining in the last 2 decades; therefore he replaces the plants after every ten years. He raises plant material in his field for replacing the old plants. In recent years the Department of Biotechnology used his plots for demonstration of cardamom crop by using planting material propagated through tissue culture.

He showed his apprehension about the changing climate and its effect on his cardamom plantation. The lower productivity of cardamom in abnormal years due to low and erratic rainfall was one of his major concerns. The water in the streams has also reduced due to increased number of farm lands requiring irrigation. The rise in temperature also limits the productivity of the local variety of cardamom which favours a colder climate. Mr. Sherpa explained that the population rise in the village and deforestation has led to the diminishing of the resources and low productivity of the land.

## Ginger Cultivation under Climate Change Scenario: A Case Study of a Tribal Farmer of Shangbangla Village of Ri-Bhoi District, Meghalaya

Ginger is an important cash crop of Meghalaya. The crop covered an area of 9.58 thousand ha in the state, with production and productivity of 60.14 thousand MT and 6.27 MT/ha in 2012-13, respectively. The spice was cultivated in Ri-Bhoi district in an area covering 991 ha with a production and productivity of 10.04 thousand ha and 10.13 MT/ha, respectively. Ginger is consumed as a spice or used in the production of ginger oil, ginger paste and ginger powder in the state.

Mrs. Phylla Shangwan was a 53 years old farmer of Shangbangla village of Ri-Bhoi District in Meghalaya. She has been cultivating ginger and pineapple for more than 20 years. She cultivates ginger in a one acre of land as *jhum* or shifting cultivation and uses around 1 MT rhizomes as seed which yields around 4 MT. She explains in the case of *jhum*, the productivity of ginger cultivation increases because of higher organic content in the soil.' She shifts the area under ginger every year and the cycle is of only one year. The cultivar which the farmer grows is a local popular variety known as *Sying Bhoi*. Labour during planting and harvesting season, is available in the village itself at Rs. 250-300 for male labourers and Rs. 150-200 for female labourers. The crop is either sold in Nongpoh market in smaller quantity or directly to the village traders from the home of the farmer. In the last year, she sold ginger at 60-70 Rs/kg in both the two channels.

Mrs. Phylla Shangwan was aware that the climate has been changing in her village in recent years. She informed that rainfall has become erratic in nature and both, the amount and time of arrival of rainfall varyyear to year. According to her, the temperature in the village has been decreasing; which does not confirm to the temperature data.

Ginger is cultivated in Shangbangla village as a rainfed crop. She informed that the yield of ginger significantly drops from 4.0 MT to 2.5-3.0 MT per acre during low rainfall years. The quality of ginger also gets deteriorated during drought because the size of the ginger decreases which fetched half the price she obtains for normal healthy rhizomes.

Incidences of pest and diseases in ginger have also increased in the area which may be due to climate change. The farmer explained that incidence of soft rot (*Pythium myriotylum*) and aphids (*Aphidoidea ssp.*) have increased over the years causing on an average of 20 per cent crop damage. She has never used any chemical pesticides for management of the pests and diseases.

Although ginger cultivation has been one of the primary sources of livelihood for the farmers of Shangbangla village, the impacts of climate change may have adverse effect over socio-economic stability of the people if not given focus. Proper scientific training on seed treatment, water conservation, pest and disease management techniques such as IPM are crucial, in order to mitigate climatic change and reduce vulnerability of the farmers.

## Climate Change Impacts on Oranges: A Case Study of Jampui Hills of Tripura

Jampui hill is the highest hill range in Tripura bordering Mizoram. The average altitude of the hill range is approximately 653 m above msl. The whole of hill range, falls within Kanchanpur sub-division with its headquarter located at Dharmanagar. The hill ranges has 11 villages inhabited by Mizos (Lushai tribes) and Reang tribes. We first visited Vaghmun ($23^0 59' 47''$N, $92^0 16' 44''$E) village at 702 m above msl and then Phuldungsei ($23^0 49' 3''$N, $92^0 15' 34''$E) village at the peak of Jampui hill at 851 m above msl where we met Mr. Zarzoliana who was an ex-chairman of YMCA, Mr. J.D. Maeia and Mr. L.C. Khiangte who is an Agriculture Assistant, Mr. Tlangzika, Mr. Dokchoro Reang and Mr. Lalthingliela who was a retired school teacher from Phuldungsei village.

The people of Jampui hills are quite advance in terms of education compared to other tribal communities of Tripura. Most of the households have at least one person in Government job. Theses villages are known for orange orchards. Nearly every household has orange trees. Ginger, betel nut and coffee plantations are also found in the area. Farmers in the area are still practicing traditional *jhum* cultivation for their livelihood. The Vaghmun village committee decides on land distribution for cultivation and land ownership is with male. Management of the orchards is done mostly by males whereas females are mainly responsible for *jhum* cultivation.

Our discussion with the villagers revealed that temperature has increased in these hilly villages over the years. About 30-40 years back, the whole year used to be cold. They lamented that now the cool soothing breeze has disappeared from their villages. Earlier, villagers reported that there were no mosquitoes but now there are, which they believed due to the increase in temperature. The rainfall has declined in *Jampui* hills and the advent of monsoon has been delayed. Before, rainfall used to start at mid-April and continued till October- November but now it starts during May-June. The chirping of birds can't be heard nowadays due to deforestation. The people of the hills are facing water scarcity as numbers of small streams are dying now, so the ladies of these villages have to go down the slopes to fetch water and fuel.

The Jampui hills were famous for its orange plantation not only in Tripura but also in India. They believed that orange seedlings are brought from Haflong by the king of Tripura during 1920s. Since then, orange plantations have been the major source of income for most of the families of Jampui. During 1977, Jampui orange got first prize in the All India Orange Expo held at New Delhi due to its unique qualities. The oranges of the hill have smooth skin, less fibre, high juice content and very sweet in taste.

Indicating decline in both the production and taste Mr. J.D. Maeia said that "Now the oranges are not to be proud of". The orange production has declined considerably due to unscientific practices and changes in the climate which leads to widespread increase of orange diseases and pest attacks. The major challenge of orange orchards faced by the growers is of dieback. The specific symptoms of dieback reported are the tips of the branches turn yellowish and later roots get rotten making the fruits smaller and juiceless. Moreover, there is less accumulation of sugar resulting into sourness of the fruit. The current plants are of 20-30 years old which may be one the reason of decline in the production as well as qualities. Even, Mr. J.D. Maeia reported that his grandfather has planted a orange tree 80 years before, but it is still bearing fruits though the fruits are not having qualities like before. Whether dieback has any link with change in climate or not is a matter of investigation. Farmers in the area adopt traditional practices of pruning mainly during February though proper pruning is not done. They applied manure by purchasing from nearby villages since, farmers in the village doesn't rear cattle's in order to protect the orchards. To shine or protect the stem of orange tree, they grind the *saal* leaves and mixed with lime and keep it for 24-48 hr. Then stir it well and apply the paste on the bulk. Ash is also used as a preventive measure from diseases and pests by applying on the stem. After pruning, if irrigated, the productions become higher. They informed that, during 1980's and back, the production was good and people want to buy oranges from Jampui hills only. Before 30-40 years, the production was about 500 trucks in a year and now it has decreased to about 70 trucks of orange. In order to supplement the income of the farmers, Coffee Board had introduced coffee as an alternative crop during 1966 by providing the technical know-how and inputs. The board collects the coffee and auctions in Bangalore. Arecanut plantations are also found in the village and marketing of the product is easy in this case, since merchants used to come in the village to buy the arecanut orchards.

Farmers of the hill don't want to lose the popularity of Jampui oranges even Mr. Zarzoliana quotes that "Oranges are still in our heart". So, in order to counter the problem, they want disease free seedlings or buddings, some specific trainings; like how to grow, how to protect from diseases and how to apply the nutrients. They enunciated that the projects on horticulture should be initiated taking along the farmers and the farmers should be trained in location specific activities.

SYMPTOMS OF DIEBACK

*Scientific name: Phytophthora*spp.

The seedling varieties grown in the hill if affected at early age, exhibit reduced cropping and vigour. Finally twig dieback occurs and the trees gradually die from secondary wood rots. Seedlings infected at an early age react more severely. Apparently the yellowing of veins and adjacent tissue in mature leaves occurs near the point of infection. Chlorotic leaf patterns develop in subsequent growth and leaves fall results in sparse foliage. Dieback and death ensue within a few years.

## Orange Orchard under Climate Change Scenario at Kalimpong, Darjeeling: An Entrepreneurial Success Story

Parwesh Gurung, a residence of Bara Mungwa (2397 m, 27.52$^0$N, 91.91$^0$E) in Darjeeling district, West Bengal who is an entrepreneur inherited an orange orchard from his grandfather, Late Nirmal Gurung. The main cultivar in the orchard was Darjeeling mandarin, which was grafted over the old plants that his grandfather planted. Mr. Parwesh Gurung, being an innovator is always looking and trying new varieties in his farm. He acquired many exotic varieties and planted them as an experiment in his farm. Exotic varieties include Washington DC and French Muntara. Although some of the cultivars are not compatible for the agro-climatic zone, it was refreshing to see a farmer experimenting with new ideas which may be successful.

