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Farmers' Perception and Adaptation Strategies Towards Climate Change: A Village Level Study in India

Dharma Teja Ratakonda, Ajit Kumar Dash† and Amritkant Mishra
Department of Economics, Birla School of Social Sciences and Humanities, Birla Global University, Bhubaneswar, India
†Corresponding author: Ajit Kumar Dash; ajitkumardash2008@gmail.com

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ABSTRACT

The present study attempted to observe the perception and adaptation strategies of farmers in the context of climate change. It observes that the majority of the farmers are aware of climate change and understand that they are facing problems due to it. The major problems faced by the farmers are the long duration of dryness due to lack of rainfall, weed pressure, very high temperatures, and crop disease. However, farmers are not very aware of technological adaptation and have changed the cropping time due to changes in the time of monsoon. The study recommends that there is a need for intensive micro and macro policy initiatives in terms of modern green sustainable technology along with awareness and skill development of the farmers. The government should also focus more on policy initiatives for sustainable agricultural practices in line with sustainable development goals.

INTRODUCTION

Around 70% of people in India depend on agriculture. It is the primary sector and is widely known as the largest producer of spices, pulses, rice, and wheat at the world level. The rural economy basically dwells on agriculture bears importance as it provides employment and livelihood to a majority of the population. However, the contribution of the agriculture sector to GDP is only 15%. Today, the greatest threat to agriculture is climate change. The global community is concerned about climate change. Climate change refers to changes in climatic characteristics like temperature and rainfall. Human activities are responsible for environmental degradation, causing pollution resulting in the greenhouse effect and ozone depletion. Agriculture is directly exposed to climate change and suffers from high temperatures, low rainfall, carbon dioxide concentration, etc. Indian agriculture is said to be a gamble of monsoon. Further, climate change is an uncertain factor that affects the cycle of monsoon which changes the water cycle as climate change alters rainfall timing due to changes in holding moisture and evaporation.

Due to high temperatures, water bodies like lakes, rivers, ponds, streams, and other water bodies dry. So, due to climate change, crops take longer time to grow, the product becomes of low quality due to weed pressure, and frequent extreme heat, and ultimately the farmer faces a high level of risk of loss. According to Germanwatch 2020, India is the fifth most vulnerable country to climate change (Eckstein 2021). The rank India was 14th spot in the year 2017 which worsened to 5th in the year 2018. The vulnerability is because of severe rainfall, heavy flooding, and landslides. The Indian states like Kerala, Odisha, Assam, and Bihar suffer from natural calamities like cyclones, floods, and drought. Floods in Kerala in the year November 2018 were realized to be the worst, which killed around 1000 people. According to the Indian Council of Agricultural Research, an increase in temperature by 3-7% cause's decrease in the yields of crops by10-20 % (Agrawal 2009). Likewise, an increase in the incidence of drought and flood increases the possibility of pest attacks and diseases. Similarly, when the sea level rises by one meter, it could submerge 0.18 % of land in Maharashtra, which is a risk for 1.3 million people. It has been observed that production will reduce by 4–5 million tons due rise in temperature by only 1 centigrade.

Therefore, climate change is a major concern for the global community as a whole. The direct sufferers are the farmers in the context of the impact of climate change on life and agricultural income. The fact of the situation is that agriculture is considered to be a long traditional occupation and people have been doing this for a long time. So, it is essential to understand and examine the perception and adaptation strategies towards climate change for effective policy formulation. This study is in this line. The rationale behind this study is to understand the behavior of the farmers

at the grass root level which can be helpful for micro and macroeconomic agricultural policy formulation. The objective of the study is to examine:

- Perception of farmers toward climate change
- Problems faced by farmers due to climate change
- The adaption risk management strategies of farmers towards climate change

PAST STUDIES

Agriculture plays the most important role in any economy. Agriculture not only supplies food but also provides employment. In recent days, food inflation has been a regular phenomenon and has become a major concern in most emerging economies like India (Mishra et al. 2023, Sargani et al. 2023, Mishra & Agrawal 2021). When agricultural productivity determines the food supply the productivity of the agriculture sector depends on good climatic conditions along with other necessary infrastructure. Over time there is a change in the climatic conditions. Agricultural workers, in general, and farmers, in particular, are the contiguous witnesses of the changing behavior of climate. Climate change creates disruptions in their life, the main cause of the struggle for their livelihood. Thus, climate change has received wide attention from academics, policymakers, researchers, and people in general. There is stock of existing literature on climate change and its impact on agriculture. In this section, a few notable recent studies relevant to the present study are reviewed below.

Fosu-Mennash et al. (2012) conducted a study on "Farmers' perception and adaptation to climate change: A case study of Sekyedumase district in Ghana." The study found that climate change has a great impact on rural farmers as their livelihood depends on agriculture. The level of impact largely depends on awareness and the level of adaptation in response to climate change. 92% of farmers feel an increase in temperature, and 87% of farmers perceive a decrease in rainfall. Diversification, planting of short-season varieties, change in crop species, and shift in planting date are the adaptation strategies by the farmers. However, poverty, lack of information, and awareness are the barriers. Another notable study in the context of Ghana (Acquah-de Graft & Onumah 2022) is "Farmers' Perception and Adaptation to Climate Change: An Estimation of Willingness to Pay." This study also observed that the majority of the farmers perceived an increase in temperature and a decrease in rainfall. Still, they found that the level of adaptation is relatively high, with the majority of the farmers who use climate adaptation measures like different crop varieties, soil conservation, changing planting dates, and water harvesting as the major adaptation measures to climate change impacts. According to this study, the barriers to adaptation are lack of information, lack of knowledge on adaptation, insecure property rights, insufficient access to inputs, lack of credits, access to water, and high cost of adaptation. They observed the probability of willingness to pay for climate change mitigation policies increases with age, years of education, and ownership of farmland.

Similarly, Guodaar et al. (2023) found that indigenous adaptation strategies to mitigate severe physical climate risks and disasters, individual farmers implement indigenous like livelihood diversification, construction of hand-dug wells in farms, migration, the building of mounds or ridges, and early marriage of young girls are used in Ghana. The farming communities also do animal sacrifices and spiritual incantations to invoke rains to address prolonged droughts. The study suggests early warning system regarding climate risks and their determinants will be highly helpful in adapting mitigation strategies.

