

CLIMATE CHANGE

Mitigation, Adaptation and Resilience: Towards Sustainable Livelihoods in Four States of Northeast India



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Acknowledgement

At the very outset, we would like to offer our sincere thanks to all the respondents for agreeing to be a part of our research and sparing their invaluable time to answer our questions and provide us with information. And to all the subject matter experts (SMEs) who took time out of their busy schedules to engage in discussions with us and provide their invaluable knowledge and inputs to this study, we are extremely grateful.

Next, we would like to extend our heartfelt gratitude to all those involved in the process of data collection in Barpeta, Bongaigaon, Cachar, Dhemaji, Dhubri districts in Assam, Bishnupur and Tamenglong districts in Manipur, Peren district in Nagaland and West Tripura district in Tripura. It was through the dedication of these teams and their hard work that we were able to complete the data collection by reaching out to those in such climate-vulnerable and even some remote areas of these districts. We are grateful to SEDO (Dhemaji), SUS (Cachar), PRDA (Bishnupur), PESCH (Tamenglong), and RBA (Peren) for their collaboration on and contribution to this research from the very beginning and throughout.

This research is also a result of the unwavering support of our funding partner, Axis Bank Foundation (ABF), which has encouraged and supported us through this journey. And lastly, we thank our colleagues at SeSTA who have also been involved in various aspects through this process of carrying out this research and producing this report based on it. Special thanks to Debasish Nath (Thematic Expert), Arifa, Raja, Mahanur and Pradyut Bhattacharjee (Executive Director - SeSTA) for strengthening the recommendation section.

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Abstract

This research looks at the changes in and the impact of global climate change on agriculture, livestock and natural resources that may affect livelihoods which are directly dependent on the climate and natural resources. The study was conducted in select districts of Assam, Manipur, Nagaland and Tripura which are some of the most climate vulnerable and have been adversely affected by such changes. The data was collected from a selected sample of respondents from these four states through household surveys, focus group discussions (FGDs) and key informant interviews (KIIs), which was then carefully analyzed. It was observed that climate change has impacted the availability of water making it a scarce resource in many areas. Changes in rainfall patterns have also adversely affected agricultural production in the absence of sustainable irrigation facilities and rising temperatures have led to several diseases and infections increasingly affecting both crop production and livestock. Another aspect of climate change-related negative impact has been a deterioration of soil quality and increasing demands for chemical fertilisers in certain parts of this region, especially in the plains where large-scale commercial farming is done. This research also attempts to highlight some of the methods and practices that are already in use or can be implemented on a broader scale to counter such negative impacts and ensure a more sustainable livelihood for the people in this region.

Introduction

The northeastern region of India consists of an area of 2.6 lakh sq. km and accounts for about 7.98 per cent of the total geographical area of India while being home to 3.78 per cent of India's total population. About 70 per cent of the region is covered with hilly terrain, and the rest consists of valleys and plains, with altitudes ranging from sea level to over 7000 metres (23,000 ft) above mean sea level. The states in this region have their unique ecosystems and rich biodiversity (Ministry of Development of North-Eastern Region, 2023). The region is rich in different natural resources ranging from coal, petroleum and natural gas to bamboo, timber and other forest products. The flora and fauna endemic to the region are also unique and consist of some rare species of rhododendrons, orchids, lilies, several medicinal plants, agarwood, and wildlife like the Hoolock gibbon, Phayre's Leaf Monkey, Blyth's Tragopan, Sangai, one-horned rhino, etc.

The fertile plains in the northeastern states, along with the indigenous knowledge and traditional systems of cultivation, have been the source of livelihood for a large section of the rural population. Even with the incorporation of more scientific technology and machinery, agricultural production and other farm-related activities have been an important source of livelihood while also contributing to the economy of the region. About 70 per cent of the population in the region is dependent on agriculture (Niti Aayog, 2021).

Being an ecologically fragile area located in the eastern Himalayan foothills and consisting of trans-boundary river basins, this region with its subtropical climate, falls under the high rainfall zone (Das, et al.). However, owing to global climate change, this region has been facing drought-like situations in addition to other extreme weather events, more frequently over the past decade or so. Since the majority of the population is engaged in agriculture

How to make agriculture sustainable? Existing practices, although believed to be eco-friendly and environmentally safe [1], have seen a shift over the past two decades or so when mechanization and large -scale commercial production have become central to much of the agricultural production in the region. Much of it, especially in the valley areas, is also driven by various incentives from the government. The fertiliser consumption rate was 37.40 kg/ha in 2004 (Department of Agriculture, Government of Assam) and has only continued to increase since. Therefore, there is an imminent need to understand the changes and the reasons behind them to design newer techniques or utilize existing ones to counter the negative impacts.

A previous study [2] conducted by SeSTA in 2024 in select districts of Assam and Manipur found that weather events like heavy rains, floods, hailstorms, heat waves and drought are some of the major climate-related problems being faced by the communities. These events have caused severe damage to life and property, destroying crops and causing soil erosion, water scarcity or water contamination in many of the areas studied. As such, crop yields varied with unpredictable growing seasons and people moved away from aquaculture as a means of livelihood. All of these impacts result in reduced income from agriculture and allied activities, and the increasing cost of living forces people to migrate to urban areas in search of better income opportunities.

Therefore, this study aims to understand the issues being faced by the communities, how they adapt to them and any mitigation strategies that they might have undertaken to combat the problems related to climate change. The research also strives to formulate strategies based on the findings, in addition to existing traditional knowledge systems as well as implementing scientific techniques to counter and mitigate such issues where necessary, so that livelihoods can be made eco-friendlier and more sustainable.

Research objectives

The objectives of this research are as follows:

- To understand any changes in cropping patterns and cropping cycles owing to climate change, particularly impacts on soil, water sources and other natural resources, and the resulting effects on the agricultural practices, harvest, etc.
- To understand any possible impacts on livestock – diseases and mortality rates, availability or non-availability of food and grazing lands, etc. – that may have risen from climate change and related issues.
- To understand traditional adaptation practices and more innovative scientific ones, and to formulate mitigation strategies based on the findings where required, to enhance climate resilience and help the communities in adaptation and ensuring more sustainable livelihoods.

Methodology

This study employs a mix of quantitative and qualitative methods, viz., survey, focus group discussion (FGD) and key informant interviews (KII). The survey is aimed to collect data from a wider pool of respondents while the focus group discussion and the key informant interviews will enable the study to gather a deeper understanding of the issues related to climate change.

The sample: The respondents for the survey were selected using the simple random sampling method. The sample for the survey consists of a total of 891 respondents. The sample includes 10 respondents per village, with one respondent representing one household in the village. 10 villages per Block were selected for this survey, and there was one Block from every district for this research, with the exception of Barpeta district, Assam, where five villages each from two Blocks were selected. The survey was administered using an online questionnaire.

On the other hand, five **focus group discussions** were conducted per block, for which the respondents were selected through purposive sampling method. There were seven to ten participants in each FGD. The participants in these FGDs included farmers, both male and female, who have been involved in agriculture and allied activities for over a decade or more, people whose livelihoods depend on common property resources like forest and woodlands, grazing lands and pastures, ponds, rivers, etc., panchayat representatives, Anganwadi sevikas and Auxiliary Nurse Midwife (ANM).

Furthermore, the **Key Informant Interviews** were conducted with different stakeholders like representatives and officials from various departments, elected committee members of village organizations, etc. These included interviews with officials and representatives of Agriculture department, Environment and Forest department, Fishery department, Irrigation department, Soil conservation department, Veterinary department, Sericulture department, Water resources department, Pashu Sakhi and Krishi Sakhi, Krishi Vigyan Kendra officials, Disaster management officials, Meteorology department officials, and SRLM staff.

Profile of study area

The study was conducted across four states in the northeast region of India. These states are Assam, Manipur, Nagaland and Tripura. From Assam, five districts – Barpeta, Bongaigaon, Cachar, Dhemaji, and Dhubri – were selected, while Bishnupur and Tamenglong districts were selected from Manipur. The district selected from Nagaland is Peren, and the district selected from Tripura is West Tripura. The following are the details regarding the districts (as per Census 2011 and other official profiles).

Name of District	Total land area in km ² (approx.)	Total population	Topography	Major sources of livelihood
Barpeta	2,244	1,678,710	Floodplains that slope slightly upwards towards the south-west	Agriculture, fishery, small-scale industry
Bongaigaon	1,093	7,38,804	Hilly in the north and floodplains in the south	Agriculture, industries
Cachar	3,786	1,736,391	Flood-prone river plains and hills	Agriculture (80%), tea plantations,
Dhemaji	3,237	6,88,077	Hilly with flood-prone plains	Agriculture (85%)
Dhubri	2,176	19,49,258	Largely floodplains with a small patch of hillocks	Agriculture, forest products
Bishnupur	530	2,37,399	Valley surrounded by hills	Agriculture and cottage industries

Name of District	Total land area in km2 (approx.)	Total population	Topography	Major sources of livelihood
Tamenglong	4,391	55,938	Hilly in general, with steep slopes and a small valley	Agriculture (95%)
Peren	1,799	95,219	Mix of hills, a valley and dense forests	Agriculture, industries
West Tripura	983	1,725,739	Undulating hills and flood-prone valleys.	Agriculture (75%)

Table 1: Study area at a glance

Study Locations: The research was carried out in selected villages in these ten development blocks of the nine districts.

District	Block	Total Respondents Surveyed
Barpeta	Mandia, Pakabetbari	79
Bongaigaon	Dangtol	100
Cachar	Tapang	119
Dhemaji	Dhemaji	92
Dhubri	Chapar-Salkocha	100

District	Block	Total Respondents Surveyed
Bishnupur	Nambol	101
Tamenglong	Tousem	100
Peren	Jalukie	100
West Tripura	Mandwi	100
Total 9 districts	10 blocks	891 sample

Table 2: List of the blocks studied in each district

All of these areas have been selected keeping in view the past incidents of natural disasters recorded in these districts which have occurred more frequently or have had unprecedented devastating effects as compared to other places in the region. The blocks selected for this study are also based on these criteria, as these blocks within the selected districts are more prone to different natural calamities arising out of altered weather patterns and other climatic conditions. More frequent or devastating impacts of seasonal floods and inundation, soil erosion and landslides, cloud bursts, dry spells or drought-like conditions, extreme heat, etc., have been recorded in these blocks of the selected districts over the last ten years, which makes them suitable areas for this research to understand the impacts of climate change in the northeastern region of India.

Review of Literature

Global climate change highly impacts the changes in temperature (both land surface temperature and the temperature of water bodies), rainfall patterns, soil moisture and soil quality, water resources, and vegetation directly and further impact other aspects like biodiversity, livestock, agriculture, human lives and livelihoods (Halder & Yaseen, 2024; Shirzaei, et al., 2021). Several states in India have been impacted in the past 20 years, and West Bengal, Jharkhand and Bihar have been the most highly affected. In terms of the northeastern states, Assam, Tripura, and Meghalaya have seen the most temperature variation (Halder & Yaseen, 2024) and other states like Nagaland and Manipur have experienced extreme weather conditions ranging from drought to cloud bursts, landslides, extreme rainfall, hailstorms and flooding in addition to heatwaves (Morung Express News, 2025; Nagaland Disaster Management Authority, 2025; Nagaland Tribune, 2024; Takhel, 2025; Relief Web, 2024). Prolonged periods of summer or heatwaves have resulted in drought-like situations in several districts across the region in the last decade and on the other hand, flash floods and seasonal flooding incidents have also increased in frequency, along with untimely rainstorms (Nandi, 2024; TOI City Desk, 2025).

Changes in temperature and rainfall patterns are two of the major issues related to climate change which impact agriculture directly. These impacts have been increasingly observed in the agricultural process and production, resulting in reduced harvest and increased struggles for farmers to irrigate their fields. Rising temperatures have been linked to changes in rainfall patterns, increasing frequency and durations of heatwaves and droughts or drought-like situations that impact crop health and productivity. Increased temperatures also accelerate crop maturity and thus impact the length of the growing season (Gray, 2021). Moreover, other livelihood activities like livestock rearing, fishery, and plantations have also suffered over the last decade across the northeastern states of India. In terms of livestock, especially dairy farming, a decrease in the availability of fodder or grazing lands has been a concerning issue (Feroze et al. 2019; Malaviya, 2024). Diseases and heatstroke among animals, and zoonotic diseases (such as the global COVID-19 pandemic and the several variants that emerged) have increased in intensity.

In terms of the temperature across the eight northeastern states, it is estimated that the maximum temperature during summers and the minimum winter temperature will increase by almost 1°C to 1.5°C in the RCP[3] 4.5 scenario, and between 1°C to 2°C in the RCP 8.5 scenario (S. & Murthy, 2022). This means the average temperature of the region is projected to increase in the next 75 years to the point of no return.