He also expressed his concern over the climate change in the area which is affecting not only his farm but also the entire village. Although a clear change in the climate of the area has not been observed, yearly variations in temperature and rainfall have been noticed in the area. He described the growing incidences of erratic rainfall which is detrimental to the crops, especially rainfall during spring at the flowering stage of the orange plants leads to falling of the flowers in the ground. He also informed about the rise in temperature in the area, which may be the reason for the incidence of new pest and diseases which are still unidentified. Some viral diseases can result in the destruction of the whole orchard if not managed in time. Also the shortage of water for irrigation has been evident in the recent decade due to deforestation along the increase in irrigated farmlands in the area putting more pressure in the already declining water source which negatively affected the production of the orchard as regular irrigation is essential for the trees especially in lean periods.

When Mr. Parwesh Gurung inherited the farm from his family, he wanted to bring new innovations in the way the oranges were marketed. Before he took over the farm, the oranges were usually sold in the regulated market in the area or brokers from the market would direct purchase the oranges from his farm. On a good year the farm usually made a turnover of Rs. 7 lakh, while in off years the turnover was around 5 lakh. Unsatisfied with the results, in 1992 he discontinued selling his oranges in the regulated market and decided to process his produce in order to obtain a better price for them. Being an MBA qualified individual, he had the knowledge to change the whole production-marketing process of the orchard. A processing and quality control facility was established inside the farm to add value and also widen the product range. This was also possible due to the training exposure of Mr. Parwesh Gurung's mother in the Central Food Technological

Research Institute (CFTRI). They are manufacturer and supplier of orange seed, orange squash, litchi fruit squash, mango squash, pineapple jam, strawberry jam, carrot jam, apple jam, mango jelly, strawberry jelly and guava jelly. The by-products like the skin of the fruits is also used for making cosmetics and the seed are resold in the market. Even the pulp is not wasted and is used as an animal feed. Now the farm sells its product under the trade name of Nirmals Farm and even has its own Facebook page for customer's feedback and to advertise new products and events related to the farm.

## Grape Cultivation at Champhai in Mizoram: An Entrepreneurial Success Story

The cultivation of the domesticated grape (*Vitisvinifera*) began 6000–8000 years ago and the earliest archaeological evidence for wine-making in human culture dates back 8000 years ago in Georgia. Grapes can be eaten raw or processed into various products such as wine, raisin, juice, jams, vinegar and grape-seed oil. Grapes can grow in various types of climatic condition but favours the Mediterranean climate. Sandy to clayey and loamy soil with good drainage and irrigation facilities is suitable for the cultivation of grapes. Temperature ranging from 15-35$^{0}$C is ideal for shoot growth and normal physiological processes of the grapevine. Grape vine do not grow well when the temperature falls below 10$^{0}$C. Grape was introduced into India in 13$^{th}$ century by the Moghul invaders. India is one of the largest producers of grapes in the world with an annual production of around 23 lakh MT. More than 80 per cent of the total production is consumed as table grapes in India Approximately, 2.5 per cent (22000 MT) of fresh grapes are exported to the Middle East and European countries. The rest of the produce is marketed within the country. Grapes are exported through three different agencies *viz.*, Grower Exporters, Growers' Cooperatives and the Trader exporters. Maharashtra is the leading producer of grapes in India with about 80 per cent share of the total country's production.

State-wise production of grapes in India in 2012

| **State** | **Area ('000 ha)** | **Production ('000 MT)** |
|---|---|---|
| Maharashtra | 92.00 | 1810.00 |
| Karnataka | 16.08 | 288.10 |
| Tamil Nadu | 2.90 | 55.10 |
| Andhra Pradesh | 1.40 | 28.90 |
| Mizoram | 1.90 | 24.30 |
| Others | 1.00 | 14.5 |
| Total | **116.0** | **2220.90** |

(Source: NHB, 2013)

### Case Study

Mr. H. S Lalfakzuala, age 60, is a resident of Champhai and a grape cultivator. He previously cultivated paddy and vegetables, but later shifted to cultivation of grapes because of its high profitability. Besides grapes, he also cultivates other crops such as beans and cabbages. He was also enthusiastic about cultivating kiwi in his farm. He has a 3 acre vineyard in Vengthlang (latitude: 23$^{0}$28''37''N, longitude: 93$^{0}$19''22''), located in the outskirts of Champhai town (1368 m), in Champhai district. The cultivar he used is

‘*Bangalore blue’*, which is dark purple, almost black with a tender green-yellow flesh when ripened. In 2014, his vineyard had a productivity of 7.9 MT/ha. He started the land preparation in the year 2010 and planted 1500 seedlings in 2011. His first harvest was in 2012 which gave him a production of 1.4 MT and in 2013 he produced 4.0 MT of grapes. He pointed out that initially the production was lower because the vines were still not fully matured.

Mr. Lalfakzuala supplies his grapes to various wineries located across Champhai district and in 2014, he has sold grapes around Rs. 40/kg. For pest and nutrient management, no chemical fertilizer and pesticide was used, except for a little wood varnish he used to protect woody parts of the vines from termites and stem borers. He only uses leaf litter and other plant material as manure and manually performs weeding three times a year. Pruning is done once a year during February to encourage lateral growth of the grape vines and to remove non-productive branches.

Mr. Lalfakzuala elucidated his experience with climate change and the impact it had on grape cultivation. He pointed out that in previous decades, Vengthlang was relatively colder and incidence of frost was common during winter. In recent years however, the temperature in Vengthlang was getting warmer and incidence of frost had declined greatly, which had a positive impact on grape cultivation. Frost is detrimental to grapes since freezing damage to wood and bud tissues occur when cold temperatures reach a critical level. Cultivation of cucumber has also been possible now in the area, due to rise in temperature. Earlier in 2003, he used to cultivate grapes in the lower valley of Champhai, but later on he found it possible to cultivate the crop in Vengthlang, which was located at a higher altitude. Therefore he shifted his vineyard to Vengthlang.

Mr. Lalfakzuala expressed rainfall has been erratic now. The arrival of rainfall has become highly unpredictable and the amount of rainfall has been decreasing. The incidence of rainfall during spring is detrimental to the plant, as flowering in grapes falls under this period. In Vengthlang, there have been incidences of rains during the spring season which negatively affects the production of grapes. The late arrival of rainfall is also detrimental towards the productivity of the grape vines. Although, the temperature and rainfall in Vengthlang has changed in recent years, Mr. Lalfakzuala has not encountered any major outbreak of pest and diseases in his vineyard. He managed pest by manually removing the pest and applying wood varnish on the woody stems, to protect the plant from termites. According to the Mr. Lalfakzuala, the rise in temperature has a somewhat positive impact on his livelihood, as in previous decade he said that it was not possible to cultivate grapes in the area. He now earns around Rs. 3.8 lakh from his vineyard, thereby letting him live a better life. He was only concern about the erratic rainfall in the area and how it might affect the productivity of his vineyard in the future.

### Climate change and Pineapple Cultivation at Shangbangla Village, Ri-Bhoi District

Ri-Bhoi district is the highest producer of pineapple in Meghalaya. The area under pineapple was 3.86 thousand ha with a production and productivity of 41.61 thousand MT and 11.28 MT/ha, respectively in the district in 2012-13.

Shangbangla village is located (25°57'7"N latitude and 91°51'51"E longitude) in Ri-Bhoi at an altitude of 523 m above msl. The picturesque village lies on the both sides of Guwahati-Shillong National Highway 40 about 8 km from Nongpoh, the district headquarters. The village covers a total geographical area of 7.15 sq. km. with a 250 households. Pineapple is one of the main crops cultivated along the hill slopes by the farmers of the village. Ginger, tomato, orange, litchi, bay leaf and betel nut are the other major crops cultivated by the villagers.

Twelve farmers comprising six male and six female farmers participated in an FGD conducted in Shangbangla village to understand the impacts of climate change on the pineapple cultivations. The age groups of the farmers who participated in the FGD ranged from 37 to 76 years with an average age about 55 years. The average area cultivated was approximately around 2.47 ha per household. Most of the farmers were cultivating pineapple for more than 15 years. Two of them have been growing pineapple since 1970. The majority of the people still followed the traditional method of *jhum* (shifting) cultivation for pineapples under rainfed conditions. During the last decade, the area under pineapple cultivation has increased due to high demand of the fruit. In most of the pineapple growing areas of the village, the age-old indigenous cultural practices are still in use. The farmers usually plant 10000 suckers/ha of the *queen* variety of pineapple and replants the suckers after 10 years, but some of them even after 15-20 years.

The main local markets are at Nongpoh town and along the national highway, where a large number of vendors, mostly women sell pineapples on the roadside. The primary buyers for pineapple crops were traders from Assam, Jaintia Hills and Shillong. The pineapples were sold at price of Rs. 200/*kuri* (1 *kuri* = 20 pieces) for smaller sized pineapples and Rs 300 for bigger sized ones. They also sold the fruit in their road side small retail shops at an average price of Rs 10-20 per piece, during flush season and the price of pineapple soars up to Rs 30-40 during off seasons. The major problem faced by the farmers in terms of marketing of pineapple is the lack of proper storage facility in the village as the shelf life of the ripened pineapple is short.