The literature evidence an important study (Akponik et al. 2010) in the context of Sub-Saharan West Africa (SSWA). This study is on "Farmers' perception of climate change and adaptation strategies" The study predicted climate change is to have the main impact on agriculture, the economy, and the livelihood of the populations. The study is based on interviews with 234 farmers in five sub-Saharan West African countries in 78 villages. This study also finds that most of the farmers admit that climate change has an impact, and they depend on geographical area and prevailing climate. The challenge for the farmers is the dryness of their present climate. The rainfall is decreasing, leading to a number of dry spells perceived to have increased. In this region, the farmers are adopting crop management to maintain soil fertility by restricting the use of fertilizer and soil water management to maintain wetness. The ritual ceremonies by rainmakers are also cited to be a core strategy to deal with long dry spells. In the milieu of smallholder farmers' perception, a study (Ayanlade et al. 2017) based on "Comparing smallholder farmers' perception of climate change with meteorological data' in Southwestern Nigeria. The study has used ethnographic analysis, along with Cumulative Departure Index (CDI), Rainfall Anomaly Index (RAI) analysis, and correlation analysis to compare farmers' perceptions with historical meteorological data. The objective is to assess the way farmers' observations mirror the climatic trends. According to their observation, 67% of farmers have felt recent climate changes. The Perceptions of rural farmers towards climate change and variability are consistent with the climatic trend analysis. The impacts of climate change on both crops and livestock appear to be

highly negative rather, it is much more in the case of crops like maize, yam, poultry, and cattle. Another insight from this study is smallholder farmers are particularly vulnerable to climate change as the majority of them do not have enough resources to cope. Farmers' perception and knowledge of climate change and the coping strategies to the related hazards were done by adopting 'Adiha' located in central Tigray of Ethiopia (Mengistu 2011). They found that climate change adversely affects the Ethiopian economy due to the heavy dependence of the agricultural sector on rainfall. Based on focus group discussion on 144 systematically sampled respondents, the study also found that temperature is rising and precipitation is decreasing. Untimely rain and frequent drought are the challenges for crop production leading to livelihood problems vulnerable to health and socio-economic hazards. Lack of modern early warning systems, inflexible cropping calendar, and narrow choice of crop varieties are the basic reasons for vulnerability. So, the study suggests adopting improvements in the forecasting methods and improvements in the dissemination of climate information systems. They also suggest prioritizing irrigation technologies and adjusting planting dates to improve resilience to climate change. A study (Okonya et al. 2013) on farmers' perception and coping strategies towards climate change in Uganda interviewed 192 sweet potato farmer households distributed in six agroecological zones. The objective of this study is to examine perceptions about the effects of climate change and coping strategies. Weather-related events like prolonged dry seasons, floods, storms, mudslides, extreme rainfall, and delayed/early rains are observed to be frequent due to which the rural poor farmers suffer from food insecurity and their livelihood is getting affected. The strategies to cope with the problem are storing food, income diversification, and digging drainage channels. Other strategies include planting trees using high-yielding variety seeds that are early-maturing, drought-tolerant, disease and/or pest-resistant varieties. Similarly, other strategies are planting at the onset of rains and increased pesticide/fungicide application, among others strategies. The study recommends wide awareness relating to changes in rainfall and temperature. In the context of Nepal, a notable study by Manandhar et al. (2010) was regarding the adaptation of cropping systems to cope with climate change. The study is a cross-regional study on farmers' perceptions and practices. It is based on a comparative study performed in two different ecological regions such as Terai (lowland) and Mountain (upland), in the western development region of Nepal. The focus of the study is on perceptions and adaptations to climate change by farmers. It observed that most farmers recognize climate change and respond to it. They believe in their own indigenous knowledge and experiences. The study suggests going beyond the individual level and planning support mechanisms for appropriate technologies and strategies for farmers to cope with climate change. The Ejura-Sekyedumase district of Ghana was considered as a case study (Kemausuor et al. 2011) to examine farmers' perceptions towards climate change. The study has compared farmers' perception of climate variability change with the actual variation on the basis of the climatic data which was recorded from 1993-2009. They conducted interviews with farmers in six out of the nineteen operational areas in the district. The study concluded that the majority of the farmers' temperature is increasing, and rainfall timing has changed, which results in frequent drought. In this line, another notable study (Esham & Garforth 2012) worked on agricultural adaptation to climate change in the case of Sri Lanka. Thus, this study considers the farm-level adaptation strategies for climate change for smallholder farmers. The study revealed that farmers perceive climate change on the basis of their experience. According to this study, there are five groups of adaptation strategies that farmers adopt to cope with climate change. These strategies are crop management, land management, irrigation management, income diversification, and rituals. It is found that non-climatic factors are important strategies to increase farmers' adaption, particularly for resource-constrained smallholder farming. Human cognition and social networks are important determinants of adaptation to climate change. Interestingly, the study observed that social workers also play a significant role in influencing adaptation. Other influencing factors are social barriers, such as cognitive and normative factors, which become economic barriers to adaptation. So, to formulate and implement adaptation strategies, it is necessary to understand the importance of socio-economic, cognitive, and normative aspects of the local groups. Similarly, a study (Alam et al. 2012) on adaptation practices to climatic vulnerabilities in Malaysia. The study has considered paddy farmers as their respondents to understand farmers' perception towards climate variation, vulnerabilities, and techniques they use to adapt to climate change. The study observed that most of the farmers do not have a clear awareness of climatic changes and vulnerabilities. Farmers decide on adaptation strategies mostly based on their common sense. The study suggests that farmers require the necessary training and support from the government. Farmers in the marshlands of South Kivu, Democratic Republic of Congo, adopt adaptation strategies like the use of mulch and manure as per their 'experience and information among fellow farmers, but sustainable practices like crop diversification, drainage, growing low-maintenance crops are advisable (Mushagalusa et al. 2022). Nevertheless, the size of the farm is an important variable in determining the adaptation strategies. It is found by Koirala

et al. (2022) in the case of Nepal that Small-sized farmers tend to adapt much more in response to their climatic perceptions than large-sized farmers. Therefore, agriculture may be losing responsiveness to climate change due to large-sized farmers dominant by holding a majority of land in developing countries.