It is noteworthy here that the two different scenarios require different levels of effort to curb emissions or slow down the rate of temperature increase. This is one of the reasons why different areas within the region require specific measures tailored to address the particular problems being faced by the people. The northeastern states of India are often classified into a homogenous entity, and the intricacies are overlooked while framing policies. However, a uniform blanket approach would not suffice to counter the impacts of climate change in the region where the terrain, soil types, weather patterns, and natural resources are so varied. This is precisely what this study aims to address by delving into the problems faced by the people in these climate-vulnerable areas.

Another aspect to be considered, as illustrated by Raj, Saharia and Chakma (2024), the national mean annual potential soil loss over India is 21 tons per hectare per year (t/h/y). Nine out of the 20 districts most susceptible to soil erosion in the country are in Assam. Goalpara, Dhubri, Chirang, Baksa, Kokrajhar, Bongaigaon, Udalguri, Nalbari and Barpeta are the districts that have been identified as the most vulnerable to this issue in Assam. The Brahmaputra basin is at the highest risk of soil erosion, with an erosion rate of 47.64 t/h/y. Additionally, inundation and siltation from frequent flooding makes the soil unsuitable for agricultural use (Sangomla, 2021).

Furthermore, the use of chemical fertilisers, insecticides, herbicides, weedicides, etc. have become increasingly popular in several states of the northeastern region over the past decade, while there has also been an effort on the part of certain sections to revive traditional and organic recipes and methods of fertilizing crops and controlling pests. There have been several steps taken by advocates of cleaner, organic methods, towards ensuring more sustainable and scientific eco-friendly techniques that would be safer for humans and the environment in the long run. Though the climatic condition of the Northeastern region of India is very much hospitable for agricultural pests, the region generally uses fewer pesticides and is experiencing a decline in consumption, except for the states like Sikkim, Meghalaya, Tripura, Manipur, and Nagaland, which are experiencing positive growth rates of pesticide use. Though Nagaland is a poor consumer of pesticides, a sharp increase in pesticide consumption has been recorded in the last couple of years (Devi, Thomas, & Raju, 2017). Studies revealed that chemical pesticides vehemently affect the seed germination process, apart from causing serious effects on the environment and physiological damage to the organisms. Especially higher concentration of pesticides largely suppresses growth in the seedling stage and reduces crop productivity. Non-biodegradable pesticides may lead to serious health hazards due to bio-magnification, leading to serious health issues, including cancers, kidney diseases, and several exposure-related diseases (Nath, Puzari, & Jamir, 2024).



Findings of the Research

This chapter captures the primary data analysis of the studied regions, where climate change has impacted the availability of water, making it a scarce resource in many areas. Changes in rainfall patterns have also adversely affected agricultural production in the absence of sustainable irrigation facilities, and rising temperatures have led to several diseases and infections increasingly affecting both crop production and livestock. Another aspect of climate change-related negative impacts has been a deterioration of soil quality and increasing demands for chemical fertilisers and insecticides in certain parts of this region, especially in the plains where large-scale commercial farming is done. The detailed findings of the research are as follows:

Demographics of the surveyed sample:

Aspects		Barpeta	Bongai gaon	Cachar	Dhemaj i	Dhubri	Bishnu pur	Tameng long	Peren	West Tripura	Total
Age Structure	18-30 years	25%	6%	28%	16%	14%	10%	6%	14%	22%	16%
	31-60 years	71%	85%	70%	78%	83%	75%	78%	81%	75%	77%
	61 years and above	4%	9%	2%	6%	3%	15%	16%	5%	3%	7%
Gender Representati on	Female	36%	66%	65%	29%	49%	14%	14%	61%	77%	46%
	Male	64%	34%	35%	71%	51%	86%	86%	39%	22%	54%
	Other	-	-	-	-	-	-	-	-	1%	0.1%

Table 3: Demographic structure of the respondents

The majority of the respondents in the various districts belong in the age groups of 31-60 years, followed by those in the 15-30 years age bracket. The percentage of male respondents is more than that of female respondents across the districts. None of the respondents identified as belonging to any other gender. The percentage of respondents from the general and OBC communities are more in the valley or plains, whereas the respondents from the ST communities are 100 per cent in the hilly areas. In addition to that, Cachar district has the highest percentage of respondents from the SC community.

Household information:

Aspects		Barpeta	Bongaigaon	Cachar	Dhemaji	Dhubri	Bishnupur	Tamenglong	Peren	West Tripura	Total
Source of Energy	Electricity	100%	99%	94%	100%	100%	99%	34%	99%	100%	92%
	Solar Cells			3%				60%	1%		7%
	Others		1%	3%			1%	6%			1%
Source of Drinking Water	Tubewell	97%	83%	45%	97%	78%		1%	1%	74%	51%
	Well		14%	34%		5%		2%	55%	1%	13%
	Tap Water	3%	2%	18%	3%	17%	51%	6%	32%	21%	17%
	River/Stream						9%	83%	12%		12%
	Canal		1%	3%							1%
	Others						40%	8%		4%	6%
Fuel for Cooking	LPG	77%	68%	39%	96%	67%	75%	11%	53%	67%	60%
	Biogas			2%			1%				0.3%
	Firewood	23%	32%	55%	4%	33%	22%	90%	46%	33%	31%
	Cowdung			4%			2%				~1%
	Others										

Table 4: Household's Information (in per cent)

Main source of power/energy: The majority of the respondents depend on electricity as the primary source of power in their household. However, in Tamenglong district, the villages and households are yet to achieve complete rural electrification. Moreover, alternative, renewable sources of energy like solar power are not yet widely used by the respondents.

Primary source of drinking water: The majority of the respondents depend on tubewells for their daily water use. Respondents in Tamenglong depend on rivers/streams and have started to use rainwater harvesting techniques to meet their water requirements. Those in Bishnupur either depend on tap water supplied by the government or have to buy water from private businesses that supply water. Many of the respondents across the districts who depend on water supply by the government stated that the quality of the water is not very good and is often cloudy or contains contaminants. Few respondents in Tripura depend on government water tank supply.

Primary fuel in the household: LPG and firewood are the two most frequently used fuels. The firewood is either collected from nearby woodlands, within their gardens or bought from the market. Several respondents mentioned that they use a combination of both firewood and LPG for their daily cooking activities, and many usually prefer to cook using LPG during the summers and firewood during the winters because of the temperature.

4. Primary sources of livelihood:

District/Primary Source of Livelihood	Barpeta	Bongaigaon	Cachar	Dhemaji	Dhubri	Bishnupur	Tamenglong	Peren	West Tripura	Total
Agriculture	70%	44%	6%	31%	47%	26%	77%	67%	16%	41%
Animal Husbandry		1%	23%	2%	3%	11%	3%	1%		5%
Horticulture		12%					2%	2%	7%	3%
Daily Wage Labour	10%	23%	60%	12%	31%	7%	3%	4%	34%	22%
Salaried Job	5%	8%	3%	10%	8%	16%	12%	10%	7%	9%
Small Business	13%	9%	4%	15%	10%	26%	3%	10%	19%	12%
Fishery/Aquaculture	1%			1%		11%				1%
Remittances		2%		22%	1%			1%		3%
Others	1%	1%	4%	7%		3%		5%	16%	4%

Table 5: Primary sources of livelihood of respondents (in per cent)

The majority of the respondents depend on agriculture as the primary source of livelihood, even though many of them cultivate for sustenance and not for sale. They may sell some surplus produce when required, but commercial farming is the most prevalent in Barpeta and Dhubri districts. Moreover, in the Cachar district, the majority of the respondents' primary livelihood source is daily wage labour, as there is a scarcity of water and cultivable land in the study area. Moreover, many of the respondents used to work in tea gardens that have now shut down due to various reasons and have to migrate to urban areas to work as wage labourers. In Bongaigaon, Dhubri and West-Tripura also, a large percentage of respondents depend on the daily-wage labour. Many respondents in Bishnupur also depend on small trade or shops for an income because of the scarcity of water. Dhemaji district also has high-migration and a large percentage of respondents are dependent on remittances.

Secondary sources of livelihood: Daily wage labour is the most common secondary source of livelihood in four districts. The respondents also engage in different kinds of agriculture and allied activities as a secondary source of income, including animal husbandry. About 19% of the respondents in Bishnupur, 3% of the respondents in Dhubri and West Tripura, respectively, and 1% of the respondents in Dhemaji left their secondary livelihood section blank as they only have one source of earning an income. Overall, 63% of the respondents are engaged in agriculture, 22% are involved with animal husbandry, 8% are dependent on horticulture and 2% on aquaculture/fishery for a livelihood. The remaining 5% of the respondents are engaged in other sources of livelihood (daily wage labour, salaried jobs, contractual jobs, small business or trade, pensions and benefits, remittances, etc.)

Impacts of Climate Change

Changing weather patterns community perspective:

Vulnerability index of the region: About 81% of the total respondents surveyed are aware of the concept of climate change and about 85% of them agreed that the climate of their area is now different than what it used to be about ten to fifteen years ago. Of the people surveyed, around 79% of the respondents mentioned that they have felt and observed a significant change in the temperature over the last five years while 21 % stated that they have either not felt any temperature changes or are not sure about it.

The table below presents the region's vulnerability index based on the responses collected during the study. Darker shades indicate higher levels of vulnerability, gradually decreasing with lighter shades.

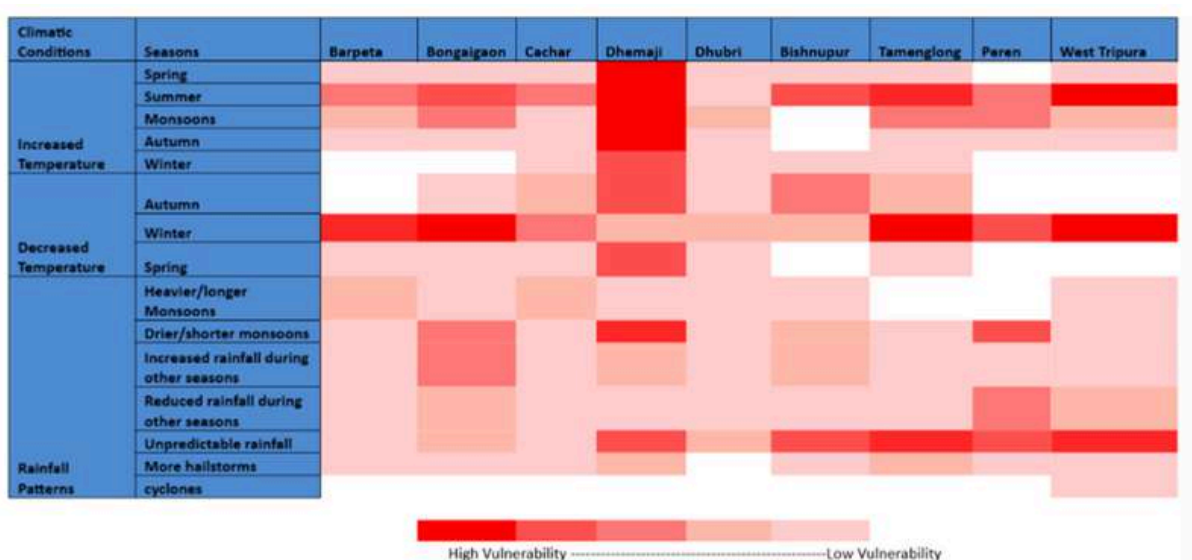


Figure 1: Vulnerability Index based on Perceived changes in temperature and rainfall pattern in different seasons

The graph shows that Dhemaji, Tamenglong, West Tripura summer months (May, June) have become hotter with a gradual increase in the atmospheric temperature over the past five years. Barpeta, Bongaigaon, Tamenglong, West Tripura mentioned that the temperature decreases during the winter months (November, December, January) only.

Respondents in Bongaigaon (93%), Dhemaji (98%), Tamenglong (94%) and West Tripura (93%) districts have stated that there have been significant and noticeable changes in the rainfall patterns.

52% of the respondents across the four states mentioned that rainfall has become unpredictable throughout the year. 32% stated that monsoons have become shorter and/or drier, while 16% of the respondents have observed that rainfall tends to be untimely, sometimes increasing in other seasons but reducing in the monsoons, more hailstorms occur and strong winds and thunderstorms accompany the rain.

Untimely, as well as shorter periods of rainfall has been devastating for agriculture over the past five years or so, especially for paddy crops in all the districts surveyed. Respondents in Dhemaji, Peren, Bishnupur, Tamenglong, and West Tripura mentioned unpredictable rainfall patterns in their areas.