All the participants were aware of the climate change in the area. The farmers showed mixed perception regarding temperature, with some expressing rise in temperature and others telling fall in the temperature in the village over the years. Rainfall in the area has become erratic in nature and they recalled about encountering drought like situations few years. They informed that late arrival of rainfall delay the planting time of the suckers.

The participants of the FGD reported that the size of the fruit become smaller and sweetness of the fruits reduces, during the periods of low rainfall. During summer, high temperatures and excess sunshine sometimes destroy the leaves of the pineapple plants and if followed by rainfall then the leaves get rotten. Under this circumstance around 50 per cent of the pineapple plants could be damaged. Some of them cover the leaves with weeds during weeding to reduce loss through sunburn of the leaves.

Rats and elephants were the major pest in their pineapple fields. As the rats eat up the succulent portions of the young pineapple plants which could lead to loss of about 20 per cent in the first year. The invasion of elephants in pineapple field has increased since 2006 leading to loss up to 50 per cent. The State Government provides immediate help of Rs. 200-1000 for each farmer who has incurred losses due to elephant attack.

The farmers in the village were dependent on pineapple for their livelihood. The majority of them were engaged in farming activities throughout the year, as they harvest pineapple in two different periods from different piece of lands. They worked as wage labourers in the fields of others within the same village when the crops in their own field failed during the periods of drought or low rainfall. Daily wage rate of Rs. 250 and Rs. 150 were earned by the male and female farmers, respectively. The wage rate was higher for male because the male workers were engaged in more laborious work, such as ploughing and land preparation.

## Pineapple Cultivation and Climate Change: A Case Study of Molvom Village in Nagaland

Molvom village in Dimapur district is declared as pineapple village of Nagaland. The village is located at 25.73$^{0}$N latitude and 93.85$^{0}$E longitude at the altitude of 324 m msl and has 260 households who are primarily dependent on pineapple cultivation as a source of livelihood. The area under pineapple is around 250 hectares. The annual pineapple yield is about 9 tons per hectare in Nagaland, which is just short of the national average of 10-14 tons/hectare.

We interviewed Laljan Misao, a progressive farmer of this village who has received the Mahendra and Mahendra award for pineapple cultivation. He is 43 years old and studied up to ninth standard. Earlier his father hardly cultivated in one hectare of land, but today they are cultivating pineapple in more than 5 ha. He was the only farmer in the village who has been practicing inter cropping system of pineapple, orange and lemon. He cultivated only Kew variety as the leaves of this variety do not have spikes which makes weeding and mulching. After every five to six years the new suckers are planted after uprooting the old ones. Till date the farmers have not faced any kind of pest and disease in pineapple cultivation, accept rodents. After receiving training from ICAR he has reduced the plant gap and adopted double row spacing. Earlier in 1 ha he planted 24000 pineapple plants but now it has increase up to 45000 plants. Weeding is done for three times in a season with labour charge of Rs 150 for 100 persons. Both husband and wife were engaged in the farm and their sons occasionally helped them during their vacation time.

Spring water was the primary source for drinking water and during drought they fetched water from the nearby river. LPG and fire wood are used as fuel for cooking, but now they face shortage of firewood due to deforestation.

They opined that, since 2009, during summer the temperature has increased and the duration of summer has also increased but during winter the severity of cold has also intensified. Earlier it used to rain during January to February and then May to October but now the period of rainfall has totally changed. Sometimes it used to rain during the month of November and December. The timing of rainfall has been unpredictable and when it rained, it rained heavily.

The price of summer pineapple is higher as compared to winter due to sweetness. In winter both, the production as well as the price is lower due to less sweetness of the fruit. The price of pineapple they sold in summer was Rs 15 per piece for large sized pineapple and Rs 8 to 10 for small sized pineapple but in winter they used to sell at Rs 8 maximum for large sized pineapple and Rs 6 for small pineapple. Marketing for pineapple is not a problem for this village as traders from Assam used to come and buy in bulk.

Normally in summer he used to harvest 50000 pieces of pineapple but due to climate change it has reduced to 30000 pieces and in winter he used to harvest 25000 pieces of pineapple but now reduced to 10000 pieces. Nowadays production fluctuates; sometimes there is higher production in winter than summer which is reverse phenomena. He has also mentioned that the size of pineapple has reduced due to the impact of climate change.

### Climate Change and Livestock Rearing at Sihphir Village in Aizwal, Mizoram

Aizawl is the largest district in Mizoram in terms of population, with about 4 lakhs residents as per Census 2011. Aizwal district is situated between 23$^{0}$30'N to 24$^{0}$00'N latitude and 92$^{0}$30''E to 93$^{0}$00''E longitude (1201 m) and the district headquarter is located in Aizawl. Wide range of cereals, fruits, vegetables, spices, oilseeds and pulses are grown in the district. There are plenty of grasslands, wherein livestock rearing is possible due to naturally available fodder.

The topography of Aizawl district, is dominated by broken mountainous hilly ranges and between them, lies the valley lands suitable for cultivation of field crops. The altitude ranges between 100 m to 1500 m above msl. Aizawl district can be categorized into three agro-climatic zones namely, as Humid mild tropical, Humid – sub- tropical hill and Humid temperate sub-alpine. The average maximum and minimum temperature of the district is 35$^{0}$C and 5.3$^{0}$C, respectively. The average rainfall in the district is around 2000 mm and concentrated during June-September.

The Aizawl district of Mizoram has the largest animal population and also the most number of veterinary institutions and personnel in the state. Pigs are the major animals in the district with a population of around 74000 and are kept mainly for the purpose of meat production. Cattle are the second important large animals with a population of roughly 7000 animals. Cattle are reared for milk, meat and also as a draught animal for agricultural activities. The annual production of milk in Aizawl district is around 8500 MT.

Sihphir village (Latitude 23$^{0}$48'28''N and Longitude 92$^{0}$44'35''E) situated in Tlangnuam block, Aizawl district and is located about 15 km from Aizawl, the capital of Mizoram. The village has a population of about 1300 household and agriculture and livestock is the main source of livelihood for the people residing there.

The FGD was conducted in Sihphir village where 20 livestock farmers participated. Majority of the farmers (65%) were male and the average age of the male farmers was 66 years. The remaining of the livestock farmers (35%) were females with an average age of 51 years. The farmers of the village have been rearing livestock since time immemorial and they consider the animals not only an important source of food but also income. They also cultivate a number of vegetables such as mustard, squash, beans, *etc*. for both home consumption and as a source of additional income. They rear mainly cattle, pigs, poultry and other animals such as goats and sheep. Cattle are considered as one of the most important animal in the village providing both meat and milk whereas pigs are reared for the meat purpose.

The farmers in the village are aware about the change in climate that is taking place in their area. The farmers expressed the changes they have observed and also provided indicators to support their observations. According to them the temperature in the area is rising especially during the summer months. They explained that tropical crops like tamarind (*Tamarindus indica*) could not grow in the area earlier, but at present it became possible to grow the crop in their village. The incidence of frost has been lesser now a days in the area and the temperature during winter is rising.

Rainfall pattern has also changed in the last few years, relative to the previous decades. They observed that rainfall is getting lesser and becoming more erratic in nature. The arrival of rainfall has been unpredictable and the months of October to May experiencing long dry spell. The low rainfall has led to decrease in the water table and also drying up of the small streams and springs which are important sources of water during winter. Other variations in climate observed by the farmers include the growing intensity of winds in the region during winter and the low incidence of hailstorms as compared to previous decade.

The majority of the farmers in Sihphir village were rearing cross bred cattle mainly for the purpose of milk production. The farmers were correlating a few problems in the animals with climate change. Milk yield was found to be lesser in some years when the winter temperature was relatively lower to normal years. They explained that the cold weather make the animal reluctant to drink water, which is necessary for milk production. Apart from this, lower milk yield was due to low quality and availability of feeds. Due to scarcity of rainfall during winter season, the amount of green fodder available in the village decreases. During this season farmers rely primarily on readymade feeds. During the times of climatic variability farmers prefer to keep pigs instead of cattle because cattle require more feed, fodder and water as compared to pigs.

The incidences of pests and diseases also affected the milk productivity of the animals. The incidences of Foot and Mouth Disease (FMD) and milk fever have risen especially during the months from January to June. Fly population has also increased which cause restlessness to cows especially during milking. These pests also act as a vector for other diseases causing organism which affects the animal's health and lowers the quality of milk. Better mechanism for veterinary services is necessary to combat these problems relating to pest and diseases. Livestock insurance is now becoming popular among the farmers due to higher incidence of pest and diseases. But many farmers found it difficult to claim the insurance when the situation arises.

Water scarcity for both domestic and farm use is one of the major constraints. Farmers rely mainly on water storage structures during times of water shortage. Minor conflicts do occur in the village due to the water scarcity.