Studies in the Indian Context

A systematic review of the literature on Climate Change and Indian Agriculture: A Systematic Review of Farmers' Perception, Adaptation, and Transformation by Datta et al. (2022) reveals that Indian farmers have perceived a temperature rise erratic and decreased rainfall. The Indian farmer's changes in land use, resource and labor allocations, occupational patterns, and cropping systems as the adapting strategies to climate change. The influencing factors in deciding the adaptation strategies for Indian farmers are access to sufficient information, adequate credit at the right time, household income, farm size, gender, and resource endowment. Therefore, large-scale investments for the farming sector in general and building farmers' capacity in particular, an adaptation of an integrated approach to understanding the farmer's perception is essential for effective policy modeling. In Banerjee's (2014) study on 'Farmers' perception of climate change, its impact, and adaptation strategies in four semi-arid Indian villages,' it was noted that the region is experiencing limited and unpredictable rainfall. Infertile soils, poor infrastructure, and rapid population affect the socio-economic life of agricultural communities. A study (Shukla et al. 2015) was conducted on Farmers' perception and awareness of climate change considering a case study from Kanchandzonga Biosphere Reserve of India. The study attempted to observe the perception of people on climate change- in five villages. They surveyed 300 households selected randomly. The result of this study is also in line with other studies. It found that the majority of households perceive climate change in the form of increased temperature, uncertain patterns of rainfall, and hot wind. Crop diversification and traditional agroforestry are the adaption strategies followed by people. Correspondingly, another study (Dhanya & Ramachandran 2016) on farmers' perceptions of climate change in a semi-arid region of south India acknowledged climate change as one of the foremost challenges that affect the performance of agriculture and livelihood. Farmers are the worst sufferers due to climatic variations. Farmers perceive climate variability and identify increasing temperatures. Due to delays in rain, the soil dryness increases, which is a critical factor affecting cultivation. Farmers''s perception of drought impacts was in the context of local adaptation and administrative mitigation measures in Maharashtra (Udmale et al. 2014). This study is based on both secondary and primary data collected from a primary survey of 223 farming households. The study reveals that environmental impacts increase in average atmospheric temperature, pasture-forest degradation, deteriorated water quality, damage to fish habitat-wild life, and groundwater depletion are perceived by farmers to a high extent. Though farmers perceive the severe impact of drought and are familiar with various adaptation strategies, they have very little option to adopt this. Though the government provides various mitigation measures, the farmers are not satisfied. Similarly, another study done in Tamil Nadu, India, on the perception of farmers shows that they observed a decrease in the quantity of rainfall over the years, along with the delayed onset of rains. In addition, the farmers felt that the monthly frequency of rains had decreased with increased dry spells (Vardan & Kumar 2014). The key socio-economic variables to influence adaptation strategies are farmer's age, gender, household size, educational level, off-farm income, and farm size influence farmers' adaptation decisions (Jha & Gupta 2021). The study by Sehgal (2023) on crop diversity and farm income found that demographic, farm, and institutional variables play an important for raising farm income. Further, Education level, irrigation, usage of technical information, and possession of the Kisan Credit Card (KCC) facility have a positive impact on agricultural income. Crop diversification helps small farmers to gain more than large farmers. When natural disasters negatively affect farm income, it is suggested that the impact can be mitigated with the help of a higher level of crop diversification. Guodaar et al. (2023) studied the perception of farmers regarding the changing climate, its impact on agriculture, and responsive adaptation strategies of farmers of a major state, i.e., Uttar Pradesh in India. According to their findings, 82% of farmers perceived a temperature rise, 85% believed that the rainfall had altered, and 95% believed that the intensity of rainfall had changed. More than 60% of the farmers agreed that alterations in temperature and precipitation reduce production as well as revenue. The majority of farmers (86-87%) adopt strategies like shifting sowing dates, change of variety, and increase in irrigation. The study also finds interesting observations conservation agriculture or water harvesting are not considered. The most important motivation to opt for such strategies is not the awareness or knowledge but rather monetary benefit.

The above review of the literature shows that most of these studies are either done in the context of foreign countries or the context of other states of India. There are very few studies in the context of Andhra Pradesh. Further, most of the studies have their specific objective and do not give a complete idea about perception and mitigation strategies combined. Our study is in this line.

MATERIALS AND METHODS

The Study Area

Andhra Pradesh is known as a progressive state but farmers' distress is widespread news about this state. An agrarian rural economy predominantly dominates the state. It is the third-largest producer of rice and groundnuts and second in cotton and sunflower flower production in the country. The state has adopted the green revolution and is expected to reap its benefits. The state registers its position in horticulture crops. The National Horticulture Mission (NHM) has identified the state as having the potential to enhance exports of mango, banana, grapes, papaya, guava, brinjal, and cabbage. Diversification is said to be identified as one potential way to enhance growth and ensure stability in agriculture. Andhra Pradesh ranked eighth among the states both in terms of share of agriculture GDP (24.7%) and employment generation (58.55%) as per the 61st round of NSS**.** Of the total geographical area of 27 million ha in the state, 39 percent is net sown area. 4.4 million ha is the net irrigated area, and 6.4 million ha is rain-fed. The average rainfall in the state is 940 mm. 61 percent are marginal farmers, and 22 % are small farmers out of 11.5 million land holdings (Fig. 1).

This field-based study was conducted in two villages, i.e., Ananthasagaram and Bedusupalli, in the Ananthasagaram Mandal in Nellore district located in the coastal Andhra Pradesh state of India. Ananthasagaram Mandal is 79 km away from the district headquarters in Nellor. The study area is located nearer to the Somasila Reservoir, constructed on the river Penna. The distance between the two villages is 3km. According to the 2011 census, the total population of the Ananthasagaram Mandal was 8588, and the total population was 4436 males and 4152 females. The average sex ratio was 936 per 1000 population. The total population of specific two villages was 3100 and there were 812 families. There are a total of 750 acres of land cultivated by 360 families from these villages. The primary occupation is Agriculture, mostly paddy cultivation. Other than agricultural farming, people are engaged in both government and private sectors. Except for rainwater, the main source of water for cultivation in Ananthasagaram Mandal is the MI Tank (Minor Irrigation). 75.2 mm is the average rainfall in this area, but in 2018, it received only 40 mm of rainfall. The mean maximum temperature varies from 39 to 41°C (usually occurring in May), and the mean minimum temperature varies from 19 to 21°C (usually occurring in January). The

Source: Google Maps and Wikipedia.

Fig. 1: The study area.

normal rainfall over the period from June 2014 to May 2019 is 4514.0 mm, but the actual rainfall is 3273.9 mm.

Methodology

Primary and secondary data have been used for this study. Primary data was collected from a survey conducted in two selected villages, i.e., Bedusupalli and Ananthasagaram. Ananthasagaram is the mandala head quarter. First, the villages were selected through a convenience sampling technique, and a random walk sampling technique was adopted in the second stage to choose the households. The secondary data on rainfall and temperature were collected from the District Metrological Department. Primary data was collected with the help of a structured questionnaire. The questionnaire was designed to refer to earlier perception studies by Saylor et al. (2019) with a necessary understanding of the socio-economic scenario of the present study. The questionnaires were administered as a face-to-face interview in the month of February-March 2020. The questionnaire intended to gather information on farmers' basic information like their demographic profile, details of farming, and also subject matter like their awareness, potential problems, and adaption and risk management strategies towards climate change. Finally, 150 data points have been considered collected from 360 families from both villages. From Ananthasagaram, we collected 90 data points, and from Bedusupalli, we collected 80 data points. We rejected 20 questionnaires due to incomplete information. The response rate was almost 100% during a face-to-face interview. For analysis, we have used simple percentage statistics using SPSS 16 software and have presented the results with the help of tables and figures.