Respondents in Barpeta, Bongaigaon and Dhemaji, mentioned that for the last paddy crop (Sali/winter/paddy), there was not enough rain during the growing period of the crop when it requires a good amount of water to grow well. Since these crops are majorly rainfed, this poses challenges to the quality of the harvest. Furthermore, just before the harvest heavy rains swept these districts which was also damaging for the grains. In terms of mustard crops and vegetables too, hailstorms and untimely rains have been damaging the crops when they are almost ready for harvest.

Incidences of natural disasters and Disease Outbreaks by the Respondents:

District/Natural Disaster	Barpeta	Bongai gaon	Cachar	Dhemaji	Dhubri	Bishnu pur	Tameng long	Peren	West Tripura	Total
Drought	24%	64%	23%	1%	43%	13%	21%	2%	34%	25%
Flood	100%	5%	89%	98%	74%	71%	2%	-	24%	51%
Heavy Rain	19%	22%	34%	96%	55%	63%	31%	9%	55%	43%
Sporadic Rain	-	10%	-	92%	4%	-	2%	6%	7%	13%
Windstorm	-	16%	7%	95%	12%	12%	67%	6%	25%	26%
Thunder storm	-	24%	27%	93%	11%	8%	54%	19%	50%	32%
Erosion	9%	-	-	93%	8%	3%	14%	-	9%	14%
Landslide	-	-	-	88%	-	-	17%	2%	14%	13%
Heatwave	1%	4%	-	92%	3%	13%	4%	51%	53%	24%
Cold Wave	1%	1%	1%	1%	-	5%	-	3%	-	1%
Fire (Forest and others)	-	3%	24%	-	3%	1%	-	11%	6%	7%
Inundation	-	-	2%	7%	20%	-	1%	2%	-	3%
Diseases/Insect Infestations	10%	13%	-	-	15%	2%	5%	62%	2%	12%

Table 6: Impacts of natural disasters on the respondents (in percent)

The biggest natural calamity faced by the respondents is flood (51%), consistent with Sphere India SitReps (2025) documenting 6.33 lakh affected in Assam's 21 districts from June floods, which is often preceded or accompanied by heavy rain (43%), windstorms (26%) and thunderstorms (32%). About 25% of the respondents also stated that they face drought-like situations and heatwaves during the summers and dry seasons and it is increasingly becoming more intense, aligning with IMD Pune's 2025 Climate Statement noting East & Northeast India's 80% LPA monsoon rainfall (deficit), and Rajraf reports on rising drought risks from 2020-2025.

In Barpeta, Cachar and Dhubri, the situation oscillates between the two extremes- drought-like situation and floods- during the dry season and monsoons respectively, almost every year in the last five to eight years. Drought-like situations have been reported by the respondents in Peren, Tamenglong and Bongaigaon as well. Year 2025 floods submerged 14,739 ha crops amid prior dry spells as per NSDMA DDMPs report. Scarcity of water, virus (Covid19), lightning strikes, etc. are some of the other issues that have been reported by less than 13% of the respondents. In Dhemaji district, sporadic rain is one of the major issues faced by the respondents (92%).

About 74% of the respondents mentioned that they have experienced a change in the intensity and/or frequency of such natural disasters over the past 15 years and approx. 65% stated that these events have increased in frequency in the last 15 years, and about 13% of the respondents have been highly impacted by these extreme weather conditions and natural disasters. 46% of the respondents have been moderately impacted whereas the rest have faced a low or very low impact due to extreme weather events over the past 15 years. NIDM's 2025 Archival Flood Records showing increased events, for e.g., 598 Mizoram landslides.

Climate change and agriculture

1. Different systems of cultivation:

Name of district	Wetland agriculture	Jhum	Terrace/Bun	Mixed farming	Plantation	Homestead	Others
Barpeta	75%	0	2%	2%	2%	17%	20%
Bongaigaon	49%	11%	0	24%	53%	39%	7%
Cachar	35%	0	0	34%	22%	28%	0
Dhemaji	67%	0	0	83%	3%	2%	0
Dhubri	67%	0	0	16%	5%	32%	6%
Bishnupur	22%	2%	0	14%	40%	10%	1%
Tamenglong	3%	83%	8%	27%	31%	19%	0
Peren	25%	53%	2%	8%	7%	22%	0
West Tripura	27%	9%	1%	5%	14%	26%	2%
Total Overall	55%	26%	2%	33%	29%	31%	4%

Table 7: Impacts of natural disasters on the respondents (in percent)

It was observed that most of the respondents engaged in some form of agriculture or horticulture or a mix of both, simultaneously using multiple methods of cultivation for different types of crops. Among these, **wetland agriculture** (55%) is the most prominent method, especially in the plain or valley areas of the districts surveyed in these four states. The second most popular method of cultivation is **mixed farming** (33%), followed by **homestead farming** (31%) including kitchen gardens and small-scale livestock rearing, practiced for growing vegetables and other items for consumption and sustenance within the household.

29% of the respondents also have some kind of plantation crop, while 26% cultivate using the jhum cultivation method. Among the respondents engaged in agriculture, 54% practice multi-cropping, while 45% practice intercropping.

1. Different types of land used for cultivation:

Among all the respondents engaged in agriculture and/or horticulture of some form, about 37% of the respondents cultivate on lowlands, 43% on medium land, and 36% on upland fields. 12% of the respondents cultivate in homestead farms, and about 1% on terrace/sloped land. Those with upland fields have mentioned of more frequent drought-like situations in recent years that has affected their harvest quality and quantity.

2. Purpose of cultivation:

The respondents stated that they cultivate for consumption and often sell the surplus. But a vast number of the respondents in Barpeta, Bongaigaon and Dhubri district usually cultivate commercially for sale in the fields and grow a few things for household consumption of a smaller piece of land or in the homestead or kitchen garden.

3. Types of crops grown:

Name of District	Cereals	Vegetables	Pulses	Oilseeds	Horticulture
Barpeta	54%	62%	0	12%	0
Bongaigaon	52%	71%	0	12%	66%
Cachar	21%	83%	0	2%	1%
Dhemaji	90%	11%	1%	5%	2%
Dhubri	68%	50%	3%	27%	10%
Bishnupur	56%	32%	0	2%	0
Tamenglong	83%	75%	4%	1%	53%
Peren	25%	71%	0	12%	10%
West Tripura	37%	50%	1%	0	10%
Total Overall	75%	79%	1%	11%	25%

Table 8: Different types of crops grown by respondents (in per cent)

In terms of different crops cultivated, respondents in Dhemaji district cultivate the highest proportion of cereals (90%), followed by Tamenglong (83%), Dhubri (68%), Bishnupur (56%), Barpeta (54%) and Bongaigaon (52%). The respondents in Cachar proportionately cultivate more vegetables (83%), and Tamenglong (75%) and Peren (71%) follow closely. About 4% of the respondents in Tamenglong cultivate pulses and about 3% in Dhubri. 27% of the respondents in Dhubri cultivate oilseeds, followed by those in Barpeta, Bongaigaon and Peren (12% each). Horticulture is most widely practised in Bongaigaon (66%) and Tamenglong (53%), followed by Dhubri, Peren, West Tripura (10% each).

Overall, in all the districts studied, the respondents cultivate vegetables the most (79%), along with other crops. They also cultivate cereals (75%), engage in horticulture (25%) and grow some oilseeds (11%). But the amount of pulses cultivation by the respondents in these nine districts is negligible at around 1% each.

Among the respondents who grow cereals, 99% cultivate paddy. Along with paddy, 18% cultivate maize and a tiny proportion of the respondents grow millets and wheat (less than 1% each).

Among the **vegetables** cultivated within the study area, eggplant/brinjal (53%) is most widely grown. Pumpkin (44%), cucumber (42%), tomato and long beans (36% each), leafy greens (34%), potato (32%), beans (30%), ladies finger/okra (23%), cabbage (19%), bitter gourd and bottle gourd (16% each), radish and peas (15% each) and cauliflower (13%) are some of the other common crops.

Other than these, carrots, colocasia, sweet potato, ridge gourd, sponge gourd, beet, mushroom, bell peppers/capsicum, ivy gourd, broccoli, squash, pointed gourd, teasle gourd, knolkhol, and taro are some of the vegetables that are grown by the respondents (less than 10% each).

Although the percentage of respondents engaged in the cultivation of pulses is quite small, two of the common pulses cultivated in the districts of Cachar, Dhemaji, Dhubri, Tamenglong, and West Tripura include **pigeon peas**, and **black lentils/black gram. Kidney beans/Rajma**, locally known as *phoraash* in Cachar, is one of the major crops in the district although it is not cultivated as widely in the Tapang block of the district.

Mustard, cultivated by about 80% of the respondents who grow oilseeds, is the most common oilseed within these nine districts. **Sesame** (about 27%) is the second most widely cultivated while 3% each of the respondents grow **sunflower seeds** and **ground nuts**, and a handful of the respondents (about 1%) grow **rapeseed**.

Among the respondents engaged in **horticulture**, a mix of several crops are grown in the nine districts. Areca nut (15%) is the most widely cultivated horticulture crop, which is followed by ginger and turmeric (11% each), chilli (both green chilli and king chilli) grown by 10%, banana (9%), pineapple (8%), orange and papaya (6% each), mango and assam lemon (5% each), jackfruit, litchi and garlic (about 4% each), coconut, onion and guava (about 3% each).

Some of the other horticulture crops grown by these respondents include rubber (1%), and other crops like betel vine, coriander, sugarcane, black pepper, pomegranate, plum, strawberry, apple, peach, pear, custard apple, cardamom, avocado and bamboo, all of which are grown by less than 1% of the respondents.

4. Quality and quantity of harvest:

According to 46% of the respondents, the **quality of the harvest (freedom from pest and disease damage and uniform maturity)** in the current season has been good, but 27% of the respondents stated that the quality has been bad. The other 27% of the respondents didn't remember and said same as before, as they lack ownership records.

89% in Barpeta, 86% in Dhubri, 58% in Bongaigaon, 51% in Dhemaji, 41% in West Tripura, 37% in Cachar, 35% in Bishnupur, 21% in Tamenglong, and 8% of the respondents in Peren responded that the harvest has been good in this season.

On the contrary, 68% in Peren, 44% in Cachar, 33% in Bongaigaon, 24% in Bishnupur, about 22% in Dhemaji, 20% in Tamenglong, 18% in West Tripura and 5% each in Barpeta and Dhubri stated that the harvest has been bad this season.

When asked if the **quantity of harvest (production increased as compared to previous year on the same land)** has increased this season compared to the previous one, 32% of the respondents replied 'Yes', 36% replied with a 'No' and the remaining 32% of the respondents were not aware of or unsure about any change in the quantity of harvest.

5. Type of soil for agriculture

Name of District	Clay	Sandy	Loamy	Silt	Others[10]
Barpeta	0	72	28	0	0
Bongaigaon	17	12	68	1	2
Cachar	6	22	2	28	0
Dhemaji	2	45	48	5	0
Dhubri	9	13	64	13	1
Bishnupur	7	8	44	0	11
Peren	56	14	15	13	1
West Tripura	9	34	56	0	0
Total	16	27	47	8	2

Table 9: Type of soil used for cultivation (in per cent)

Different types of crops take precedence for cultivation in various kinds of soil. The study area has a diverse mix of soil types, and the majority of the farmers stated that they attempt to grow crops that are suitable to the soil type.

6. Irrigation methods used by respondents (in per cent): Tubewell irrigation dominates at 38.2% among 756 Northeast India respondents, reflecting groundwater reliance in flood-prone Assam amid erratic monsoons (IMD 2025: 80% LPA rain). Traditional canal/Dong (11.4%) and surface methods (10.3%) follow, suited to Brahmaputra basin rice paddies, while bamboo drip (innovative Ahom technique) is niche at 1.9%. Micro/subsurface (0.5-0.3%) and sprinklers (0.4%) remain marginal, limited by costs in rural CSO areas. "Others" (28.3%) likely includes rainwater harvesting or manual lifts, underscoring diverse smallholder adaptations. Combinations (e.g., tube-well + canal 3.2%) highlight hybrid practices boosting resilience in districts like Dhemaji/Barpeta.