The interaction made it clear that climate is changing and has negative impact on milk productivity and disease outbreak. Hence, the State Animal Husbandry Department and Veterinary College has to play a significant role in bringing forward the animal health and production management techniques suitable to climate change scenario to the farmers so that the adaptation of the technology will help to minimize the negative impact of climate change.

## Climate Change Impacts on Yak Rearing: A case study of North Sikkim and Dirang Valley of Arunachal Pradesh

We interviewed five yak rearers in Lachen (838 m) and five in Yakshee, nearer to Yumthang (3597 m) in North Sikkim district of Sikkim where a number of yak farms (locally known as '*kot*) can be traced to understand their livelihood and how the change in climate is affecting the yaks. We also interviewed three employees of state government managed yak rearing farm in Jemma (2694 m).

About 250 households of mainly Lepcha and Bhutia community who follows Bhudhism are the resident of Lachen and Lachung. Lachen has its own governing body, which is elected by the villagers through voting system and functions for a period of one year. The head of the council is known as *Pepon Sajang* and responsible for making decision on all issues related to village. Similarly, *Pepon* (a council of 18 members, like *Panchayat*) headed by Chongsa in Lachung. The villagers prefer to go to this local body at first but if unsatisfied with the decision they go to police and formal judiciary system. Polygamy which was quite common earlier is hardly found now-a-days in the society.

The agriculture practiced here is of subsistence in nature and mainly for home consumption. Other than rice and maize, a number of vegetables are grown in the area. Potato, cole crops such as cabbage, cauliflower, radish, beans and pea are major vegetables grown in small scale and many times in kitchen garden. The productivity of these crops has declined as state government has stopped supplying fertilizer (urea), only a few could purchase urea from Assam. Besides agriculture, the villagers work as labourer, some are in government job and yak rearing also contribute to the village income.

The yak rearers expressed that the climate is changing in this hilly terrain. Earlier up to 15 years back Lachen used to experience heavy snowfall and it was up to 4-5 feet but now a days the snowfall is only about 1-2 feet in Lachen and whereas about 2-3 feet in Yakshee (20 km from Lachung). Now the snowfall is restricted to higher altitude only. The lower altitudes which earlier used to receive occasional snow some time now for long period never experienced snowfall. The season of snowfall has also changed. Earlier during the end of November or in December, snowfall would occur but now snow fall starts at the end of January and may continue up to March. They could perceive that the temperature both in winter and summer has risen in comparison to last decade but they did not find much difference in amount of rainfall in the region.

As the temperature is increasing year by year, the mortality rate in yak has increased due to liver disease (liver becomes black in summer season). Moreover pregnant *bree* (Yak female) sometime die in summer season as they cannot survive in warm climate.

Tsering Lama has a herd of 35 yaks out of which five are male but Hadka Bahadur, a 35 year old Nepali yak rearer from Tezpur is taking care of his animals for last 8 years. He has experience of rearing yak for more than 12 years. While serving namak chai (salt tea prepared with churning butter made of yak milk) Bahadur told us that now even 10-12 yaks die in summer. Ten years back he used to go 10 km down from Yakshee but as temperature is in rise in the lower altitude he has to make his winter halt at Yakshee only. Similarly, he migrates up to 32 km at higher altitude in summer which is about 10 km more than earlier and it makes difficult to find any labor for maintenance of yak herds in such a place.

**Lubrang village at Dirang in Arunachal Pradesh**

A FGD was conducted at Lubrang village of Dirang in Arunachal Pradesh. Five yak rearers along with two scientist of National Research Centre for Yak, Dirang have participated in the discussion. The village is about 2134 m above the mean sea level. The village is known as yak village as all the 45 households rear yak for time immemorial. The interaction revealed with villagers that the temperature has increased slightly over the years but rainfall has not changed much. They reported that snowfall has reduced and now it is delayed. It is important to note that they feel there is no effect of climate change on yak production or rearing. What is the matter of concern for them is that the young generation is losing interest in yak rearing and they feel once the current generation dies there is no one to rear yak. Another important observation was made that the yaks are facing problem due to increasing leach population in the village which was not in existence 10 years back which may have its root in increase in temperature, *i.e.,* climate.

## Climate Change and Mithun Rearing: A Case Study of Khonoma Village of Nagaland

To understand the impact of climate change on mithun (*Bos frontalis)* rearing in Nagaland, key informants from NRC Mithun and Khonoma village were identified and interviewed. Dr. Kobo, Farm Manager of NRC Mithun, Nagaland; Secretary, Mithun Association, three mithun rearers of Khonoma village were interviewed.

Khonoma village is located at 25.65$^0$N latitude and 94.02$^0$E longitude at 1506 m above msl in Kohima district of Nagaland and is in existence for nearly 550 years. It is the home of *angami* tribe of Nagaland. Majority of the households depend on rice and vegetable crops as their means of earning livlihoods. Mithun is the proud possession of many of the villagers and the village also has mithun owned by the community. Out of 596 registered households in the village 300 households rear mithun and the population of mithun in the village is approximately 700 in numbers.

Earlier the villagers used to cultivate rice and vegetables only for household consumption but, since 2009, they started cultivating vegetables commercially for enhancing their household incomes. *Thever, Teckferer* and *Ngomba* are the popular rice varieties cultivated in the village. Potato is also widely cultivated in the village. They also practice alder farming system. In terrace upland farming they used to cultivate once in every seven years on the same land, but in low land terrace they cultivate every year. Availability of water is not a major problem for the residents of Khonoma village.

In India, mithun is found in different states of NEH region. According to breeding tract, the mithun population are divided into 4 strains, *i.e.,* Nagamese, Mizoram, Arunachalee and Manipuri. The villagers of Khonoma have community mithun which are reared jointly by the villagers. The mithuns are reared in six different pockets in the forests. Fences are constructed around these pockets so that the mithuns would not trespass the paddy and vegetable fields in the village.

Sheds are constructed in the mithun pockets for mithun boys who look after the animals. The mithun boys receive 20 kg of rice per year per mithun as wage. Earlier it was easy for them to employ mithun boy but nowadays it is becoming difficult to find mithun boys as the wage rate is very low when compared to alternative opportunities available to them. To overcome the problem the villagers have decided to increase the wage rate for the mithun boys. The mithun boy also has a role if quarrel breaks out among villagers about the ownership of the animals as they do not practice tagging for identification of mithun.

Two to three different places are identified and stones are placed for feeding of salt to animals. The mithun boy blow horn in morning and evening to call the animals for feeding salt. During the rainy days mithuns do not come down the hills for salt. The animals are fed green grass and eggs if they fell sick. Earlier during the time of their fore fathers one mithun used to give birth to 10-11 calves but now the birth rate has reduced to approximately 7 calves.

Mithun has an important part in the village's economy. Every year, they sell about 50-60 mithuns at the price of Rs 50 thousand to Rs 70 thousand per adult animal. During different ceremonies or festivals the prices can go up to Rs 1 lakh. The skin of mithun is also consumed by the people. The animals sometimes face the attack of forest animals. They villagers have reported that 20-25 mithun died because of fox attack in 2014.

They reported that the temperature during summer season has increased, especially in June-July while, the temperature in winter season has decreased at night time during March and April in the area. Rainfall has declined in the area over the years as well as it the arrival of rainfall has become unpredictable which implies the erratic nature of rainfall. This year (2015) they have observed heavy rainfall in April which they have not seen earlier. The monsoon rainfall has been delayed by 15-30 days. Earlier rain used to set in the month of May but now it has moved to middle of June. The occurrence of hailstorm has been reduced nowadays.

Mithuns were thriving well in this place 10 years back but nowadays mithuns move to higher altitudes even up to Dzuko valley (2458 m) which may be due to increase in temperature. But according to the villagers, it may also be due to higher pressure on grasslands in lower altitudes due to increased mithun population. Earlier the population of leech in forest was less and green grass for mithun was sufficient due to burning of forest. Now Government of Nagaland has strictly prohibited the burning of forest so the population of leech has increased and the availability of new fodder leaves have decreased. Hence, now the villagers are not much interested in higher population of mithun rather they are now focused in maintaining the quality (size and weight) of animals. Normally, mithuns are affected by foot and mouth disease which has not changed over the years but the infant mortality has slightly increased due to increase in leech population.

The key informants made it clear about change in climate in the area. Mithuns are moving to higher altitude and the number of calves given birth by an animal has declined. Scientists need to be cautious about the effect of change in temperature or rainfall on mithuns so as to protect the animals.

## Climate Change and Fish Cultivation: A Case Study of Khowai District of Tripura

Fish is considered as one of the most healthy and easily accessible foods in India. In a country which is defined by multiple social and religious taboos in consumption of meat, fish is regarded as one important sources of animal protein by its inhabitants. An FGD was conducted in Khowai KVK in West Tripura district of Tripura. Ten fishermen of Sachindranagar village and Programme Co-ordinator, KVK Khowai and a Technical Assistant participated in the FGD. The average age of fishermen participant was 48 years and majority of them had schooling up to primary level.