RESULTS AND DISCUSSION

Climate Change in the Study Area

Temperature and rainfall are two important parameters to understand the climatic conditions. A rise in temperature and rainfall affects agricultural production negatively. When a rise in temperature affects agricultural production due to an increase in heat stress on crops, a decrease in rainfall is due to an increase in weed and insect pressure. If there is less rainfall, it leads to drought, and if there is heavy rainfall, it leads to floods. Therefore, climate is the most important factor for agriculture in particular and life in general. So, before studying the perception and adaptation strategies of the respondent farmers, we have tried to understand the nature of climate change in the study area.

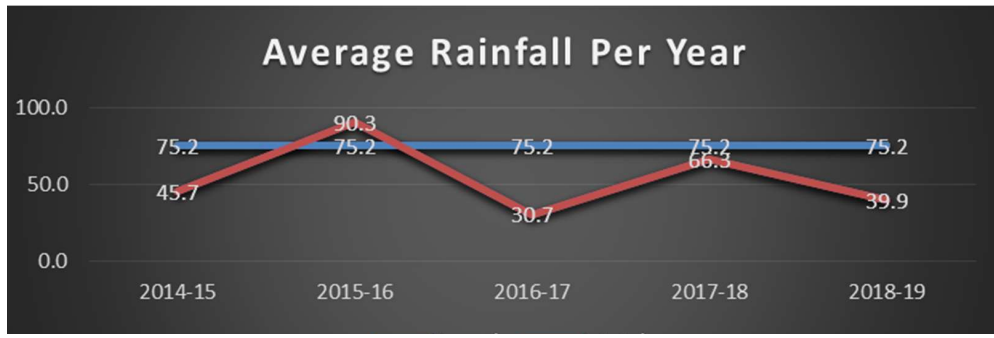
Rainfall

Fig. 2 presents a comparison between the average annual rainfall in the state and the average rainfall per year in the study area in the last 5 years. The average rainfall in the state (75.2mm) is considered here as normal, and the fluctuation of rainfall in the study area is considered as actual. It can be observed that there is rainfall deficiency in the study area in all the years except in the year 2015-16. In 2014-15, the rainfall was 45.7 mm. In 2015-16, it increased by 90.3 mm, but in 2016-17 there was a fall in rainfall of 66.3 mm, and in 2018-19 again, it decreased by 39.99mm. This indicates that the area is experiencing low rainfall comparatively at the state level.

It is necessary to observe the season-wise rainfall as farming is subject to different seasons. Fig. 3 presents the season-wise rainfall last 5 years. One year is divided into 4 seasons that are Southwest Monsoon (from June to September), Northeast Monsoon (from October to December), winter (from January and February), and summer (from March to May). The graph shows that there is rainfall deficiency in every season except in 2015-16 (Northeast monsoon). Because of rainfall deficiency in the southwest monsoon, they changed their cropping time from southwest monsoon to northeast monsoon.

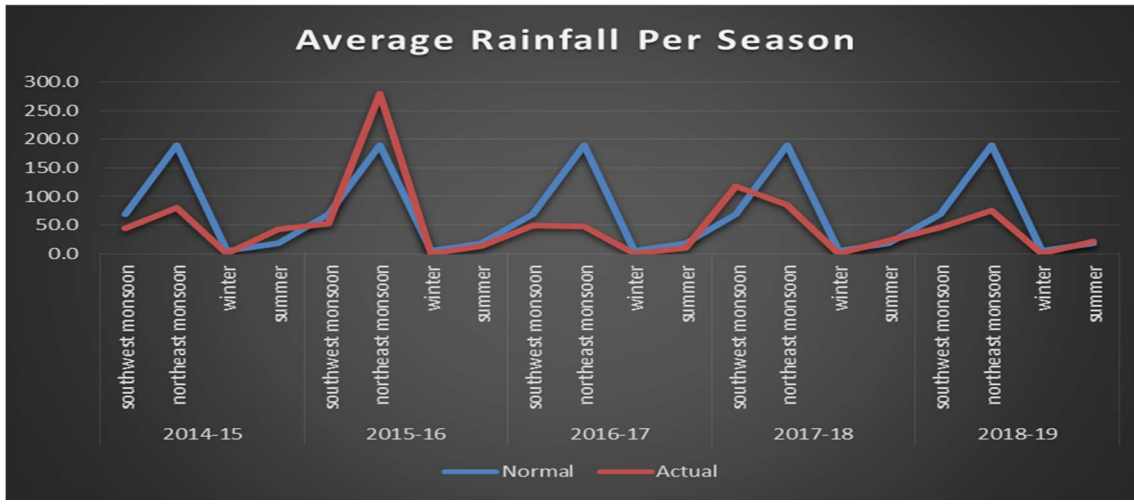
Temperature

It can be observed that the area is experiencing above



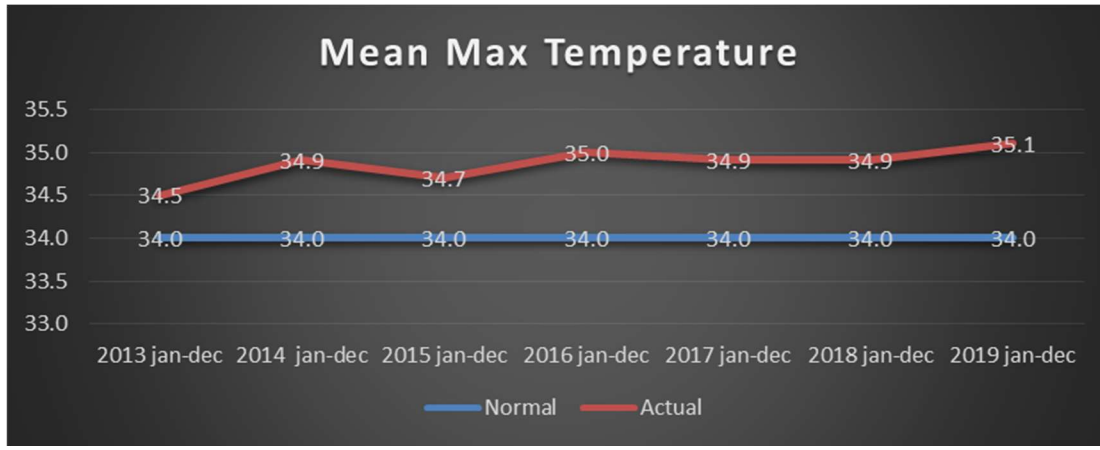
Data Source- IMD District Office, Nellore

Fig. 2: Average annual rainfall (in mm).