Irrigation Methods	Percentage of Respondents
Bamboo Drip	1.9
Bamboo Drip, Canal/Dong	0.1
Bamboo Drip, Others	0.1
Canal/Dong	11.4
Canal/Dong, Others	0.6
Canal/Dong, Sprinkler	0.3
Sprinkler	0.4
Surface	10.6
Surface, Others	0.7
Surface, Sprinkler	0.1
Tubewell	38.2
Tubewell, Bamboo drip	0.3
Tubewell, Canal/Dong	3.2
Tubewell, Canal/Dong, Surface	0.3
Tubewell, Surface	1.6
Tubewell, Others	1.5
Others	28.7

Table 10: Combination of Irrigation methods used for Agriculture

Name of district	Different irrigation methods used (in percent)					
	Tubewell	Bamboo drip	Canal/Dong	Surface irrigation	Sprinkler	Others[11]
Barpeta	58	0	8	40	5	14
Bongaigaon	46	3	6	1	0	48
Cachar	54	13	2	0	0	1
Dhemaji	19	0	52	24	0	2
Dhubri	91	0	7	4	0	2
Bishnupur	15	0	22	9	3	45
Tamenglong	0	0	0	2	0	81
Peren	0	0	24	27	0	46
West Tripura	59	1	3	6	0	4

Table 11: Irrigation methods used in the different districts

Overall, 37% of the respondents use tube-wells or pumps to irrigate their fields, 21% depend on rain, 13% use dong/canal as a source of irrigation, about 11% use surface irrigation, about 2% use bamboo drip method, and the remaining 16% use other methods that include sprinklers, sub irrigation methods, and streams, ponds, rivers etc. 72% of respondents in Tamenglong, 46% in Peren, 38% in Bongaigaon, and 15% in Bishnupur are engaged in rain-fed agriculture. The irrigation method is used combinedly with two- three methods, to fulfill the need.

7. Mechanization:

Of the respondents engaged with agriculture and horticulture in some form or the other, 66% use machines like tractors, power tillers, threshers, irrigation pumps etc. to aid with cultivation and harvesting. However, 34% of the respondents engaged in agriculture work manually in the fields for various reasons that may include issues like the terrain/slope, the size of the plot, the quantity of cultivation, etc.

8. Seed Choices:

The respondents mentioned that they use different varieties of seeds for different crops. For instance, if they cultivate vegetables for sale, they prefer to use HYV or Hybrid varieties that give more yield with the same amount of input as traditional/local varieties. For paddy too, especially in Assam, farmers are increasingly moving towards hybrid and high yielding varieties are still cultivated largely for consumption within the household or selling some surplus amount.

In terms of paddy, more than 50% of the respondents in **Barpeta** mentioned using hybrid varieties like Lal Ganga, Syngenta's S-9001, INDAM 200-017, Mahyco, etc., while about 29% mentioned cultivating traditional varieties. Cucumber variety like Durga is widely grown, while both hybrid and traditional varieties of mustard are grown. The farmers in Barpeta also grow traditional garlic varieties, and potato varieties like Kufri Pukhraj, Bengal (Jyoti), Bhutia, are popular choices. Other vegetables of hybrid varieties are widely cultivated by these respondents.

In **Bongaigaon** district, Aijong, Bira Bhonga Bao and Boni are common traditional varieties, while Ranjit (cultivated by 23%), Ranjit sub-1 (grown by 8%), Ranjana, Jamuna, Bangalakhi, etc. are popular hybrid varieties of paddy. Phulpakhru and Gulabi variety of brinjal/eggplant are the most commonly grown by the respondents. Potatoes of both traditional/local varieties like Bengal (Jyoti), and hybrid ones like Kufri Jyoti, Kufri Pukhraj are grown. Hybrid tomatoes like those of Yodha variety are preferred for cultivation here. Traditional variety of pumpkins are grown, but other gourds cultivated are of hybrid variety. The Mahyco brand of chilli, a hybrid variety, is also commonly grown by the respondents.

In Cachar district 14% of the respondents grow hybrid vegetables like beans, tomatoes, cucumbers, long beans, brinjal, while about 17% grow traditional varieties.

Among the respondents in Dhemaji who cultivate paddy, traditional varieties like Bao, Bali Bao, Joha, Tiptipi, Bora, Maguri, Bira Bhonga Bao, Masuri, Kokua Bao, Kon Joha, Aghuni and hybrid varieties like Ranjit, Bahadur, Basanti are widely cultivated. Nirajan is a popular traditional variety of brinjal/eggplant, while local varieties of potato and mustard are major cultivations.

In Dhubri district, the respondents mentioned that they cultivate both hybrid and traditional/local varieties of paddy and vegetables. Among traditional paddy varieties (14%), Joha, Bora, Basmati, Eriare popular and hybrid varieties like Ranjit, Ranjit sub-1, Bahadur, Swarna sub-1, CR Dhan, Chamak, Jaymati, etc. are also cultivated. Maize from the KMH 4210 variety is a popular choice among the respondents.

While a traditional variety of mustard is grown by some, others cultivate hybrid mustard varieties like TS-38, M-27. Brinjal varieties like Pusa Purple Long, Pusa Gulabi, Mahyco, Shamli F1 are popular. Pusa snowball cauliflower; Pusa Mukta and Golden acre cabbage; Rishika and Arkka Vishal varieties of tomato; Rongpuria variety of potato (traditional), etc. are widely grown.

Ganga, Kaveri, Pusa and Yamuna are popular brands of seeds for several hybrid varieties of cereals and vegetables. The respondents also grow local/traditional varieties of gourds, okra, beans, Colocasia, cucumber, brinjal, radish,

In **Bishnupur**, Kufri Badshah and red potatoes are widely grown. Potatoes are both from HYV and traditional varieties, just like paddy varieties grown in this district. Some hybrid varieties of paddy and peas are also grown here. Sweet potato, mustard, cabbage, cauliflower, and other vegetables are mostly of traditional variety. Among indigenous paddy varieties, Dharamphou, Meitei cheng, Khongan, Moirangphou, Taothabi are widely grown.

The crops grown in **Tamenglong** district are majorly (81%) traditional varieties for both paddy (hill rice) and vegetables. However, areca nut and avocado varieties cultivated here are usually hybrid ones.

In **Peren**, the respondents (94%) usually grow traditional and heirloom varieties of paddy and vegetables. However, the rubber plantations are of hybrid variety here.

The cultivation done in **West Tripura** mostly includes local/traditional varieties of vegetables, with a few exceptions such as brinjal, cauliflower, cabbage, some chillies, which are hybrid varieties and some maize and chillies which are HYV grown here. The paddy varieties are usually traditional ones (46%), except those like Tripura Chikan Dhan, which is a HYV paddy.

9. Soil quality, Fertiliser and Pesticide Use:

An example of the challenges faced in agriculture owing to poor soil quality is that in the Tousem block of Tamenglong district. The soil is medium to high in nitrogen and potassium content, but has very low or trace amounts of phosphorus. This area also has highly acidic soil, which is why the phosphorus content is low. Acidity of soil reduces the availability of essential nutrients like phosphorus, calcium, magnesium, and molybdenum, while increasing the solubility of toxic elements like aluminium. It also results in stunted plant growth, reduced yields, and increased susceptibility to soil-borne diseases.

Among the respondents, 54% stated that the quality of the soil where they cultivate has deteriorated over the past ten years, while 16 % said that it has not. 21% of the respondents are not aware of any changes in the soil quality while 9% of the respondents stated that this question does not apply to them as they do not cultivate much for a livelihood.

The farmers use several varieties of chemical fertilizers as well as pesticides, usually as per their hunch regarding the need for such added chemicals. Over 51% of the respondents involved in agriculture and horticulture use chemical fertilizers in their crops, of which 10% use only chemical fertilizers. Approx. 68% use organic fertilizers in their crops, of which 27% strictly use only organic fertilizers. Among these respondents, 41% use both chemical and organic fertilizers as required.

Among the respondents engaged in agriculture and horticulture, 43% use chemical pesticides and 41% use organic pesticides. About 18% of them use only chemical pesticides, 16% use only organic pesticides and 25% use a mix of both organic and chemical pesticides. Approx. 48% mentioned that the need to add fertilizers and/or manure to their cultivable land has increased over the past ten years or so. Furthermore, 40% of the respondents stated that the quantity of manure/fertilizers to be added has increased over the last decade. About 33% of the respondents also mentioned that the frequency of adding manure/fertilizers has also increased in these ten years.

Among those respondents who practice jhum cultivation, 30% mentioned that the time of leaving the land fallow between cycles of cultivation has gradually increased, but 43% of the respondents mentioned that it is not so. About 3% of the respondents in Bongaigaon who practice jhum cultivation stated that they use a mix of organic and chemical fertilizers, 3% use only organic fertilizers but the rest of the jhum cultivators (94%) across the study area do not use any chemical fertilizers for cultivation.

The majority of the farmers who use chemical fertilizers, regardless of their cultivation method, mentioned that they have not received any training in this regard and do not follow any scientific method to determine the type of fertilizers or the quantity required for the different crops. They reported that usually the shopkeepers who sell them the fertilizers, tell them the measurements. A minor segment of these farmers also mentioned that they read the labels of the chemical fertilizer packaging to determine the quantities and method of administering the chemicals to the crops. But in general, the farmers expressed that they just learn through observation and practice.

Nitrogen, Phosphorus and Potassium (NPK) are the main chemicals added to the soil for cultivation. Other than these, Urea, Single Super Phosphate (SSP), Muriate of Potash (MoP) are the most commonly used. Among pesticides, Plantic is an organic insecticide used by some farmers in Tripura and Bavistin is a chemical fungicide used by several farmers across the study area. Moreover, some chemical herbicides and weedicides are also used, but it is not a very widespread practice overall.



Name of District	Chemical fertilisers	Chemical pesticides	Organic fertilisers	Organic pest control
Barpeta	Urea, Potash (DAP [12]), SSP[13], zinc and calcium	DDT [14], Endosulfan, Bifenthrin, Clothianidin, Profenofos, Cypermethrin, Imidacloprid (Talstar, Profex Super)	Cow dung, compost	Agniastra, neem oil, traps, crop rotation.
Bongaigaon	NPK[15] - Urea, Super Phosphate, DAP, Potash,	Rogor, Cypermethrin, Profenofos, Chlorpyrifos (Ustaad, Crolis, Lara 909, Yorker, Profex, Super Killer)	Cow dung, goat manure, vermicompost	Agniastra, neem oil, bamboo erections
Cachar	Urea, DAP, SSP, MOP[16]	Fipronil, Lambda-cyhalothrin, Imidacloprid, Emamectin benzoate	Cowdung, vermicompost	Wood ash, traps, neem oil, kerosene and lime dust
Dhemaji	NPK - Urea, DAP,	Fungicides - bavistin	Vermicompost, animal manure, compost,	wood ash, agniastra, neem oil, different kinds of traps.
Dhubri	Urea, SSP, Borax, DAP, Potash, MOP, Nano urea	Bavistin, BHC[17], Mancozeb, Malathion, Carbenazim, Endosulfan, Metalaxyl Thiamethoxam, Imidacloprid,	Cowdung, compost,	Sticky traps, neem oil and neem products, ash

Name of District	Chemical fertilisers	Chemical pesticides	Organic fertilisers	Organic pest control
Bishnupur	NPK - DAP, SSP, Urea, Ammonium Sulphate	Monocotophos, Mancozeb, Carbendazim, (Dhanuka M-45, Sixer)	Compost, animal manure, vermicompost	Traditional traps, lime powder, ash
Tamenglong	Various micronutrients (boron, zinc)	Bavistin	Woodash (for potassium), compost, Goat dung	Lime, wood ash, pheromone traps
Peren	NPK - Urea, ammonium sulfate,	Insecticides	PSB[18], Rhizobium, animal manure, vermicompost, humic acid, kitchen waste compost	Intercropping with pest repellent plants, wood ash,
West Tripura	NPK - Urea, SSP, MOP, Potash, calcium nitrate,	Bavistin, other fungicides, insecticides	Vermicompost, animal manure, Planting	Ash, agniastara

Table 12: Popular types/brands of fertilizers and pesticides used by the respondents.

In **Barpeta** brands like IPL (Indian Phosphate Limited), Mukta (by BVFCL), IFFCO (Indian Farmers Fertilisers Cooperative Limited), etc. are popular among the farmers who use chemical fertilisers. Among chemical pesticides and insecticides, Ustaad, Bayer Admire, Talstar, Profex Super, Sprint fungicide, etc. are the most commonly used ones.

In **Bongaigaon** popular brands of pesticides include Ustaad, Profex Super, Yorker, Lara 909, Super Killer, Crolis.

In **Cachar** popular brands of pesticides include Actara, Hattrick, Srigal. There's also an increasing use of herbicides that was noted by the key informants.

Dhemaji district shows very minimal use of chemicals for agriculture, especially chemical pesticides. Bavistin is one of the common fungicides used here, while some amount of DAP and urea are also used in some paddy fields.

In **Dhubri** pesticide brands like Indofil, Actara, Bayer Confidor, Rallis India (insecticides, herbicides, fungicides) are popular.

In **Bishnupur** district, popularly used brands of fungicide include Dhanuka M-45 and Dhanuka Sixer. The farmers use chemical herbicides, weedicides, insecticides and other pesticides along with chemical fertilisers, especially for the paddy crops. Herbicides are also used in different vegetable crops including potato.