The average annual rainfall in the district is around 2000-3000 mm and temperature ranges from around $10^0$C to $25^0$C in winter and $22^0$C to $32^0$C in summer. The total cultivable area of the district is around 1.36 lakh ha and the forest area accounts for around 27 per cent of the total area of the district. Aquaculture is considered as one of the important sources of livelihood for the people of the area. In recent times, the cultivation of fish species such as *gagar, boal, lacho, nuthari, chinqri, kalbasu, masul, grass carp, silver carp, katla* and *rohu* have increased. On the contrary, fish species like *tengra, pabda* (deep water fish), *singhi,* and *magur* have experienced a significant decrease in the area.

The participants have communicated that temperature during summer months has increased in the area over the years and rainfall has reduced and also become erratic in nature. They reported earlier there were good rains for two and half months during the rainy seasons. The area has witnessed floods during 1983, 1993 and 2003 which were beneficial for fish cultivation. But low level of rainfall, in recent times, resulted into low water level and shrinking (in width) of the rivers, in particular the khowai river, and this negatively affected the species diversity. As the current of river has become slower the growth of fishes reduced nearly by half due to low level of mobility. Moreover, the population of planktons has also decreased resulting into changes in the habitats of fishes which made fishing more uncertain. Earlier a fisherman can easily catch around 1 kg of fish in one hour, but today it takes him four times longer to catch the same quantity. While describing the change in the quantity of fish available in the water bodies they said that earlier at least 20 people of the village can catch sufficient fish in a day but now it is only five persons. Studies revealed that migration of fishes from the river Gomati to the lake Rudrasagar has also been affected, resulting in fewer catch by the fishermen who depend on the river for food and income. Due to the low productivity of the rivers and availability of IMC due to artificial (induced) breeding in many private hatcheries, the number of fish ponds have increased and the harvest of river fish (capture fishery) have decreased in the district.

All this have also negatively affected, the breeding cycle of the fishes. Earlier the spawning period for the fishes was usually during *Baisakh* (May) during *kaal baisakhi* (a strong wind accompanied by rain) and now due to the lower frequency of *kaal baisakhi*, the breeding of the fish has been adversely affected.

The fishermen informed that the incidence of alcerative disease has also decreased but require further investigation. They also reported about new and unknown diseases, locally known as *manit* and *baghai.*

Due to the less availability of smaller indigenous fishes and cat fishes in the river, the prices of those fishes have soared up significantly recently whereas, fishes like rohu and katla which were earlier costlier are relatively cheaper due to increase in supply.

## Climate Change and Pisciculture: Case Study of Loktak Lake in Manipur

Loktak lake is the largest freshwater lake in the NEH and is famous for the *phumdis* (heterogeneous mass of vegetation, soil, and organic matters at various stages of decomposition) floating over it. It is located at $24.55^{0}$N latitude and $93.78^{0}$E longitude at the altitude of 768.5 m covering an area of 286 sq. km. The lake is the source of livelihood for the fishermen who live in the surrounding areas and on *phumdis*, also known as "phumshongs". About 55 rural and urban hamlets around the lake have a population of about 100,000 people.

An FGD was held with 10 members of Educated Unemployed Youth Pisciculture Co-operative Society Limited" in the village named 52 Moirang Part 1. The majority of inhabitants of Moirang are dependent on fishing for their livelihood. The society registered in 1970 and has 60 members who have education up to matric or higher level. The eldest member is 75 years of old, whereas, the youngest is 35 years old. The fishing area is about 100.95 acres of 'touthabi' (floating) land. Earlier rice was cultivated in these fields but after the start of loktak project the fields are used for fisheries. They have 4 boats each costing around Rs 3-4 thousand and the life period is about 6-7 years.

The local medium sized species like nga-mu, nga-chick, uhkabi; local big sized species like nga-pai, porong; and the small sized local fish species: ngakijou, ngasang, mukanga, fabou-nga; and common carps, kuri, silver carp are cultured in the wet land. The size and population of porong increases during the winter season and the volume of catch is higher in the winter seasons. A number of fish species such as pengba, ngakra, khabak, ngaton are about to extinct from the area. Shareng fish is hardly found now due to removal of floating flora and higher level of pesticides in the water. They apply limestone and urea when water get polluted.

The members felt that the temperature has increased both in summer as well as in winter seasons. Rainfall is irregular and both, flood and drought occurs in the area. They reported that the rainfall has been more irregular in last 6 years. They also informed that with the increase in temperature the size of common carps and silver carp has increased. Skin diseases are now more prevalent in fabou-nga and porong during the winter season.

### Case study of fish farmer of Sendra

Arun Moirangtham is a young fisherman of the Sendra Island at Loktak. He was 35 years of age and went to primary school. He has been fishing since childhood. About 100 households of Sendra depend on fishing in Loktak lake for their livelihood. He has informed that both winter and summer temperature has increased over the years in the area. The last year (2014) was drought whereas, this year it was flooded. He said that rainfall has become irregular, some year early and some year late difficult to predict. During flood they catch mainly small fishes as the big fishes remain in the dipper part of the lake. He has seen only one foot of water level during the drought years (2009 and

2014) and even 20 feet during the period of flood. Winds make catching of fishes difficult as the floating flora used to disturb the net. He catches fish species like nga-pai, porong, common carps, grass carp, bao, nylon nga-mu, muka-nga and khaging (prawn) and earns on an average Rs 3 lakh per year. The species like ngakra, uhkabi, and pengba has become lesser in number now a days due to less floating flora which is now been cleaned for the hydro-electricity project. It is also creating hindrance in fishing, mainly in cyclones or rainy days, earlier they used to take rest on the floating flora. Now the quantity of species like ngakijou and nga-chick has increased.

The societies in North Eastern Himalaya (NEH) region of India are rich and diverse in their languages and cultures. Each society is basically a clan of a specific tribe having its own local dialect, unique attire and way of living. In a state there are number of such tribes. These societies are community oriented and family is the unit. The families are of medium to big in size with well-knit relationship among the family members. Meghalaya has matrilineal system where the inheritance goes to the youngest daughter of a family. In most of the NEH states, majority of the people are Christian, while the sample farmers of Arunachal Pradesh were Buddhist. The literacy rate among the sample farmers in most of the sample states are satisfactory to good, as the missionaries have set up schools even in the interior villages, century ago.

In NEH states in most of the cases the villagers do not have the title of land and basically the land is owned by the community. The village head or community head who are known by different names in different regions (*i.e.*, *Nokma* in Garo Hills and *Rongba Shnong* in East Khasi Hills of Meghalaya) distribute the land to the villagers for cultivation. The operational holdings are very small, except Karbi Anglong and Dimapur where rice is cultivated mainly in the valley or plain area. The percentage of cultivable area under irrigation is too less, except Darjeeling and Meghalaya, which makes the cultivation totally dependent on rainfall and more risky. That's why the productivity of different crops varies with the climatic variability.

The rainfall is mainly concentrated in the monsoon season, and July is the month which receives maximum rainfall within a year. If we consider the Standard Meteorological Weeks (SMW), highest weekly rainfall is received within 27$^{th}$ to 31$^{st}$ SMW. Sikkim, Darjeeling, Mizoram and Meghalaya receive very high rainfall, whereas, Nagaland, Karbi Anglong and Manipur receive comparatively low rainfall among the NEH states. It is found that during 1990-2007, the seasonal and annual rainfall declined over the years, except Meghalaya and Tripura. The monsoon weeks have the probability to be dry in all the NEH states but in case of post-monsoon weeks the probability is opposite. In addition, lack of irrigation facility makes cultivation of *rabi* crops difficult which force the farmers to mono-cropping.

The rainfall has become erratic in nature but the trend in temperature is very clear in the NEH region. In the entire sample states the minimum and maximum temperature has increased, especially 1990 onwards.

The farmers could also perceive that the monsoon rainfall is declining. The precipitation was very high in one year and low in another; moreover, it rains heavily in limited number of days which reduces the number of rainy days without much altering the average quantum of rainfall in the season. The advent of monsoon rainfall has been delayed by a fortnight. In case of temperature, summer months are perceived to be hotter now-a-days by the farmers of NEH region. Some of the famers also opined that the peak winter period has become more chilling than 10 years back.

Despite changing climate, the mean yield of the important crops has increased due to technological progress in the form of introduction of new varieties, access to scientific crop production advisories from agricultural agencies. Though the mean yields of the important crops have not been much affected, except maize, due to change in rainfall and temperature but the variability in yield was substantial. The farmers of the region reported about yield losses of 24 to 48 per cent during the low rainfall or drought years.

The farmers cultivate lesser area during the period of late or low rainfall, than the normal periods especially in case of rice in Darjeeling, Lunglei, West Tripura and Karbi Anglong. In case of maize, the area remained unchanged, except in Darjeeling.

The reduction in area under cultivation coupled with decline in yield has the potential to severely threaten the livelihood of the farming community in the region. The availability of food through PDS has cushioned them from the negative effect of climate change. Availability of job as wage labourers, especially under MGNREGA in the village or starting a petty business has given them the source of alternative income which enabled them to purchase food from PDS as well as nearby village market. Though some of them said that they lack liquid money but by and large they did not starve. Moreover, their daily diet or food habit is based upon the local production system, which allows them to sustain in difficult and harsh situation also. The *jhum* production system is one of that kind of system in which multiple crops are taken at a time and in interval on the slopes of the hills.