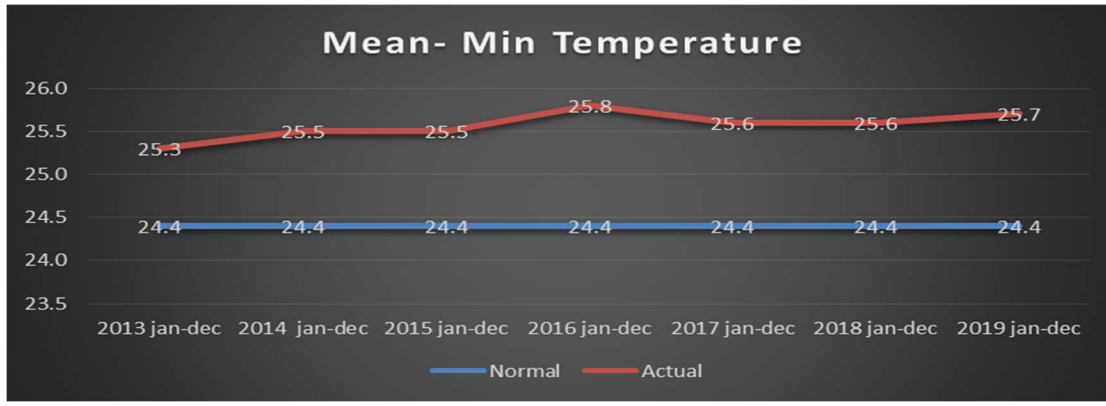
Data Source- IMD District Office, Nellore

Fig. 3: Average Rainfall per Season.



Data Source- IMD District Office, Nellore

Fig. 4: Mean maximum temperature per year.



Data Source- IMD District Office, Nellore

Fig. 5: Mean-minimum temperature per year (in Celcius).

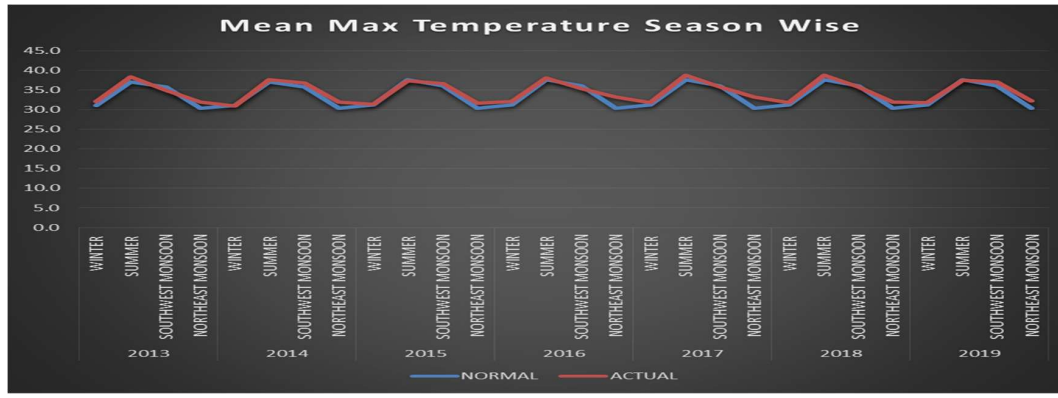
the normal temperature. Fig. 4 explains about mean – the maximum temperature of the Nellore district from 2013-2019. The mean maximum temperature is 34.0°C but every year, it has increased around 0.5°C to 1.1°C. So, every year there is above the normal temperature.

Similarly, Fig. 5 explains the mean of the minimum temperature of the Nellore district from 2013-2019. The mean minimum temperature is 24.4°C, but every year, it has increased from 0.9°C to 1.3°C, which indicates that there is an increase in temperature. Fig. 6 explains the mean maximum temperature according to the seasons. By observing the above graph with respect to the variability of temperature in different seasons, it is understood that there is an increase in the average temperature up to 2° Celsius, mostly during the summer season. Fig. 7 presents the mean min- the temperature in different seasons. If we observe the temperature in winter, there is an increase in average temperature up to 2° Celsius.

Field Survey, Data Analysis and Interpretation

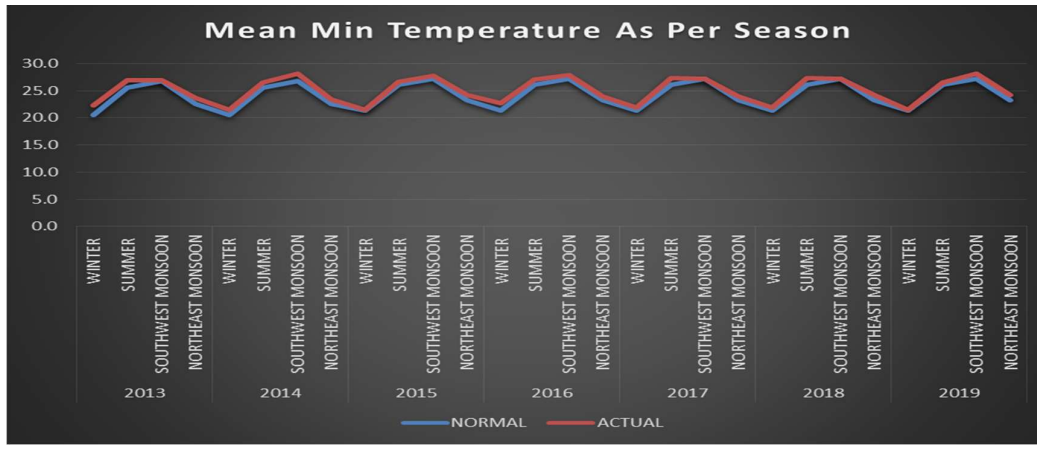
Demographic profile: The total data points are 150. Out of that, 3% are female, and the other 97% are male. In the case of age group, 72.7% are above 50 years and 27.3% are 18-50 years. In the case of educational qualification, 4% are illiterate and 94% are less than class 12. Out of the total respondents, 68.7% of people's income is between rupees 20000-60000, and only 5% of farmers' income is above 200000. In the case of financial assistance, 66% of farmers are dependent on bank loans, and 32% are from other sources.