In **Tamenglong** district, chemical fungicides like Bavistin are used for pest control in the orange farms, but otherwise there is minimal use of chemicals here. Some micronutrients are added to the farmlands as and when required, but such use is not extensive.

In **Peren**, NPK, urea and ammonium sulphate, as well as some insecticides are used. But the respondents stated that they prefer to use organic fertilisers and pest control methods.

The respondents in **West Tripura** have reported that Bavistin is a popular brand of chemical fungicide, while Plantic is a popular organic option for crops.

10. Effects of temperature, rainfall and other aspects of climate change on crops:

Rising temperature is an undeniable fact that can impact agricultural production. 44% of the respondents stated that they believe that a change in temperature (gradual increase) has adversely affected their crops.

Farmers have reported symptoms like **brown spots** on paddy stalks and leaves, empty husk with **no grain development**, yellowing leaves, etc., in paddy crops. **A shorter flowering period reduced seed production and reduced grain filling** are common problems faced by the respondents who grow paddy.

Among other issues reported by the respondents, **sunburn or sun scalding** (especially on pineapples), different kinds of **mildew infections, fruit rot, black, brown and white spots on leaves** of different crops, worms, and other insect infestations are common. Other prevalent issues include **drying up, wilting and shrivelling of plants, decreased quantity of harvest** (mustard, sesame, paddy, pumpkin, tomato, bottle gourd, areca nut, tea leaves, etc.), **premature yellowing** and **rapid softening of the fruit/crop**, or **stunted growth** of the produce due to dehydration.

All nine districts studied here reported that there are **seasonal fluctuations in water availability**, and increasingly, there is water scarcity for agricultural and domestic use. The lack of soil moisture leads to problems like yellowing, wilting and falling leaves in different crops, and impacts the quantity, quality, shape and size of fruiting as well.

Mulching has been identified as an important measure to prevent soil moisture reduction, especially in the hilly terrains of these four states where the drainage is already high due to the slopes and **increasingly irregular and untimely rainfall** makes the situation worse.

Apart from the increasing demand for irrigation facilities to counter the **longer dry spells, topsoil erosion in hilly areas, erosion near riverbanks, landslides, forest fires, and wildfires** are some of the issues that have become more intense in recent years, according to the respondents.

Hailstorms, thunderstorms, and excessive or untimely rainfall have also been identified as a reason for damaged crops, especially paddy and vegetables like pumpkin, ridge gourd, king chilly, sponge gourd, and betel leaf. In Assam, several respondents, especially in Barpeta, Bongaigaon, and Dhemaji reported that there was little to no rain during the sowing season of Ahu, and Boro/Eri paddy when water is required, but it rained very heavily when the grains were almost ready to harvest, thus damaging a lot of the harvest last season.

It was also found that too much **moisture** also causes **fungal, viral and bacterial infections** in the crops like **blights, canker, root rot, mildew, leaf spots, mottle, curled leaves** and **wilting** of the plants. This often happens when extremely heavy rainfall occurs that leaves the soil soggy for an extended period or when there is an extended period of rainfall that increases the overall atmospheric humidity as well. Such events have been occurring more frequently over the past decade or so, according to the respondents.

There are also additional infrastructural problems that the respondents face due to changing and unpredictable weather conditions like dry spells, heavy, unseasonal, or extended periods of rainfall. For instance, in **Peren**, since rainfall has been heavier in the last 2-3 years, the respondents have experienced bridges and roads being destroyed by flood last year. Landslides in some places have destroyed paddy fields. On the other hand, random wildfires in the jhum fields or jungle during the dry seasons tend to discourage the villagers from continuing with horticulture and other plantations. So, many respondents have opted for alternatives like backyard or homestead gardening for a livelihood.

They also reported an increase in insect infestation, which they suspect results from changes in rainfall, temperature and other climatic conditions. However, the respondents do not have any recorded evidence or data to prove it.

Studies confirm gradual warming (0.17 degree Celsius per year in Meghalaya) shortens paddy phenophases, causing empty husks, poor grain filling, and 5-10% rice yield losses. Projections indicates 4-40% declines in rice and maize by mid-century, with heat accelerating pest cycles and sunburn in fruits like pineapple. Delayed monsoons, 15-19% increased variability, and dry spells reduce harvests by 12-28% in paddy, mustard, and gourds, fostering wilting and stunted growth; heavy rains trigger floods, hail damage, and fungal blights (e.g., mildews, rots). About 65-99% of farmers perceive rising pests/diseases (12.5% yield loss) from humidity spikes, aligning with regional trends. Acidic hilly soils face amplified erosion, landslides, and wildfires from irregular rains, slashing rice output up to 70% in events like Nagaland droughts; mulching and irrigation demands match low-adaptation studies. (Manoj (2017), Lyngbaek (2022), Laishram (2022), Thakuria (2024)).

11. Crop diseases and/or insect infestations:

The respondents have reported increasing varieties of insect infestations over the years. However, 65% of the respondents stated that they have not noticed any significant or large-scale infestation of crops, which may be attributed to climate change or related issues. On the other hand, 35% of the respondents believe that climate change and different aspects of changing climatic conditions have increasingly given way to insect or pest infestations in crops.

Name of District	Pests/Insects	Other Diseases
Barpeta	Menda pook/gall midge, Armyworm, brown planthopper, rice grasshopper, rice leaf folder, mustard aphid, Mustard sawfly,	Fungal infections (blast, brown spot), bacterial leaf blight
Bongaigaon	White stem borer, yellow stem borer, rice leaf folder, brown planthopper, white backed plant hopper, armyworm	Fungal and bacterial infections - blights
Cachar	White flies, leaf folder, yellow stem borer, armyworm, brown plant hopper, green leaf hopper	Leaves dry and shrivel up, some fungal infections
Dhemaji	Armyworm, Grasshopper, Rhinoceros beetle, termites, crickets, cutworms, whiteflies, aphids, stink bugs.	Blast, Leaf spots, leaf blight, stem rot

Name of District	Pests/Insects	Other Diseases
Dhubri	Yellow stem borer, green leaf hopper, rice hispa, gall midge	Bacterial Leaf Blight, Yellow Mosaic Virus, white rust, wilted plants, dark/brown spots on leaves, downy mildew, stem rot, sun scald, root rot, White dried leaves,
Bishnupur	Green leafhopper, leaf miners, cutworms, planthoppers	Yellowing and drying up of leaves, grey spots on leaves, fungal diseases (black, necrotic, grey spots on leaves)
Tamenglong	Black ants, locust, rice stalk stink bug, mealybugs, fall armyworm, Bark borer	Fungal infections (white leaves, leaves fall off), bacterial – citrus canker
Peren	Aphids, caterpillars, ants, white flies, spider mites, fruit borer, birds	Fungal infections – Powdery mildew (white patches on leaves, branches and flowers), yellowing leaves, stem blight, root rot
West Tripura	Yellow stem borer, shoot borer, gundhi bug, fruit borer, leaf folder, rice hispa, brown plant hopper, green leaf hopper, thrips, fruit flies, aphids	Fungal infection (wilting, stem rot, leaf blight),

Table 13: Most common diseases or insect infestations

Painted bug in mustard crops, yellow stem borer, armyworm, in paddy crops, downy mildew (fungus-like), powdery mildew in several crops is some of the common pests/insects and microbial infections.

In **Bishnupur**, premature yellowing, dehydration, drying leaves in cabbage, tomato, cauliflower crops and in paddy, has been a difficulty faced by the farmers. They attribute these problems to a lack of soil moisture and the general increase in temperature.

In **Cachar** district too, reduced soil moisture has been a recurring issue. The lack of proper irrigation facilities coupled with untimely and increasing longer dry spells and drought-like conditions affect the crops inadvertently. In addition to several bacterial, fungal and viral diseases that lead to the yellowing of leaves and stalk, drying and dead leaves, etc. lack of certain micronutrients like Nitrogen, Phosphorous, Potassium and Iron have also been pointed out as causes for crop diseases and crop failure.

In **Peren** district, fruit farmers face the issue of sunburn on pineapples, and spots on bananas. Several crops also show the issue of curled leaves and stem rot, which may be caused by different factors including insects and microbes.

Sclerotium delphinii, a fungus, has been reported to cause collar rot disease in Sugandh mantri plants in Agartala, West Tripura.

12. Changes made to counter impacts of climate change:

About 14% of the respondents have stated that they have made certain changes to their methods to counter the losses caused by the impacts of climate change. Climate-induced stressors, such as heat-accelerated pests, dry spells causing wilting, and untimely floods damaging harvests, directly cause yield declines (e.g., paddy husks, reduced mustard output), compelling 31% to adopt HYV seeds for cultivation for heat tolerance and 30% of the farmers to alter irrigation for moisture deficits. These changes counter specific effects, HYVs resist disease amid humidity spikes but falter without supplemental water/fertilizers during extremes, as seen in Bongaigaon, Dhemaaji failures. Similarly, 23% have shifted to a different crop than what they used to cultivate about a decade ago to address dehydration stunted growth.

Diversification tactics yield mixed results, 15% have started multi-cropping, 12% has taken up intercropping buffer rainfall variability, 11% each have started crop rotation and on the other hand, and extended land fallow for a longer period to restore soil post-erosion, 7% of the farmers stated that they have changed the time or season of sowing their crops to evade hailstorms.

About 8% of the farmers have gone back to using traditional varieties of seeds, while 5% have shifted to hybrid varieties and only about 2% have shifted to heirloom varieties. , whereas, 5% have taken recourse to organic fertilisers. 2% each of the respondents have started using organic pesticides, chemical fertilisers and chemical pesticides. 3% of the respondents had to change their means of livelihood due to impacts of climate change, reflect irreversible infrastructure losses like Peren landslides. Overall, about 9% of the respondents believe that making such changes has been beneficial for them, 52% have not made any changes to their existing methods, 23% have seen some improvements and the remaining 16% did not comment on the matter.

A farmer in Barpeta mentioned that they have shifted to using chemical fertilisers over the last decade due to reduced harvest and more pest damage resulting from increasing heat and uncertain rainfall. They believe that traditional, organic methods of cultivation can't produce the required quantity and quality in the harvest anymore, and the crops need supplements like chemical fertilisers to grow well. Similarly, in the other districts studied, those who have shifted to HYV or hybrid seeds from traditional or heirloom ones stated that these varieties provide a more abundant harvest with almost the same amount of investment. However, in a few instances from Bongaigaon, Dhemaji, Barpeta, and Cachar, the farmers stated that although these varieties are more resistant to diseases, dry spells or heavy and untimely rains have affected production on several occasions. It is not enough to just change the variety of seeds, but it has to be accompanied by an improvement in irrigation methods and investments in fertilisers and pesticides.

The respondents who have shifted to using machinery like tractors and power tillers reasoned that these are less labour-intensive, save time and require less investment in the long run. They stated that using bullocks to plough the land, for instance, is not cost-effective anymore because having a pair of bullocks is increasingly becoming difficult. There is a lack of fodder, more possibilities of diseases, and animal rearing is more high-maintenance than investing in a machine or borrowing one during sowing season. Rearing bullocks has also become increasingly difficult due to the lack of grazing land and pastures, and during floods there is no place to keep such livestock, especially in the flood-prone plain areas like Barpeta, Dhemaji, Dhubri, etc.

Those who have shifted to traditional or heirloom varieties of seeds have raised concerns over the need for chemical inputs in HYV or hybrid varieties. They worry about the depleting soil quality and the effects of these chemical inputs on their health. Instead, they have opted for methods like intercropping and using organic fertilisers and pesticides. This has been observed especially in Tamenglong, West Tripura and Bongaigaon. There are also several farmers, especially in Barpeta and Dhubri, who stated that they use organic methods to grow food for their consumption but use chemical inputs in the fields where they grow crops for commercial purposes.

Climate change and animal husbandry:

1. Types of livestock/animals reared (in per cent)

Name of District	Cows	Buffalos	Goats	Sheep	Pigs	Chicken	Ducks	Fish	Others
Barpeta	81	5	68	23	3	88	55	23	0
Bongaigaon	77	1	61	1	19	79	51	2	1
Cachar	77	0	26	1	3	59	47	19	1
Dhemaji	78	0	11	0	38	60	33	10	0
Dhubri	52	0	54	0	8	41	5	0	0
Bishnupur	10	2	2	0	5	14	4	9	0
Tamenglong	9	2	23	2	47	69	0	7	0
Peren	1	0	5	0	38	71	6	1	2
West Tripura	1	0	1	0	2	1	0	0	-

Table 14: Types of livestock/animals reared (in per cent)

Overall, 44% of the respondents rear cows, less than 1% rear buffalos, 30% rear goats, 2% rear sheep, 24% rear pigs, 58% rear chicken, 21% rear ducks, 7% rear fish, and less than 1% rear other livestock like pigeons, dogs and rabbits for meat.