The pest and disease attacks on crops have also increased in the recent periods but linking it to directly to climate change is little difficult. But the changes in climatic variables may have become conducive to the growth and spread of the pest and diseases.

Though the dairy sector is not up to the mark in the region, the NEH states have observed steady progress in case of milk production due to introduction of high yielding crossbred dairy animals under different State and Central Government schemes. The variability in annual milk yield is to increase with increasing maximum temperature, as un-availability of fodder affects the milk yield of dairy animals and losses due to curdling of milk is more during the hotter years.

The productivity of fisheries sector is not much affected with the change in climate in the NEH states as the sector is yet to develop. But the farmers reported that the size and depth of water bodies reduces during the low rainfall period. The flow of water in rivers has slowed down in Khowai river of Tripura. The behavioural pattern of fishes and the area of fishing are changing due to change in current and temperature of flow. The local fish varieties which earlier used to be easily available has become scarce now and prices of those fishes has gone up.

In one hand the irrigation facility is nearly non-existent, in another hand; it shrinks during the low rainfall period. Similarly, the water availability for drinking purpose dwindles during low rainfall period, despite improved drinking water facilities in normal period in the villages. The increase in population has put additional pressure to it. The respondents informed that the number of pipes they put at the source to fetch water has increased many fold over the years. But due to this reason conflicts have been reported only in few cases, except Darjeeling and East Sikkim where the number of conflicts for water was little higher comparatively to other NEH states.

The share of extra burden, if any, is mainly shared by both male and female members of the households. The work of fetching water is mainly performed by the female members, except West Tripura.

Delaying the timing of sowing or transplanting in case of late rainfall is the main adaptation strategy the farmers have adapted in the study area. Many of them have also changed the time of harvesting. They also have changed the varieties they grew to maintain the yield stability, in addition to adapt to changing climate. The farmers of region have stopped cultivating a number of cereal varieties which they considered to be suitable in water stress situation mainly due to their low yield potential as well as unavailability of seeds, especially when new verities were made available by government agencies or their fellow farmers. The decisions to change or continue with a variety were mainly taken by either both male and female member of a household together or only the male member.

To sustain the livelihood they resorted to wage labour and in Tripura and Nagaland, a limited per cent of them have migrated, also.

The farmers expressed their preference for stress tolerant cultivars, management of animal health, shift to improved cropping system, pest and disease management and cultivation of short duration crops as mitigating options to combat climate change.

The study recommends:

1. As late rainfall has been common in the region, farmers should adjust the date of sowing or transplanting depending upon the arrival of rainfall.
2. Research effort may be directed towards developement of varities suitable for late sowing, which should perform better in condition of water stress and increased temperature. Development of short duration varieties is also another way out to recover from the losses due to late arrival of rain.
3. Focus should be put on conserving and upgrading the existing landraces considered to be suitable for climate change situation and making available the suitable varieties at the time of need is very important for combating climate change.
4. Farmers may be advised to take up short duration cash crops to minimize the economic losses due to rainfall variability. Lentil after rice, soybean, vegetables especially tomato may help to sustain the economy of farming households. Fruit crops in limited numbers may also help to provide flow of income to the farmers of the region.
5. Emphasis may be given to crop diversification due to its agronomic (*i.e.,* improvement of soil health) as well as economic benefit. In case of climatic variability, if one crop fails other may still provide some return to the farmers.
6. The NEH region has special farming system which is more often sustainable in nature and in consonant with the local food system. The community can survive without much external interventions. Focus should be put on dairy and meat animals, and on fisheries, as these sectors have great potential to thrive well and contribute towards the overall sustainability of the farming system. *Jhum* is such a sector which is going to stay in the region. Hence, research should be conducted on augmenting the productivity of all the farm enterprises so as to make the system more resislient to climate change.
7. Adaptation of social forestry and muti-tier farming may help to solve the problem of firewood, in addition to supply of food and fodder.
8. Crop protection is an important area for the researchers due to increase in and arrival of new pests and diseases, which needs to be identified and studied. Researchers need to focus on biological or organic solution of the problems as this

region is still pristine. The available local knowledge system to control the pests and diseases may be utilized for better results.

9. The farmers of the region still use the primitive tools and implements in agricultural operations. Agricultural engineers should develop tools and implements suitable to the region which may reduce the time of operations and drudgery of farmers, especially women farmers.
10. For combating drought government should invest on irrigation structures suitable to the terrain of the region. Water may be stored in watersheds, such as *jalkunds,* to be utilized in the lean periods. Application of drip irrigation may help to increase the water use efficiency in vegetable and fruit crops.
11. PHE department should make necessary infrasturcutre to supply clean drinking water to each of the villages.
12. As migration is not common in the interior villages, providing alternative employment opportunities through employment generation schemes and strengthening the PDS should be the priority for the government to sustain the livelihood of the farming houseoholds of the region.
13. Formtion of Farmers' Club or Self-help Group (SHG) for joint learning, doing (cultivation and marketing) and interventions will increase the capability of the farmers to combat climatic variability.
14. As the spread of banking sector is very poor in the hills, devising mechanism to make credit available in need and implementing crop or livestock insurance schemes will be a challenging task to the authority. Use of mobile banks at the doorstep of the villagers and use of mobile phones may be the cheaper options.
15. As rainfall has been erratic, scientific forecasting of rainfall and disseminating the information to the farmers will help to minimize uncertainty and better crop planning by the farmers.

Policy initiatives

In the event of changing climate scenario, it is necessary to invest heavily on research on climate change and its various dimensions vis-à-vis agriculture. Location specific focused micro studies which look into it in holistic manner, *i.e.,* not only the agronomic side of it but also the social side of it shall be financed by the government. The knowledge gained from these studies will help to take up further action oriented research as well as formulate developmental programme. The beneficial affect or the success stories may be replicated in other areas. The strategies adapted to cope up the effect of climate change and the available planned adaptation strategies need to be studied so as they can be manipulated in favour of improving the adaptation capacity of the farming community of the region as the projected change in the climate is alarming.

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# ANNEXURE

***Annex III_Temp_I***

| Linear trend coefficients of maximum temperature in NEH of India | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | | 2010-13 | |
| | b | p | B | p | b | p | b | p |
| Sikkim | 0.02 | 0.36 | 0.01 | 0.55 | 0.00 | 0.82 | -0.22 | 0.42 |
| Darjeeling | 0.03 | 0.17 | 0.00 | 0.84 | -0.01 | 0.32 | | |
| Meghalaya | 0.00 | 0.79 | 0.06*** | 0.00 | 0.02** | 0.02 | 0.06 | 0.72 |
| Arunachal | 0.00 | 0.86 | 0.06*** | 0.00 | 0.02** | 0.02 | | |
| Karbi Anglong | 0.01 | 0.51 | 0.07*** | 0.00 | 0.02*** | 0.00 | | |
| Nagaland | 0.00 | 0.86 | 0.07*** | 0.00 | 0.02*** | 0.00 | 0.35 | 0.10 |
| Manipur | 0.01 | 0.66 | 0.07*** | 0.00 | 0.02*** | 0.00 | 0.28 | 0.23 |
| Tripura | -0.01 | 0.63 | 0.03** | 0.03 | 0.00 | 0.46 | | |
| Mizoram | 0.00 | 0.99 | 0.03** | 0.02 | 0.01 | 0.16 | 0.09 | 0.71 |

***Annex III_Temp_II***

| Linear trend coefficients of minimum temperature in NEH of India | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| State/District | 1975-1989 | | 1990-2009 | | 1975-2009 | | 2010-13 | |
| | b | p | B | p | b | p | b | P |
| Sikkim | 0.00 | 0.96 | 0.06*** | 0.00 | 0.04*** | 0.00 | -0.32 | 0.09 |
| Darjeeling | 0.00 | 0.97 | 0.07*** | 0.00 | 0.04*** | 0.00 | | |
| Meghalaya | 0.01 | 0.56 | 0.05*** | 0.00 | 0.03*** | 0.00 | -0.26 | 0.32 |
| Arunachal | 0.00 | 0.79 | 0.07** | 0.01 | 0.04*** | 0.00 | | |
| Karbi Anglong | 0.00 | 0.98 | 0.04*** | 0.00 | 0.03*** | 0.00 | | |
| Nagaland | -0.01 | 0.52 | 0.04** | 0.01 | 0.03*** | 0.00 | -0.48 | 0.06 |
| Manipur | 0.00 | 0.83 | 0.02 | 0.23 | 0.02*** | 0.00 | -0.24 | 0.35 |
| Tripura | 0.01 | 0.38 | 0.05*** | 0.00 | 0.03*** | 0.00 | | |
| Mizoram | 0.01 | 0.46 | 0.04*** | 0.00 | 0.03*** | 0.00 | 0.01 | 0.97 |