Details of farming: The total cultivated land by respondents is approximately 740 acres. At the same time, the mean of acres of land cultivated is 4.33 acres. More than 10 acres of land are cultivated by only 12.7% of respondents and 51.4% of respondents are cultivating 2 to 4 acres of land each. In the case of farming experience, 66% of farmers have experience



Data Source- IMD District Office, Nellore

Fig. 6: Mean-maximum temperature season-wise (in Celcius).



Data Source- IMD District Office, Nellore

Fig. 7: Mean-minimum temperature as per season (in Celsius).

of more than 10 years, and 34% of farmers have experience of less than 10 years. Mainly, they produce paddy and some of the farmers produce Chilli and groundnut as second crop. 16% of respondents are adopting double crops (Rabi and Kharif). In the case of access to irrigation, 66% are using ponds and river water for irrigation.

Farmer's perception of climate change: Out of the total responses, 96.3% of the population is aware of climate change, and 3.3% are not very aware of climate change. Their means of awareness are TV/Radio, their own experience, and the newspaper. 50% of farmers know about climate change from their own experiences. A total of 98% of farmers said that the major climate event experienced is high/extreme temperature. 98% are interested in taking crop insurance as they do not know about crop insurance. Farmers in these two villages are aware of climate change. Their most experienced climate change is high/extreme temperature. Due to the temperature rise, the heat stress on crops is increasing. 68% of farmers are concerned about this and very much concerned about the pressure of heat stress on crops. So, the increase in temperature is having an impact on crop production.

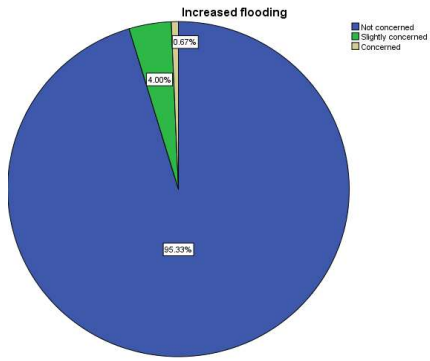


Fig. 8: Increased flooding.

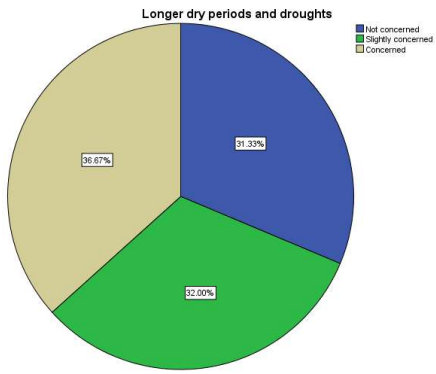


Fig. 9: Longer dry periods and droughts.

Farmers' concern about potential problems in agriculture due to climate change: To collect the views of farmers regarding the degree of their concern about the impact of climate change on crop production, the questionnaire included four options on a Likert scale, i.e., not concerned, slightly concerned, concerned, and very much concerned. Here, if they are not facing that problem, then that is a concern; if they face a very small percentage, then that is a slight concern. If they face that problem frequently, that is a concern, and if the loss is heavy, then that is very much a concern.

Increased flooding: Climate change is responsible for uncertain heavy rain, which causes floods. It is found that 95.33% are not concerned, 4% are slightly concerned and 0.67% of farmers are concerned about this (Fig. 8). The farmers whose farmland is nearer to the canal are facing the problem of flooding, and they are slightly concerned about this. This is due to the problem happening only when a heavy flow of water comes. The heavy flow of water is basically what they experience when the reservoir opens the gates to release extra accumulated water due to heavy rains. The concerned farmers are facing that problem frequently. Flooding only due to heavy rain is not observed to be frequent due to rainfall.

Longer dry periods and droughts: Farming regularly needs water; otherwise, the land becomes dry and disturbs the steps and process of cultivation. This problem occurs when rainfall is deficient or the alternative source of irrigation can provide water. Most farmers depend on rainfall and try to manage with water from irrigation only during shortages or off-season. From the field survey, it is found that a longer dry period is a major concern for the farmer. Fig. 9 shows that 68% of respondents are concerned and slightly concerned about this problem and only 31% revealed that they are not concerned about this problem. The categories of respondents who are not concerned about dryness are having land nearer to the canal or irrigation project.

Increase weeds pressure: The weed pressure damages the crop and results in low productivity and even no output. This creates loss and the farmers' financial management gets affected directly. This problem may occur in different types of seasons. The basic reason behind this problem is irregular and uncertain weather conditions. When the weather condition does not follow their normal feature, the moisture level changes, and the farmers need to withdraw unwanted plants grown with the crop. This further requires care and cost to be incurred. This is one frequent problem faced by the farmers. Fig. 10 shows 83% of respondents are concerned about this problem.

Higher incidence of crop disease: Crop diseases are the most

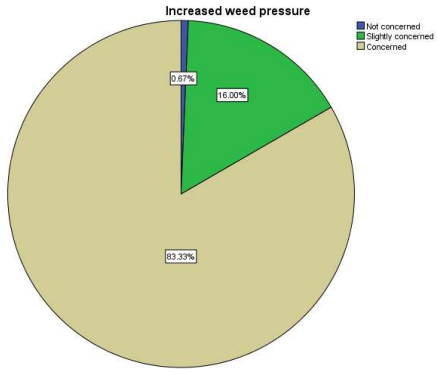


Fig. 10: Increased weed pressure.

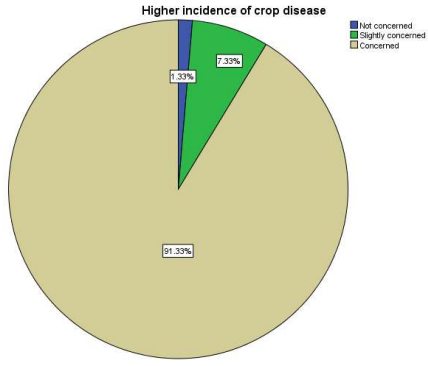


Fig. 11: Higher incidence of crop diseases.

frequent cause of the loss of farmers. The reason behind this problem is uncertain variability in weather causing change in the environment of plants to grow. This is observable due to high moisture in the climate and variability in temperature. In the study area, the cropping time is November; at this time, the temperature comes down crop diseases increase. We can observe from Fig. 11 that 91.33% of farmers are concerned about this, 7% are slightly concerned, and only 2% are not concerned about this.

Most frequent extreme rains: There is a rainfall deficiency in that area., we can say that this is not a problem for them. Approx. 98% of farmers are not concerned about this, and 2% are slightly concerned about this (Fig. 12).