2. Purpose of rearing (in per cent)

The majority of the respondents (53%) rear animals/livestock for the dual purpose of household consumption and sale, wherein some cases, they sell any surplus but do not rear them with sale as the goal. About 22% of the respondents only rear them for consumption within the household and about 9% of the respondents rear livestock/animals solely for sale, which is a source of livelihood for them.

3. Community views on climate change on the animals/livestock:

Among the respondents, 28% have felt, observed or attributed different aspects of climate change for certain adverse effects on the livestock/animals that they rear. 20% believe there have been no such impacts while 39% are not sure or aware of any such impacts of climate change.

4. Community perception of the types of impacts of climate change on livestock:

In terms of the various perceived or observed impacts of climate change on livestock or animals reared, the respondents stated that there is a combination of more than one factor that affects the animals. 67% believe that increasing diseases or infections are the most obvious impact of climate change on livestock. 66% believe that it is related to increased mortality rates among domesticated animals and livestock. 40% stated that a lack of fodder and/or decreasing grazing lands and pastures as a result of climate change impacts livestock/animals, 11% responded that they have observed altered mating habits or seasons among animals and 6% have observed a change in water levels of fisheries which they attribute to climate change. These issues are believed to be impacts of climate change and the inability of animals to adapt to sudden changes in weather can make them sick and vulnerable.

The following data was gathered from each district regarding the impacts of climate change on livestock and animals reared.

Name of District	Diseases	Increased Mortality	Lack of fodder/grazing land	Altered mating seasons/habits	Changes in water level of fisheries	Others
Barpeta	92	15	0	0	8	0
Bongaigaon	72	53	38	11	1	1
Cachar	28	14	50	7	21	0
Dhemaji	62	95	61	20	5	0
Dhubri	93	70	50	13	0	0
Bishnupur	25	69	12	12	19	12
Tamenglong	67	33	8	0	17	0
Peren	42	100	33	0	0	0
West Tripura	-	-	-	-	-	-

Table 15: District-wise division of issues arising from climate change (in per cent)

Meta-analyses like Morgado et al. (2022) quantify heat stress-induced declines in welfare metrics, such as elevated respiration, reduced milk yields, and immune suppression, directly underpinning disease proliferation and mortality observations across bovines, ovines, and caprines. It also substantiate fodder deficits through precipitation variability and forage nutritional degradation, alongside reproductive dyssynchrony from thermal exceedances, which establishes a coherent hierarchy of direct (health/mortality) over indirect (feed/reproduction) stressors.

5. Diseases among livestock:

The following diseases have been commonly observed among livestock, poultry and fish reared by the respondents.

Name of District	Cows/buffaloes	Goats/sheep	Pigs	Chicken/ducks	Fish
Barpeta	LSD[19], bloated stomach, FMD[20], cold and fever	Fever, cold, diarrhoea, Bloated stomach, swollen throat	Fever,	White diarrhoea, fever, loss of appetite	Redness on back, swollen head, wormson belly, gas/bloating
Bongaigaon	Bloating, LSD, pox, FMD, ringworm, diarrhea, fever, swollen throat	PPR[21], FMD, diarrhoea, ringworm, fever, tympany/bloating, blindness, pneumonia, CAE[22]	Fever, Nipah virus, SMEDI,	Ranikhet, bird flu, DVE[23], fever, dry fowl pox, coccidiosis	-
Cachar	FMD, fever,	Skin diseases	-	Fever, white dysentery,	Changes in water levels and quality causes diseases and deaths
Dhemaji	FMD, fever, diarrhoea	Tympany, diarrhoea	African Swine Flu	Bird flu, Sudden Death Syndrome	-
Dhubri	FMD, LSD, PPR, Paralysis, brucellosis, Black leg, HS[24]	Goat pox, PPR, foot rot, mastitis, diarrhoea, Orf virus, blindness	Swine flu, fever	Ranikhet, Fowl pox, Infectious Bursal Disease, bird flu, cholera	-
Bishnupur	Heatstroke	-	African Swine Flu	Bird flu, fever, pneumonia, Colibacillosis	-
Tamenglong	Skin diseases	Scabies, diarrhoea	Swine flu, skin infection	Bird flu, Ranikhet, fowl cholera	Reduced water levels cause diseases
Peren	FMD, LSD	Skin infections, dysentery	Diarrhea, organ swelling, swine flu, skin diseases/scabies, tape worm,	Seasonal flu, white dysentery,	-
West Tripura	LSD, FMD, Bloating, diarrhoea, skin diseases	FMD, LSD, Pox, skin diseases, diarrhoea, mastitis,	Skin diseases, swine flu, fever, stroke	Bird Flu, eye infection,	-

Table 16: List of common diseases among different livestock across the districts

The respondents stated that mortality rates usually depend on diseases, mostly seasonal, or if there are any outbreaks in the area. But in Tamenglong, one of the reasons is the unavailability of proper medication for the livestock. Lack of proper veterinary care is an issue in most of the villages in the study area, with a few exceptions.

In West Tripura, bird flu was reported as one of the main causes of mortality among domesticated birds like chicken. The respondents have lost about five birds to the flu last season. However, the respondents have not taken any measures to counter this effect since seasonal death of a few birds is considered to be a normal thing that is not very concerning.

Several respondents also mentioned that pigs tend to die of heatstroke during the summer months.

6. Changes adopted to counter these problems

About 10% of the respondents have stated that they have taken measures to prevent, control or treat diseases in their livestock. 9% of these respondents have mentioned that they have shifted to a more disease-resistant breed, 22% opt for traditional medicine and healing techniques, 45% have chosen more frequent medical interventions (vaccines, medicines, etc.), 60% take help from veterinary and other informed sources, 18% have built more scientifically sound sheds, stys, coops, etc. and 8% each have shifted to adding supplements to the fodder/feed, and sourcing commercially available feed.

General impacts of climate change:

Natural resource management

1. Impact of climate change on water bodies:

68% of respondents believe that there has been some impact of climate change on natural water bodies. 14% do not think there are any effects of climate change, while 18% are either not aware or unwilling to comment on the topic.

Among those who believe that there have been changes, 69% stated that there has been a decrease in water levels in streams, rivers, rivulets, springs, etc. 25% believe that the water levels have increased instead, and 3% each believe that there has been no change or that they are not aware.

According to 65% of the respondents, water levels in wells and ponds have changed, while 13% believe that there have been no such changes. 22% are unaware of any such possible changes in water levels due to climate change. Of this 65%, 87% stated that there has been a decrease in the water level, while 11% believe that water levels have increased in ponds and wells.

36% respondents have made the observation that streams, rivers, rivulets and springs are gradually becoming lesser in number and several of these are gradually drying up. However, 35% do not think that these water bodies are drying up. 29% of the respondents are not aware of any such changes. In the case of wells and ponds, the changes in the groundwater levels have been drastic in some parts of the study area. 36% believe that these water bodies have dried up in their locality. 33% think that wells and ponds have not dried up. 31% are not aware of any such changes.

58% of the respondents also stated that they have observed a gradual deterioration of the quality of the water in natural streams, springs, rivers and rivulets. A lot of the natural water bodies have become choked with human waste and garbage and have been reduced to mere drains, while in other cases chemicals seeping into the water, or simply runoff water from nearby fields, industrial sites, and residential areas make the quality poorer. 16% do not believe that the water quality has deteriorated, while 26% are either unaware or not concerned about it.

In Peren district, for instance, groundwater quality is decreasing due to extensive use of fertilizer in farming and water bodies have been affected by the use of bleaching powder for fishing. Water levels have also decreased due to lesser rainfall and shorter duration of the rainy season.

In Cachar, especially where the urban sprawl has been unregulated so far, the natural reservoirs around the city of Silchar have dried up. The natural drainage systems have been lost to concrete structures and pollution of the existing waterbodies.

The respondents referred to a combination of several factors as a reason for such changes in the quality and quantity of water that is naturally available. The majority of the respondents believe that changes in rainfall patterns is one of the most prominent causes of the climate change.

Reasons	Percentage of respondents
Inadequate rainfall	71
Adequate rainfall	6
Increasing temperature	58
Decrease in temperature	7
Landslide/erosion	4
Construction (roads, buildings, etc.)	3
Rapid and unplanned urbanization	12
Overuse of groundwater	10
Deforestation	40
Mining and excavations	1
Increasing population	14
Others	0.6

Table 17: Perceived reasons for the scarcity of water

2. Water management techniques:

As part of the efforts to manage such impacts on water bodies, the quantity and quality of water in them, some action has been taken by the respondents, but only about 24% of the total respondents engage in some form of water management practices.

In **Tamenglong**, 69% of the respondents practice some form of water management technique. This includes the conservation of forests and reforestation drives on the upper side of water ponds in the hilly terrain, protecting forests through reservations, reforestation and preservation of water catchment area, harvesting rainwater for domestic as well as for agricultural use through the construction of community tanks as well as individual ones, other watershed management techniques, and practicing SALT farming method.

About 49% of the respondents in **Bishnupur** practice rainwater harvesting for daily use and avoid the wastage of water within the domestic space and the fields. They use some traditional methods of replenishing ponds through seasonal rains as well, and water conservation is given priority at the individual and community level.

38% of the respondents in **West Tripura** practice rainwater harvesting using different techniques. They also practice minimizing water wastage by reusing wastewater from the kitchen, for instance, to water their vegetable patches at home or other similar purposes.

In **Dhemaji**, about 21% of the respondents use various rainwater harvesting methods to replenish their water sources or manage water for daily use. They use tanks to collect the water for domestic use and minimize the wastage of potable water.

In **Bongaigaon**, 7% of the respondents have made jalkund or reservoirs in their fields and dug wells to store rainwater as well as to replenish the groundwater levels.

4% of the respondents in **Peren** district have dug wells to collect rainwater and constructed check dams to prevent run-off water during the monsoons. About 3% of the respondents in **Dhubri** use rainwater harvesting methods and reservoirs like ponds in their fields. The respondents in **Barpeta and Cachar** did not mention any water management techniques but are aware of the need for it.

3. Biodiversity and climate change:

As human wants and population increase yearly, flora and fauna have rapidly decreased. Since the soil quality is diminishing, agricultural produce has decreased too. Forest produce, aquatic animals and wildlife are becoming less common because of deforestation due to wood logging and the collection of more firewood, especially in the hilly regions with natural forest cover.

In **Peren** district, for instance, the common grazing lands, wetlands and ponds have dried up, and the landowners continue to convert such land into sizeable plots and sell them for human habitation instead. Peren used to be referred to as the rice-bowl of Nagaland due to the abundance of harvest in this region. But over the past decade or so, dry spells have become more frequent, and the soil has also lost fertility, leading to such measures from the people for a livelihood.

27% of the respondents reported some kind of **monoculture plantations** in their area, ranging from a micro scale to a macro level. The most widely grown plantation crop mentioned is rubber trees (16%), followed by teak and fruit trees (9% each), bamboo (5%), gamari (3%), tea (about 2%) and kadam, oil palm, titasopa, sal and others (all mentioned by less than 1% of the respondents).

In **Bongaigaon**, 30% have mentioned plantations around them, including teak, sal, titasopa, gamari, bamboo, rubber, tea, fruit trees or horticulture, and kadam trees. In Cachar, bamboo and fruit tree plantations have been mentioned by 3% of the respondents. There are 5% of respondents from **Dhemaji** who have stated that there are bamboo, teak, gamari, and fruit tree plantations in the district. About 31% in **Dhubri** mentioned bamboo, rubber, titasopa, gamari, kadam, sal, and fruit trees plantations and 62% in **Peren** have fruit trees, rubber, oil palm, bamboo, teak, gamari, titasopa plantations around them. In **Tamenglong** 24% of the respondents mentioned fruit trees, rubber, gamari, and teak plantations, while 79% respondents in **West Tripura** stated that there are teak, rubber, bamboo, fruit trees and tea plantations.

4. Types of increasingly rare biodiversity:

Through this study, it was discovered that several species of flora and fauna endemic to the region have either become rare to find or are almost extinct.