***Annex III_Rain_I***

| Linear trend coefficients of annual rainfall in NEH of India | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| State/ District | 1975-1989 | | 1990-2007 | | 1975-2007 | | 2008-13 | |
| | b | p | b | p | B | p | B | p |
| Sikkim | 12.37 | 0.56 | 5.23 | 0.88 | 8.54 | 0.44 | -12.27 | 0.92 |
| Darjeeling | 18.50 | 0.44 | -6.83 | 0.78 | 1.96 | 0.82 | -58.48 | 0.36 |
| Meghalaya | 68.20** | 0.01 | 52.52 | 0.09 | 19.97 | 0.06 | -495.66** | 0.03 |
| Arunachal | 5.88 | 0.72 | -5.89 | 0.61 | -6.47 | 0.17 | -36.63 | 0.65 |
| Karbi Anglong | 30.32 | 0.06 | -7.41 | 0.49 | -2.40 | 0.61 | 20.19 | 0.67 |
| Nagaland | 15.01 | 0.37 | -24.38 | 0.20 | -19.32** | 0.01 | -48.75 | 0.51 |
| Manipur | 20.66** | 0.04 | -18.49** | 0.04 | 3.53 | 0.32 | -57.02 | 0.54 |
| Tripura | -37.34 | 0.29 | -10.57 | 0.67 | -17.22 | 0.09 | -1.23 | 0.97 |
| Mizoram | 31.71 | 0.34 | -76.24** | 0.04 | -15.62 | 0.23 | 71.20 | 0.37 |

***Annex V(SK)_I***

| Whether changed rice cultivar and who decides what to cultivate in East Sikkim? | | |
|---|---|---|
| Particulars | Frequency (%) | |
| | Rice | Maize |
| Changed cultivar | 53.52 | 2.20 |
| Who decides? | | |
| Husband | 25.83 | |
| Wife | 0.83 | |
| Both husband and wife | 65.00 | |
| Grown up children | 1.67 | |
| Elders in the house | 6.67 | |
| Government organization | 0.00 | |
| Others | 0.00 | |

***Annex V(SK)_II***

| Factors influencing decisions to continue with or change a rice cultivars in East Sikkim | | | | | (in %) |
|---|---|---|---|---|---|
| Factors | Rice | Maize | Factors | Rice | Maize |
| Taste | 74.58 | 3.30 | Yield | 74.58 | 10.99 |
| Look/appearance | 7.63 | 0.00 | Financial status | 7.63 | 0.00 |
| Size | 30.00 | 0.00 | Availability of credit | 30.00 | 0.00 |
| Stickiness | 1.67 | 0.00 | Availability of water | 1.67 | 61.54 |
| No. of panicle | 1.67 | 0.00 | Availability of seeds | 1.67 | 73.63 |
| No. of shoots | 0.00 | 0.00 | Availability of fertilizers | 0.00 | 2.20 |
| Tolerance to flood | 0.83 | 0.00 | Storability | 0.83 | 3.30 |
| Tolerance to drought | 0.00 | 45.05 | Market price | 0.00 | 0.00 |
| Tolerance to heat | 22.50 | 0.00 | Market demand | 0.00 | 0.00 |
| Tolerance to cold | 0.00 | 0.00 | Recommended by Department of Agriculture | 1.67 | 5.49 |
| Resistant to diseases | 1.67 | 41.76 | Recommended by University | 0.00 | 0.00 |
| Resistant to pest | 5.83 | 62.64 | Recommended by NGO | 0.00 | 0.00 |

***Annex V(SK)_III***

| Preferred trainings in East Sikkim | |
|---|---|
| Area | Frequency (%) |
| Seed health management | 8.33 |
| Crop production management | 35.83 |
| Water management | 27.50 |
| Crop nutrient management | 10.83 |
| Weeds, insects and disease management | 15.83 |
| Post-harvest including storage | 2.50 |
| Animal management | 28.33 |
| Other income generation | 5.83 |

***Annex V(D)_I***

| Whether changed rice cultivar and who decides what to cultivate in Darjeeling? | | |
|---|---|---|
| Particulars | Frequency (%) | |
| | Rice | Maize |
| Changed cultivar | 43.53 | 8.79 |
| Who decides? | | |
| Husband | 63.33 | |
| Wife | 2.50 | |
| Both husband and wife | 20.00 | |
| Grown up children | 3.33 | |
| Elders in the house | 11.67 | |
| Government organization | 0.00 | |
| Others | 0.00 | |

***Annex V(D)_II***

| Factors influencing decision to continue with or change a rice cultivar in Darjeeling (in %) | | | | | |
|---|---|---|---|---|---|
| Factors | Rice | Maize | Factors | Rice | Maize |
| Taste | 49.41 | 9.89 | Yield | 63.53 | 9.89 |
| Look/appearance | 16.47 | 3.30 | Financial status | 4.71 | 0.00 |
| Size | 9.41 | 1.10 | Availability of credit | 0.00 | 0.00 |
| Stickiness | 0.00 | 1.10 | Availability of water | 9.41 | 6.59 |
| No. of panicle | 2.35 | 0.00 | Availability of seeds | 14.12 | 4.40 |
| No. of shoots | 2.35 | 0.00 | Availability of fertilizers | 0.00 | 1.10 |
| Tolerance to flood | 0.00 | 0.00 | Storability | 4.71 | 3.30 |
| Tolerance to drought | 9.41 | 0.00 | Market price | 5.88 | 4.40 |
| Tolerance to heat | 0.00 | 0.00 | Market demand | 3.53 | 3.30 |
| Tolerance to cold | 0.00 | 0.00 | Recommended by Department of Agriculture | 0.00 | 0.00 |
| Resistant to diseases | 9.41 | 2.20 | Recommended by University | 0.00 | 0.00 |
| Resistant to pest | 8.24 | 1.10 | Recommended by NGO | 0.00 | 0.00 |

***Annex V(D)_III***

| Trainings preferred by the farmers in Darjeeling | | | |
|---|---|---|---|
| Areas of training | Frequency (%) | Areas of training | Frequency (%) |
| Seed health management | 3.33 | Pest management (weeds, insects, disease) | 25.00 |
| Crop production management | 35.83 | Post-harvest including storage | 2.50 |
| Water management | 14.17 | Animal management | 23.33 |
| Crop nutrient management | 3.33 | Other income generation | 1.67 |

***Annex V(MG)_I***

| Whether changed cultivar and who decides in a family what to cultivate in Ri-Bhoi? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 76.92 | Member of a family | |
| Member of a family | | Grown up children | 0.00 |
| Husband | 1.67 | Elders in the house | 5.00 |
| Wife | 5.83 | GovernmentOrganization | 0.00 |
| Both husband and wife | 88.33 | Others | 0.00 |

***Annex V(MG)_II***

| Factors influencing decision to continue with or change a rice cultivar in Ri-Bhoi | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 70.09 | Yield | 89.47 |
| Look/appearance | 26.72 | Financial status | 3.16 |
| Size | 17.09 | Availability of credit | 2.13 |
| Stickiness | 9.47 | Availability of water | 10.53 |
| No. of panicle | 90.53 | Availability of seeds | 28.72 |
| No. of shoots | 74.74 | Availability of fertilizers | 8.42 |
| Tolerance to flood | 1.05 | Storability | 1.06 |
| Tolerance to drought | 75.79 | Market price | 43.16 |
| Tolerance to heat | 41.05 | Market demand | 41.05 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 6.32 |
| Resistant to diseases | 66.32 | Recommended by University | 0.00 |
| Resistant to pest | 65.26 | Recommended by NGO | 0.00 |

***Annex V(MG)_II***

| Preferred trainings in Ri-Bhoi | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 40.83 | Weeds, insects and disease management | 65.83 |
| Crop production management | 8.33 | Post-harvest including storage | 0.83 |
| Water management | 42.50 | Animal management | 12.50 |
| Crop nutrient management | 4.17 | Other income generation | 4.17 |

***Annex V(AP)_I***

| Whether changed cultivar and who decides in a family what to cultivate in West Kameng? | | |
|---|---|---|
| Particulars | Frequency (%) | |
| | Rice | Maize |
| Changed cultivar | 5.08 | 0.00 |
| Person | | |
| Husband | 3.33 | |
| Wife | 2.50 | |
| Both husband and wife | 75.83 | |
| Grown up children | 1.67 | |
| Elders in the house | 17.50 | |
| Government organization | 0.00 | |
| Others | 0.00 | |

***Annex V(AP)_II***

| Factors influencing decisions to continue with or change a rice cultivars in West Kameng (in %) | | | | | |
|---|---|---|---|---|---|
| Factors | Rice | Maize | Factors | Rice | Maize |
| Taste | 13.56 | 0.00 | Yield | 8.47 | 0.91 |
| Look/appearance | 8.47 | 0.00 | Financial status | 0.00 | 0.00 |
| Size | 3.39 | 2.73 | Availability of credit | 0.00 | 0.00 |
| Stickiness | 0.00 | 0.00 | Availability of water | 1.69 | 0.00 |
| No. of panicle | 1.69 | 0.00 | Availability of seeds | 1.69 | 0.00 |
| No. of shoots | 1.69 | 0.00 | Availability of fertilizers | 1.69 | 0.00 |
| Tolerance to flood | 0.00 | 0.00 | Storability | 0.00 | 0.00 |
| Tolerance to drought | 1.69 | 18.18 | Market price | 6.78 | 0.00 |
| Tolerance to heat | 1.69 | 0.00 | Market demand | 8.47 | 0.00 |
| Tolerance to cold | 1.69 | 0.00 | Recommended by Department of Agriculture | 0.00 | 0.00 |
| Resistant to diseases | 1.69 | 0.00 | Recommended by University | 0.00 | 0.00 |
| Resistant to pest | 1.69 | 0.00 | Recommended by NGO | 0.00 | 0.00 |