Increase in saturated soils and ponded water: According to the field survey presented in Fig. 13, farmers are not prone to this problem. It occurs in cooler soil temperatures and because of ponded water. The average temperature is increased to 3°Celsius so the farmers are more worried about high temperatures than cold weather. 99% of the respondents have opined that they are not concerned about saturated soil or ponded water.

Increased heat stress on crops: High-temperature level

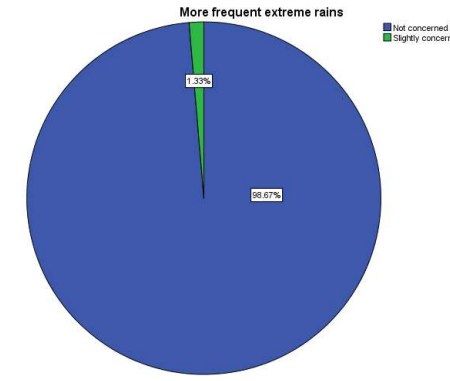


Fig. 12: More frequent extreme rains.

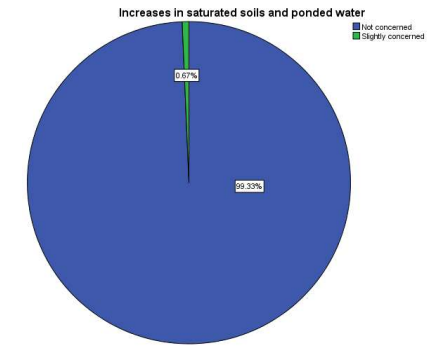


Fig. 13: Increase in saturated soils and ponded water.

creates heat stress on crops which is observed to be a frequent problem in the study area. The sum of the respondents said slightly concerned and very much concerned is 86% (Fig. 14) and only 13% responded they are slightly concerned.

Increased loss of nutrients into waterways: According to farmers, when the flow of water is very high, they need to cut the barricade of the farmland to release the extra water. The problem is when there is uncertain rainfall, and they need to release the extra water. The nutrients given to the crop for better growth also go with the flow of water. This is a loss of nutrients. However, Fig. 15

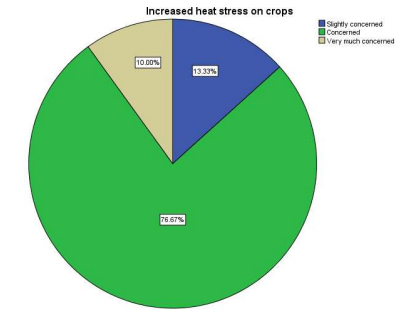


Fig. 14: Increased heat stress on crops.

shows that 98% of farmers are not concerned about this problem.

Increased soil erosion: From Fig. 16 it can be seen that 97% of farmers are not concerned about soil erosion. This is due to low rainfall in the area. Land which is located near the river or canal is prone to this but land which is far away from that is not prone to this. However, the farmers are concerned about a decrease in the fertility of land due to changes in the soil quality.

Adaption and Risk Management Strategies

In the early days, the cropping time was July to January, but due decrease in the variability in rainfall/precipitation, the farmers changed the cropping time from November to April, and due to this, there is a change in harvesting /cutting of crops from January to April. Earlier, the cropping time was spread over 6 months, but currently, the cropping time is spreading over 4 months because of the use of HYV seeds. As the study area is located nearer to the sea and the rainfall from southwest monsoon to the area has decreased in recent days is also a reason for the change in the cropping time. So, farmers are now depending on the northeast monsoon.

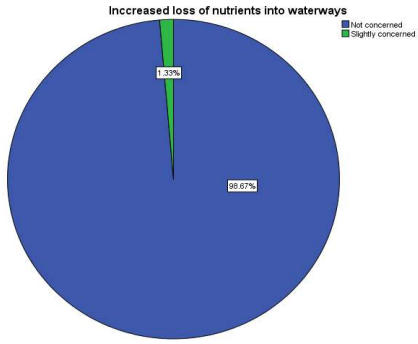


Fig. 15: Increased loss of nutrients into waterways.

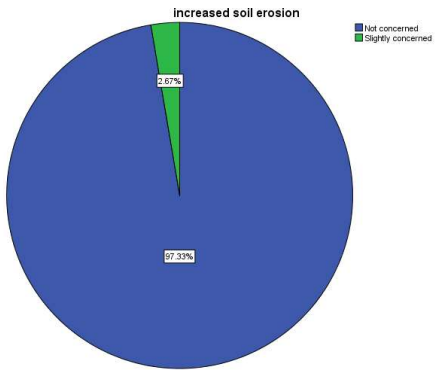


Fig. 16: Increased Soil Erosion.

Different types of adaptation and risk management strategies can be adopted to mitigate climate change. The study assumed few adaptation strategies learning from collected existing literature and attempted to observe whether the farmers in the study area are adopting them or not. The questionnaire included strategies such as adaptation of conservation practices, Purchase of crop insurance, Use of new technologies, Join off-farm jobs to supplement farm income, Restructure expenditure/ income to have less debt, Focusing more on farm production, investing more in inputs, Adopting crop diversification and multiple cropping, Selling or giving a part of the total land for some other purposes, Using a part of the land for some other purposes and finally Thinking/planning to quit farming. To quantify the qualitative response, a Likert scale format has been adopted. The questionnaire includes 3 options in the context of different types of risk and adaptation practices, i.e., doing to manage risk and adopt climate change, not doing now but planning to do, and not doing and not having any plan to do. The objective is to observe the behavior of the farmers toward climate change. The observation is explained below.

Adaptation of conservation practices: Conservation practices include the use of cover crops, the use of green and composted manure, and the gradual reduction of the use of chemical fertilizer. It is observed from Fig. 17 that 42% of farmers are not doing and do not have any plan to do, 36% of farmers are not doing now but to implement, and 22% of farmers are managing risk to adapt to climate change on the use of chemical fertilizers. It is found that though the farmers are not solely following conservation practices as an adaptation categorically they understand that heavy use of chemical fertilizer is changing the composition of soil and reducing the fertility of the land. However, they are using

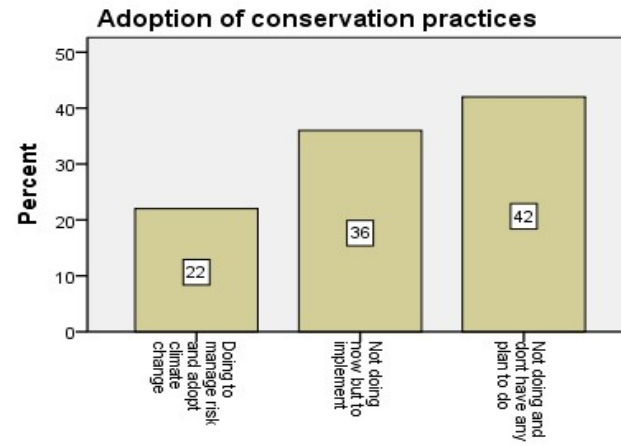


Fig. 17: Adoption of conservation crops.

it because they have to increase productivity. This is not suitable from a long-term productivity point of view, and they are gradually shifting to green and composed manure.