Name of District	Trees/Shrubs/Herbs	Wild animals/aquatic animals	Birds	Aquatic plants	Insects
Barpeta	teak	fox	Sparrow, vulture	-	firefly
Bongaigaon	Teak, Bermuda grass, manimuni (Centella asiatica), fruit trees – leteku, jamun, jackfruit, gamari, sal, silk-cotton tree, sandalwood, seesham, peepal, banyan, stinkvine, Arjun, Amla, silikha, Aparajita, roselle, Bermuda grass,	Indian gharial, fox, rabbit, monkey, tiger, pangolin, deer, mongoose, elephant, bears, crab, fish, turtle, frog, porpoise/river dolphin.	Spotted dove, vulture, hargila, crow, sparrow, kite, bulbul, mynah, parakeet, weaver bird,		Grasshopper, crickets, bees, wasps, spiders, fire ant, dragonfly,
Cachar	Teak,	-	-	-	-
Dhemaji	Gamari, sandalwood, teak, titasopa, bamboo,	Foxes, wild cats, jackal, hollock gibbon, elephants, monkeys, local fish, frogs,	Crows, sparrow, vultures, kingfisher, parrot and parakeets	Azolla, water lily, lotus,	Grasshopper, crickets, prayingmantis
Dhubri	Agarwood, Sal, Arjun (Terminalia arjuna), Bakul or Indian Medlar, Teak, Sisu (Indian rosewood), Hollong, Manimuni (Centella asiatica), Bermuda grass, xilikha (Terminalia chebula), gamari, mango, jackfruit, giloy, ashwagandha, bermuda grass, Ikora/elephant grass,	hog deer, golden langur, freshwater dolphins, fox, rabbit, squirrel, hoolock gibbon, water buffalo, wild boar, channa bleheri fish, borali fish, chitol fish, Magur fish, turtles.	hornbill, sparrows, hargila (Greater Adjutant Stork), vultures, eagles, oriental turtle dove, white winged wood duck(deuhah), owls, quails, bulbul, sunbird, tailor bird, pink-headed duck,	Lotus, water lily,	Honeybees, some varieties of butterflies, firefly

Bishnupur	Indian pennyworth, Ishing kambong,	Wild boar, fish – nunga, sareng, walking catfish, ngakha,	Migratory birds	Water mimosa	Moth, grasshopper, termites,
Tamenglong	Sugandhi mantri, Champa, Parkia, Gamari, yellow jasmine, neem, gooseberry, hill broom, marigold, bamboo, touch-me-not,	Bear, hoolock gibbon, capped langur, porcupine, deer, tiger, wild boar, squirrels, sangai, turtles, shrimp, crab, snail, tortoise, fish, jackals,	Hornbill, owl, wild chicken, peacocks, kingfisher, woodpecker, kite, crane, eagle, bulbul, mynah	-	Stinkbug/gandh ipoo k, grasshopper,
Peren	Parkia, hollock, Titasopa, gamari, Agarwood, Lali (Rhododendron Arboreum), Chinese knotweed,	deer, wild boar, rabbit, tortoise, bats, porcupine, squirrel, monkey, wild cats, pangolin, elephants, fox, tiger, different types of fish, crabs, snails, frogs, shrimp, snakes	skylark, sparrow, bulbul, parrot, owl, mynah, dove, green pigeon, hornbill, kingfisher, crane, weaver bird, woodpecker	-	leech, butterfly, bees, cicadas, wasps
West Tripura	Wild fruit trees like Khwrwi, jamun, Arjun/Garjan, teak, sal, Gamari, Taal palm, agarwood, bel (Aegle marmelos), amla, Centella asiatica, haritaki (Terminalia chebula), Hedychium coronarium(KHUMP UI), bermuda grass, Jasminum listeri, henna plants	Deer, wild boar, wild cats, porcupine, elephants, leopards, sloth, Himalayan black bear, fox, tokay gecko, tortoise, jackal, snake	Vultures, house sparrows, wild chicken, parrot, owl, crow, mynah, weaver bird, kingfisher, green imperial pigeon, eagle, dove, nightingale, woodpecker, great egret, crows, sunbirds	-	Butterflies, fireflies, crickets, dragonflies, grasshoppers, stinkbug, ladybug, locusts, stick insect

Table 18: List of species that are increasingly becoming rare

5. Gradually increasing or invasive biodiversity:

In Barpeta, mosquitoes, ants and stinky bugs have increased over the years. Rodents like squirrels have proliferated in Bongaigaon, and animals like stray dogs and monkeys often result in human-animal conflicts here. Houseflies and mosquitoes are also increasingly becoming problematic for health concerns. In Dhubri, invasive plants like parthenium weed, Lantana camara, water hyacinth are found, while insects like brown planthopper, rice stem borer, gall midge, rice hispa, flies, mosquitoes, black and red ants have become widespread. Crows, common mynah, and pigeons also seem to be thriving here. Rodents like rats and mice, animals like monkeys and the stray dog population have increased over the years.

In Bishnupur, green leaf hopper, brown plant hopper, mosquitoes, rice hispa, are found to be increasing lately, and they harm crops and human beings. In Tamenglong, ferns, parrots, frogs, rats, houseflies, mosquitoes, ants, stink bugs, termites, and leeches are some of the flora and fauna that have proliferated.

In Peren, red ants, termites, mosquitoes, flies, locusts and grasshoppers cause problems in crops. Areca nut and rubber plantations are also contributing to the clearing of indigenous flora and replacing it with a single variety that is becoming more widespread.

In West Tripura, Lantana camara is an invasive species. Monkeys and squirrels, flies, brown plant hopper, and mosquitoes are increasing in numbers. Moreover, rubber plantations are making rubber trees replace local flora like an invasive species.

6. Impacts on the natural environment:

Several respondents have noted that changes in weather patterns and temperature have altered certain aspects in the natural environment. One of the noticeable impacts is the early or late flowering or fruiting in different plants. About 23% of the respondents stated that they have observed that the flowering and fruiting season has advanced gradually over the years. In their opinion, plants like mango, jackfruit, guava, plum, peach, areca nut, litchi, coconut, papaya, pear, banana, pineapple, mulberry, parkia have started to flower and fruit earlier than the expected season. Mustard also flowers earlier than expected and marigold, jasmine, and different wild flowers are also flowering before time.

Additionally, oranges, lemons, pomelos, gooseberry, jujube and Sali paddy have been reported to flower and fruit later than usual. Some of the respondents also noted that parkia or tree beans have also become **late-blooming and late-fruiting**. 22% of the respondents have stated that they have observed late flowering and fruiting in some plants gradually. These respondents also mentioned that local mango varieties flower later than usual.

Of all the respondents, 47% stated that they have noticed some **change in the size of flowers and fruits** in some plants. They mentioned that the size gradually becomes smaller as the plant ages, but this has become more prevalent even in relatively newer plants. Stunted growth in plants has also been attributed to a lack of water, nutrients or an excess of heat, and microbial or insect infestation.

21% of the respondents stated that they have noticed **changes in the wetlands** around them, 34% mentioned that there have been no changes, 43% mentioned that they are not aware of any changes while 2% stated that this question does not apply to them because they do not have any wetlands in their area.

The changes include the following:

- Fewer numbers or a lesser area covered
- Deterioration of soil and water quality
- Drying up
- More fluctuations in water level
- Unseasonal flooding
- Changes in river stream result in less water in wetlands
- Concrete structures constructed over them
- Polluted waterbodies

22% of the respondents believe that **grazing lands and pastures** are gradually vanishing. 35% don't think that there are any changes, 37% don't have any knowledge about it, and 6% did not comment on it.

Perceived changes in grazing lands include reasons like increased urbanization, agricultural expansion, dry spells, decreasing grass and overgrazing, encroachment, privatization of land, government policies for reservation and conservation of such land, afforestation drives, plantation crops like rubber plantations, infrastructure development like roads, etc.

47% of the respondents have noted **changes in woodlands**, 26% state that there are no changes, 25% are not aware of any changes and 2% chose not to comment on it. Major reasons perceived by the respondents include deforestation for various purposes like illegal logging, for firewood, developing infrastructure like roads, railway tracks, etc, urbanization, jhum cultivation, rubber, palm oil or other monocrop plantations. Encroachment and construction of houses by clearing away wooded areas is also another reason.

Conclusion and Recommendations

This section draws recommendations based on the problem and issues found during the study. About 27% of the cultivation done by the respondents is in lowlands, while 31% is on medium land. This is crucial for agriculture in the region, which is largely rainfed and lacks much in terms of alternative irrigation methods. It is also worth noting that a good percentage of the farmers cultivate sali/winter paddy, which is water intensive. But the increasingly unpredictable rainfall patterns have been a setback for these farmers. Over the last two decades, farmers have gradually started using irrigation methods like shallow tubewells with pumps to access groundwater. This is especially true in the plains where large-scale commercial farming is done. The introduction of several initiatives like Prime Minister Krishi Sinchan Yojana (PMKSY) is meant to aid farmers to be self-reliant for irrigation, but most of the respondents are either unaware of the scheme or stated that it is more expensive and a bigger hassle for them to get the mechanism in place than to borrow a water pump seasonally.

In Bongaigaon district, rainfall is the main source of irrigation. In the last year, 2024, there had been less rainfall when the Sali paddy crop required water, and it affected the harvest. There was less produce that season. But unpredictable rainfall happens sometimes, and it negatively impacts the crops. Early showers lead to a lack of water at the later stages of cultivation, late showers destroy the grains just before harvest, and so on. Many respondents feel that such unpredictability is natural and can't be humanly addressed, but they believe that adapting to such changes is important.

In Cachar and West Tripura, several respondents have mentioned that due to a scarcity of water, many people have given up on agricultural activities and now they engage in daily wage labour for a livelihood or migrate out of their villages for work in other sectors. In the Barak Valley, the gradual rise in the temperature of water bodies also impacts aquatic life and the fish population, making it a challenge for the fish farmers. Farmers are also opting to move towards an integrated farming method by introducing ducks to their farmlands and fisheries, which ensures some kind of a fallback plan for them.

In Dhemaji, the last Kharif season (Sali paddy) recorded an average rainfall of 2600 mm, whereas usually it rains well over 3000 mm. In recent years, the rainfall has also not been well distributed and has been irregular. Moreover, due to the sandy-loamy soil type, there can be drought-like situations in the rabi crop even after a season of heavy rain. In Barpeta too, in the char areas where a lot of cultivation is done, less rainfall affects the crops negatively due to the soil type and the water run-off.

The need here is to invest in and adopt strategies and mechanisms to **prevent the runoff water** from flowing away and store it for use during drier seasons. Furthermore, the excessive rain and flooding during monsoons causes submergence, which requires the cultivation of **submergence-resistant varieties** of paddy like Ranjit Sub-1 and Bahadur Sub-1 that have been introduced in the district by the Krishi Vigyan Kendra (KVK), Dhemaji. **Traditional bao dhan** is also favourable in such submergence situations.

The ‘Atmanirbhar Dhemaji’ scheme has been undertaken to **preserve local, traditional and heirloom seed varieties**, and attempt to use less of the harmful chemicals in farming. But the many tea gardens in the area continue to use chemical fertilisers and pesticides, which contaminate the soil and water sources around. Existing varieties of **millets** have also been reintroduced, but there are no **processing facilities** readily available in the area which discourages the farmers from cultivating millets. This is being considered under the Atmanirbhar Dhemaji scheme.

Jalukie valley in the Peren district was previously regarded as the ‘rice bowl’ of Nagaland. However, in recent years, untimely, sporadic rainfall coupled with increasing temperatures has impacted paddy harvests in the district.

It is essential to reintroduce indigenous methods along with newer scientific interventions to adapt better to the impacts of changing climate. Rainwater harvesting through construction of jal kund or water reservoirs/ponds in the fields is a scientifically improved take on traditional water bodies near fields.

Soils are exposed to threats, such as moisture deficits and wind erosion, organic matter decline, loss of nutrients, compaction, salinization and contamination. To address these issues, adoption of practices and systems with a high **available water capacity** (AWC) and **water-use efficiency** (WUE); maintenance of soil fertility and productivity; protection against new pests and pathogens; promotion of C sequestration. This requires planned investments that benefit green water storage (precipitation that is stored in the soil and potentially available to plants).

SeSTA has adopted a set of interconnected, actionable climate adaptation practices that weave together agroecology, agroforestry, integrated farming and locally led planning towards resilient livelihood strategy. At the core is the promotion of **agroecological inputs** for soil fertility and pest management, such as vermicompost, bio-fertilisers, biofungicides and Jivamrit, which are used especially in mustard, chilli and vegetable cultivation to reduce dependence on chemical inputs and improve soil health. Alongside this, SeSTA supports agro-horticulture and agroforestry models in which trees and shrubs, such as areca nut, mango, orange,

jackfruit, turmeric, amla and other food and medicinal plants, are integrated. with crops so that they provide fodder, fruits, timber and non-timber forest products, while woody plants on field boundaries function as windbreaks, enhance carbon sequestration and indirectly support biological nitrogen fixation by sustaining soil microorganisms.