***Annex V(AP)_III***

| Preferred trainings in West Kameng | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 41.67 | Weeds, insects and disease management | 28.33 |
| Crop production management | 11.67 | Post-harvest including storage | 1.67 |
| Water management | 19.17 | Animal management | 6.67 |
| Crop nutrient management | 11.67 | Other income generation | 4.17 |

***Annex V(KA)_I***

| Whether changed rice cultivar and who decides in a family what to cultivate in Karbi Anglong | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 58.33 | Member of a family | |
| Member of a family | | Grown up children | 0.83 |
| Husband | 70.00 | Elders in the house | 5.00 |
| Wife | 0.00 | Government Organization | 0.00 |
| Both husband and wife | 23.33 | Others | 0.83 |

***Annex V(KA)_II***

| Factors influencing decisions to continue with or change a rice cultivar in Karbi Anglong | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 42.50 | Yield | 88.33 |
| Look/appearance | 3.33 | Financial status | 0.00 |
| Size | 0.83 | Availability of credit | 0.00 |
| Stickiness | 0.83 | Availability of water | 0.00 |
| No. of panicle | 5.83 | Availability of seeds | 30.00 |
| No. of shoots | 5.00 | Availability of fertilizers | 0.00 |
| Tolerance to flood | 0.00 | Storability | 0.00 |
| Tolerance to drought | 71.67 | Market price | 4.17 |
| Tolerance to heat | 0.00 | Market demand | 1.67 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 3.33 |
| Resistant to diseases | 3.33 | Recommended by University | 0.00 |
| Resistant to pest | 2.50 | Recommended by NGO | 0.00 |

***Annex V(KA)_III***

| Preferred trainings in Karbi Anglong | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 3.33 | Weeds, insects and disease management | 33.33 |
| Crop production management | 39.17 | Post-harvest including storage | 0.83 |
| Water management | 35.00 | Animal management | 37.50 |
| Crop nutrient management | 0.83 | Other income generation | 2.50 |

***Annex_V(NL)_I***

| Whether changed cultivar and who decides in a family what to cultivate in Dimapur | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 83.33 | Member of a family | |
| Member of a family | | Grown up children | 0.83 |
| Husband | 36.67 | Elders in the house | 13.33 |
| Wife | 1.67 | Government Organization | 0.00 |
| Both husband and wife | 44.17 | Others | 12.50 |

***Annex_V(NL)_II***

| Factors influencing decisions to continue with or change a rice cultivar in Dimapur | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 92.50 | Yield | 79.17 |
| Look/appearance | 27.50 | Financial status | 0.00 |
| Size | 7.50 | Availability of credit | 0.00 |
| Stickiness | 23.33 | Availability of water | 0.83 |
| No. of panicle | 50.83 | Availability of seeds | 49.17 |
| No. of shoots | 50.83 | Availability of fertilizers | 0.83 |
| Tolerance to flood | 0.00 | Storability | 0.00 |
| Tolerance to drought | 80.83 | Market price | 30.83 |
| Tolerance to heat | 0.00 | Market demand | 10.83 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 8.33 |
| Resistant to diseases | 2.50 | Recommended by University | 0.00 |
| Resistant to pest | 2.50 | Recommended by NGO | 0.00 |

***Annex_V(NL)_III***

| Preferred trainings in Dimapur | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 5.00 | Weeds, insects and disease management | 25.00 |
| Crop production management | 36.67 | Post-harvest including storage | 2.50 |
| Water management | 39.17 | Animal management | 40.00 |
| Crop nutrient management | 5.83 | Other income generation | 0.83 |

***Annex V(MN)_I***

| Whether changed cultivar and who decides in a family what to cultivate in Senapati? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 45.83 | Member of a family | |
| Member of a family | | Grown up children | 0.83 |
| Husband | 9.17 | Elders in the house | 26.67 |
| Wife | 8.33 | Government Organization | 0.00 |
| Both husband and wife | 55.00 | Others | 0.00 |

***Annex V(MN)_II***

| Factors influencing decisions to continue with or change a rice cultivar in Senapati | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 77.50 | Yield | 62.50 |
| Look/appearance | 15.83 | Financial status | 0.00 |
| Size | 1.67 | Availability of credit | 0.00 |
| Stickiness | 6.67 | Availability of water | 0.83 |
| No. of panicle | 3.33 | Availability of seeds | 11.67 |
| No. of shoots | 3.33 | Availability of fertilizers | 0.00 |
| Tolerance to flood | 0.00 | Storability | 0.00 |
| Tolerance to drought | 35.00 | Market price | 0.83 |
| Tolerance to heat | 0.00 | Market demand | 0.83 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 12.50 |
| Resistant to diseases | 2.50 | Recommended by University | 12.50 |
| Resistant to pest | 5.00 | Recommended by NGO | 3.33 |

***Annex V(MN)_III***

| Preferred trainings in Senapati | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 6.67 | Weeds, insects and disease management | 62.50 |
| Crop production management | 42.50 | Post-harvest including storage | 0.00 |
| Water management | 23.33 | Animal management | 26.67 |
| Crop nutrient management | 16.67 | Other income generation | 3.33 |

***Annex V(TR)_I***

| Whether changed cultivar and who decides in a family what to cultivate in West Tripura? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 79.49 | | |
| Member of a family | | Grown up children | 0.83 |
| Husband | 75.00 | Elders in the house | 8.33 |
| Wife | 1.67 | Government Organization | 0.83 |
| Both husband and wife | 10.83 | Others | 0.00 |

***Annex_V(TR)_II***

| Factors influencing decisions to continue with or change a rice cultivar in West Tripura | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 73.50 | Yield | 24.37 |
| Look/appearance | 31.03 | Financial status | 3.51 |
| Size | 73.50 | Availability of credit | 41.88 |
| Stickiness | 17.24 | Availability of water | 49.14 |
| No. of panicle | 41.03 | Availability of seeds | 14.53 |
| No. of shoots | 41.03 | Availability of fertilizers | 2.56 |
| Tolerance to flood | 14.53 | Storability | 1.72 |
| Tolerance to drought | 63.16 | Market price | 78.95 |
| Tolerance to heat | 2.56 | Market demand | 81.97 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 34.43 |
| Resistant to diseases | 36.75 | Recommended by University | 1.67 |
| Resistant to pest | 18.10 | Recommended by NGO | 1.67 |

***Annex V(TR)_III***

| Preferred trainings in West Tripura | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 19.17 | Weeds, insects and disease management | 52.50 |
| Crop production management | 15.00 | Post-harvest including storage | 19.17 |
| Water management | 45.00 | Animal management | 11.67 |
| Crop nutrient management | 39.17 | Other income generation | 10.00 |

***Annex VI(MZ)_I***

| Whether changed rice cultivar and who decides in a family what to cultivate in Lunglei? | | | |
|---|---|---|---|
| Particulars | Frequency (%) | Particulars | Frequency (%) |
| Changed cultivar | 35.29 | | |
| Member of a family | | Grown up children | 0.00 |
| Husband | 23.33 | Elders in the house | 9.17 |
| Wife | 3.33 | Government Organization | 0.00 |
| Both husband and wife | 60.00 | Others | 0.83 |

***Annex VI(MZ)_II***

| Factors influencing decisions to continue with or change a rice cultivar in Lunglei | | | |
|---|---|---|---|
| Factors | Frequency (%) | Factors | Frequency (%) |
| Taste | 74.58 | Yield | 69.49 |
| Look/appearance | 7.63 | Financial status | 0.85 |
| Size | 15.25 | Availability of credit | 0.85 |
| Stickiness | 30.51 | Availability of water | 3.39 |
| No. of panicle | 37.29 | Availability of seeds | 8.47 |
| No. of shoots | 28.81 | Availability of fertilizers | 0.85 |
| Tolerance to flood | 0.00 | Storability | 0.85 |
| Tolerance to drought | 33.05 | Market price | 17.80 |
| Tolerance to heat | 20.34 | Market demand | 15.25 |
| Tolerance to cold | 0.00 | Recommended by Department of Agriculture | 8.47 |
| Resistant to diseases | 14.41 | Recommended by University | 0.00 |
| Resistant to pest | 18.64 | Recommended by NGO | 0.00 |

***Annex VI(MZ)_III***

| Preferred trainings in Lunglei | | | |
|---|---|---|---|
| Area of training | Frequency (%) | Area of training | Frequency (%) |
| Seed health management | 17.50 | Weeds, insects and disease management | 69.17 |
| Crop production management | 25.83 | Post-harvest including storage | 4.17 |
| Water management | 41.67 | Animal management | 29.17 |
| Crop nutrient management | 4.17 | Other income generation | 0.00 |