Purchase of crop insurance: To meet the uncertain loss due to climate change, there is a facility for adopting crop insurance. The farmers can purchase crop insurance, but the majority of the farmers do not have crop insurance, or they do not want to go for it. According to the respondent, the main problem in the case of crop insurance is in claiming of insurance amount. The main assumption is they can get a return only when there is damage to the crop in the total area. The total area should be declared as a damaged crop or drought. If the loss happens in individual farmland, then crop insurance does not give any benefit. So, the farmers feel that paying the insurance amount is a net loss. Thus, 98% of farmers are not doing and do not have any plan to take crop insurance as an adoption and risk management strategy.

Use of new technologies: The choice of technology in general and the use of modern agricultural technology is considered to be useful for increasing farm productivity. In the context of modern farm technology, it requires large farmland holding size. Most of the farmers have small farm sizes or do not have the financial capacity to purchase their own. They prefer to hire and use technology like tractors and thresher machines etc., when there is a requirement. Even though loan facility is available they fear taking loans because they fear being defaulter in paying installments to be over debt and financially more stressed. 98% of farmers have opined that they do not consider the use of new technology to be an adaptation strategy.

Join off-farm jobs to supplement farm income: The farmers are engaged in farming during the season and prepare the land during the off-season. They do not join off firm jobs may be due to they do not have the skills for that, or they do not get time for them. Farming is a full-time job and requires regular attention. It is found that 100% of farmers are not interested in joining off-firm jobs.

Restructure expenditure/income to have less debt: Financial management is an important aspect of any production process. When climate change is an influencing factor to production, leading to revenue and expenditure nexus, it is necessary to understand whether farmers are revenue and expenditure to maintain balance. It is observed from the field interaction that they find scope to manage the expenditure rather than having to face the new increase in expenditure due to an increase in input price. They do not have any standard accounting and financial management plan but rather believe in their common sense to manage revenue and expenditure. All the respondents opined that they had not done any restructuring to manage their revenue-expenditure or debt in relation to climate change or change in weather.

Focusing more on farm production, investing more in inputs: Input-out management is another aspect of production. To achieve more productivity, input is managed. To analyze whether the farmers follow any special input management or increase in input to retain production or not, the study had this angle. Conversely, the farmers said that there is no such specific investment. More on the input plan is followed. Whatever expenditure is required, they do. They maintain the soil in whatever possible way.

Adopting crop diversification and multiple cropping: Crop diversification is a scientific way to maintain soil fertility and to have sustainable agriculture. Similarly, multiple cropping is important from a production and income point of view. In the study area, multiple cropping and crop diversification are not observed. The percentage of people who adopt multiple cropping is very low. They basically produce paddy. Their important response is they have changed the month of cropping to face the changing climate.

Selling or giving a part of the total land for some other purposes: Due to the gradual reduction in farm income and increased cost of production, the farmers are facing problems and losing confidence to pursue agricultural farming as their primary occupation. They have debt and are unable to repay to become completely debt-sustainable. Nevertheless, they do not like to sell or show interest in giving a part of their land for some other purposes. Farmers do not consider this is way to face climate change. If there is any emergency, they put the land they own for any mortgage purpose or for some other reason they want to get it back.

Using a part of the land for some other purposes: Most of the farmers are small landholders. They have sufficient land so that a part can be used for some other business purposes. They use a small part of the land for regular use for agriculture-related activities. So, there is no other source of income from the land they own. Totally 100% of farmers are not interested in using a part of the land for some other purposes.

Thinking/planning to quit farming: Weather change due to overall climate change has created a great challenge for farmers. The farmers feel that agriculture is not at all a profitable business, keeping other things like commercialization and the use of modern technology constant. Particularly the small farmers express that agriculture has been a generational occupation for them, and they have to do it. Neither do they have the skills and education to opt for better employment, nor do they have the financial strength to convert their farming to a business model. Though the government is implementing different policies and programs to help them the fact is the prime

variable to influence their farming is climate change in terms of low or uncertain rainfall and increasing temperature. It is observed from the field that 80% of farmers believe that they will not quit farming. They have long years of experience in farming and do not have any other option to opt for.

CONCLUSION

The study focused on three important dimensions such as farmers' perception of climate change, problems faced by farmers in agriculture due to climate change, and farmers' adaption and risk management strategies. It is observed that 97 % of farmers are aware of climate change. 68% of farmers are concerned, and 32% of farmers are not concerned about longer dry periods. 83% of farmers are concerned, and 16 are slightly concerned about weed pressure. 76% are concerned, and the remaining are slightly concerned or not concerned about heat stress on crops. 91.33% of farmers are concerned about crop disease, 7% are slightly concerned, and 2% are not concerned about crop disease. So, climate change is playing a vital role in agriculture. It is affecting farming and farmers' adaptation strategies toward climate change. Due to changes in climate and weather, farmers are changing their cropping time and depending on southwest monsoon to northeast monsoon. Due to changes in cropping time, they are facing problems like an increase in weed pressure and heat stress on crops.

Similarly, due to the lack of rain and increased temperature, a longer dry period is another big problem for them. The major adaptation strategy is changing the period of cropping time and shifting dependency from southwest monsoon to northeast monsoon. However, this has led to problems like increasing weed pressure and heat stress on crops.

The study recommends that the government should focus more on climate change mitigation strategies in one hand and implement effective environmental policies to control factors causing climate change. The findings of the present study are in line with conclusions derived by notable studies like (Banerjee 2014, Guodaar et al. 2023). Farmers must be given priority for skill development in terms of training and awareness programs for suitable agricultural practices. There is a need for the adaptation of sustainable green technology in line with sustainable development goals. Necessary financial assistance schemes should be implemented effectively by the government to encourage farmers to adopt green technology. The study is subject to many limitations, but one of the major limitations is it is based on a specific area, and the conclusion may not be generalized at the global level. However, the study is an important contribution to the literature in the sense that it can be referred to as a case for other regions with similar socio-environmental characteristics. The present study opens a broad perspective of scope in the area of climate change and its impact on agriculture. Further studies can be conducted with an intensive microscopic and ethnographic approach to the behavior of farmers and the changing dimensions of climate.

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