These ecological practices are rooted in **integrated farming systems** that combine crop rotation and intercropping with livestock and fisheries, enabling farmers to manage pests and diseases more naturally while using livestock waste for farmyard manure and vermicomposting as a key climate adaptation measure that builds soil organic matter and moisture-holding capacity. To make these transitions viable, promoting **Bio Resource Centres** that produce, package, brand and market bio-inputs and seeds, and encourages community seed banks so that climate-resilient varieties and diversified production systems are locally available. Region-specific **agroforestry models** that integrate fruit trees, medicinal plants, timber plants on homestead or other available land, works on carbon sequestration along with providing an income source to the community. **Integrating on-farm and off-farm activities**, like vegetable cultivation, fishery and livestock rearing, with manure from livestock feeding back into crop production. The methods adopted were also thought in terms of providing sustainable income to the community.

The Climate adaptation plans should be grounded in systematic assessment of climate-related events and trends over the past decade and translate into concrete livelihood strategies, including off-farm options such as pickle making, jute and water hyacinth-based enterprises and intensified use of homestead plots, as well as promoting short-duration crops in wildlife-affected and flood-drought prone areas to reduce loss. These plans can be supported by **digital weather and pest advisories** delivered through community institutions, with simultaneous guidance on control measures, and by ensuring that all training includes climate-specific discussion so that farmers can continually refine their responses.

Technical measures such as **soil testing and customized nutrient management, water harvesting, revival of traditional water bodies like beels, diversion-based irrigation in flood-prone catchments, strengthening community forest management and local waste management** further reinforce the ecological base of livelihoods. Across all of this, there should be dialogue with communities in collaborations with stakeholders to co-create a synergistic climate action agenda, rather than treating each practice as an isolated intervention. Soil testing and customized nutrient management help farmers understand the specific needs and deficiencies of their fields, so that fertilizers, manures and soil amendments can be applied in the right quantity and at the right time,

reducing costs, preventing overuse of chemicals and improving long-term soil health and resilience.

Water harvesting structures and the revival of traditional water bodies such as beels increase the landscape's capacity to store "green water" in the soil and ponds, which sustains crops through dry spells and supports fisheries and livestock, while diversion-based irrigation systems in flood-prone catchments make productive use of excess flows and reduce dependence on increasingly unreliable rainfall.

At the same time, strengthening community forest management helps protect catchments, reduce erosion and regulate local microclimates, while local waste management, such as composting organic waste and safely handling household and farm residues; reduces pollution and returns nutrients to the soil. For these measures to have lasting impact, they need to be designed and implemented through continuous dialogue with communities and active collaboration among farmers, local organisations, and government departments, so that climate risks, local knowledge and livelihood priorities are all reflected in a shared climate action agenda. Such a co-created approach helps align technical interventions, public schemes and community initiatives, avoids contradictory efforts, and ensures that each practice reinforces the others rather than being treated as an isolated project.

Some of the existing **indigenous methods of farming** in the northeastern states have been highlighted in a study by Das, Idapuganti, Choudhury, & Patel (2012) where they explain how these indigenous farming

systems have been handy during difficult weather conditions but also help in making agriculture more sustainable in the long term.

1. Panikheti system of rice cultivation: Practiced in Nagaland and Sikkim, it involves cultivating rice on bench terraces with good soil and water conservation practices.
2. Apatani method of water management (Rice and fish systems): Practiced by the Apatani tribe in Arunachal Pradesh, it integrates rice cultivation with fish culture in terraced fields.
3. Zabo farming system: Practiced in Nagaland, it combines forest, agriculture, and animal husbandry with water harvesting and soil conservation.
4. Alder-based farming system: Practiced in Nagaland, it utilizes the nitrogen-fixing ability of alder trees to maintain soil fertility.

5. Alder and large cardamom farming system: Practiced in Sikkim, it integrates large cardamom cultivation with alder trees.
6. Bun method of cultivation: Practiced in Meghalaya, it involves growing crops on raised beds using locally available biomass.
7. Bamboo drip irrigation: Practiced in Meghalaya, it uses bamboo channels to irrigate crops on hill slopes.
8. Rotating cattle shed in vegetable fields: Practiced in Sikkim, it involves rotating temporary cattle sheds in vegetable fields to utilize the manure and urine.
9. Pond-based integrated farming systems: Practiced in the plains of Tripura, Assam, and Manipur, it integrates fish, livestock, and crop production around a farm pond.

These indigenous farming systems demonstrate the wisdom of local communities in conserving natural resources and maintaining sustainable agricultural practices. These techniques can be made more robust, if required, and implemented on a wider scale to ensure knowledge and skills regarding ecologically friendly, sustainable systems of farming and livelihood.

Furthermore, local/traditional seed varieties are more adaptable to the local climatic conditions, but they may not always produce a very high yield. Since seeds are an important part of ensuring increased productivity and profits for farmers, in the past two decades or so, farmers, especially those who farm commercially on a larger scale, have shifted to more HYV and hybrid varieties. However, seed production and preservation need to be further developed in the northeastern states, especially in Assam. Organisations like NESFAS and Pabhoi Greens are making efforts to preserve traditional and heirloom varieties and popularise them in cultivation again. These traditional seed preservation methods, mixed with more scientifically enhanced techniques can be a way to ensure a sustainable agrobiodiversity in the northeastern region of India.

Another sustainable method that can be adopted is the **Sloping Agricultural Land Technology** (SALT) of cultivating in the hilly areas of the region. It has already been tested in Tamenglong district of Manipur through individual and community efforts and appears promising in preventing runoff water from washing away the topsoil in hilly and sloped terrain. The planting of hedgerows and mulching the soil with locally available sources makes the soil more productive by trapping moisture for longer periods and providing essential nutrients. Communities in Meghalaya are also adopting this practice gradually.



In addition to SALT, **half-moon terrace farming** has also been suggested as an alternative, but its efficiency is yet to be documented. On the other hand, **raised and sunken beds** for different crops is a technique that is being tested by the KVK, Barpeta, to make agriculture more flood resistant.

Furthermore, **integrated pest management (IPM)** techniques can assist in killing diseases and improving the health of the plants. There has to be more participatory tech development, focusing on the local issues and finding solutions that are contextual. This may involve some use of chemicals or medicines for pest control, but it has to be monitored and regulated.

Making **context-based informed choices** is also important while opting for fertilisers and pesticides. The agricultural soil in Cachar district, for instance, is quite nitrogen-deficient in general. For any kind of pH-related issue or nutrient deficiency in the soil, it is important to have a clear understanding of the requirements of the soil first, through testing samples of the soil. This process has become much easier and more affordable in recent years, and it would be beneficial for farmers to know what their soil needs before adding any kind of chemicals to it.

In terms of animal husbandry or livestock rearing, there have not been very alarming problems, except mortality during floods. But rearing bullocks for ploughing fields has been reported as a very labour-intensive, tedious and increasingly expensive part of agriculture. Fodder has become scarce, and the upkeep of bullocks far outweighs that of machines like power tillers or tractors, which many farmers just borrow from others during sowing season.

However, the seasonal flu outbreaks do hamper rearing chicken on a larger scale, which is why most of the respondents either rear them in smaller numbers or do not rear them at all. Many have started constructing more scientifically sound coops for the chicken and ducks, others build well-designed sheds or sty for their bovine animals, goats and pigs and have stated that these newer sheds help in preventing many diseases.

Summary of the Recommendations:

Irrigation and Water Management: Rainfall unpredictability severely impacts sali paddy in rainfed lowlands and medium lands. It is recommended to prioritize rainwater harvesting via jal kunds, beel revival, and diversion irrigation in flood-prone areas to store green water and enhance water-use efficiency. Scale PMKSY through subsidized community pumps, addressing respondent concerns on cost and access, while promoting tubewells in commercial plains.

Crop Adaptation and Varieties: Erratic rains, floods, and soil runoff in char areas (Barpeta), submergence zones (Dhemaji), and rice bowls (Jalukie, Peren) demand climate-resilient crops like Ranjit Sub- 1, Bahadur Sub-1, bao dhan, and reintroduced millets under Atmanirbhar Dhemaji. Shifts from water-intensive HYVs to traditional/heirloom seeds via community banks (NESFAS, Pabhoi models) balances yield with adaptability. A critical highlight is to establish millet processing units to boost uptake, integrate short-duration crops in flood-wildlife zones.

Soil Health and Erosion Control: Sandy-looms soils (dhemaji), char runoff (Barpeta), and hill slopes (Peren, Nagalnad) face moisture deficits, nutrient loss, and contamination from tea garden chemicals. Adopt SALT, hedgerows, mulching, raised/sunken beds (KVK Barpeta), and half-moon terraces to boost available water capacity and organic matter. It is recommended to do the technical measure, like mandate soil testing for customized nutrient plans, prioritizing nitrogen-deficient Cachar soils to curb chemical overuse.

Integrated Farming Systems: Water scarcity drives livelihood shifts to wage labour/migration in Cachar-West Tripura, counter via duck-fish-crop integration, pond-based systems (Tripura-Assam), and agroforestry with areca nut, mango, jackfruit, and turmeric for fodder, NTFP, and carbon sequestration. Vermicompost, Jivamrit, bio-inputs, and Bio Resource Centres reduce chemical reliance while linking livestock waste to soil fertility. Promote indigenous systems, Panikheti, Apatani rice-fish, Zabo, alder-based, bamboo drip for sustainability.

Livestock and Pest Management: Climate exacerbated fodder scarcity, flood mortality, and flu outbreaks limit bullock, chicken rearing, transition to power tillers and scientific sheds/coops mitigate labour costs and diseases. Implement integrated pest management (IPM) with regulated chemicals, alongside digital advisories for weather-pests. It is recommended for region-specific agroforestry for fodder, participatory tech for contextual IPM.

Policy and Institutional Actions: Schemes like PMKSY and Atmanirbhar face awareness/cost barriers, bridge via community institutions delivering advisories, training, and co-created plans. Strengthen KVKs, community forests, and waste composting for microclimate regulation. Develop stakeholder dialogues to align interventions, avoiding silos, for e.g., linking seed preservation, off-farm enterprises, and homestead intensification for resilient livelihoods. Long term invest in seed systems and processing to sustain agrobiodiversity.

Challenges faced during the research

While collecting the data through surveys, there were certain human errors like incorrect or incomplete entries, which had to be verified thoroughly before the data could be used for analysis. This process of cleaning the data took a lot of time and effort.

However, the entire study had been a learning process, and a lot of previously lesser-known facts have emerged through this research, which we hope would help devise further plans and strategies to counter the negative impacts of climate change and allow for more sustainable livelihoods.



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[1] The use of chemical fertilisers and pesticides is quite common currently, especially in the Brahmaputra valley and the Barak River plains, leading to concerns over health issues among humans and animals alike. The increasing use of these chemicals also raises environmental concerns.

[2] The study titled Impacts of Climate Change on Rural Communities in Assam and Manipur: Social, Economic and Environmental Aspects was conducted in 2024 by SeSTA with assistance from Axis Bank Foundation.

[3] Representative Concentration Pathways (RCP) refers to climate change scenarios that project future greenhouse gas concentrations (not emissions), to understand potential climate change impacts and inform policy decisions. The numerical values

(2.6, 4.5, 6.0, and 8.5) in RCPs represent the radiative forcing (additional energy retained by the Earth system) in 2100.

[4] Others include Bathouism in Bongaigaon district, and Meitei in Bishnupur district.

[5] Other sources of power/lighting mentioned by the respondents include candles, firewood, bamboo, etc.

[6] Tap water' refers to water supplied by the Jal Jeevan Mission (JJM) of the Government of India.

[7] Others includes lakes, private water suppliers (water tankers), packaged drinking water, etc. in Bishnupur; harvested rainwater and ponds in Tamenglong; and government water tankers in West Tripura.

[8] Among primary sources of livelihood, the 'Others' option included having rubber plantations, being a weaver, teacher, contractual worker in companies, mason, contractor, driver, carpenter, electrician, cooking at religious events, and driving an e-rickshaw.

[9] Among secondary sources of livelihood, the 'Others' option included carpenter tuition teacher, Anganwadi worker, auto driver, tea garden labour, working under MGNREGA, and being a religious worker.

[10] Other soil types include clayey loam, sandy clay and sandy loam.

[11] Other methods of irrigation here include sub-irrigation, pumping/diverting water from rivers, streams, ponds, etc. using pipelines, or depending on rain.

[12] DAP: Di-ammonium Phosphate

[13] SSP: Single Super Phosphate

[14] DDT: Dichlorodiphenyltrichloroethane

[15] NPK: Nitrogen, Phosphorous, Potassium

[16] MOP: Muriate of Potash

[17] BHC: Benzene Hexachloride

[18] Phosphate Solubilizing Bacteria

[19] LSD: Lumpy Skin Disease

[20] FMD: Foot and Mouth Disease



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