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PROBLEMS FACED BY THE RICE AND MAIZE GROWERS DUE TO CLIMATE CHANGE, MITIGATION AND ADAPTATION MEASURES UNDERTAKEN

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ABSTRACT

A research study was conducted in the state of Arunachal Pradesh in order to identify the various problems faced by the rice (*Oryza sativa* L.) and maize (*Zea mays* L.) grower in the state due to climate change and the various mitigation and adaptation measures undertaken by them in view of the problems faced by them. The study was carried out for the time period from 1987 to 2018 in two districts viz. East Siang and Lohit of Arunachal Pradesh; being the highest producing district of rice and maize in the state respectively. The study showed that the respondents perceived climate change and reported to have observed a change in the timing and duration of rainfall received along with changes in temperature. They reported various problems faced by them in the duration of the study while ranking decreasing yield as the most important problem faced by them, followed by pest and disease infestation and weed infestation in the fields. The farmers also adopted various means in order to counter the problems faced due to climate change like changing the cropping time and pattern, introducing climate resilient varieties and switching to more economically profitable crops. In view of the observations made during the study, some policies and future course of actions suggested for the problems faced by the farmers can include adoption of sustainable and diversified form of agriculture, involvement of Government, cooperative and self help groups to reduce price risk. Farmers can adopt water saving technologies like controlled irrigation, development of crop monitoring, climate forecasting and mapping the climate susceptible areas are the immediate need of the hour.

Keywords: Climate, rice, maize, trend, measures, mitigation.

INTRODUCTION

Climate is often described as the 'average weather' and expressed in terms of the mean and variability of temperature, precipitation and wind, over a time period that can range from months to millions of years. The climate system is a complex interactive system and evolves with time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called 'forcings'). External forcing includes natural phenomena such as volcanic eruptions and solar variations, as well as human-induced changes in atmospheric composition (Thomas *et al.,* 2005).

Climate change is any significant long term change in the statistical distribution of weather patterns of a region or the whole earth, when that change lasts for an extended period of time. It often refers to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i. e; more or fewer extreme weather events) and is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as global warming (Arndt *et al.,* 2012).

Climate is a direct determinant of agricultural productivity wherein the climate of a region has a direct or indirect impact on the quality and the quantity of agricultural produce of the said region. Global climate change is a change in the long-term weather patterns that characterizes the regions of the world and in the long run is expected to influence crop and livestock production, quantity and quality of crops in terms of productivity, growth rates, photosynthesis and transpiration rates, moisture availability etc. across the globe. It can also have a significant impact on input supplies and other components of agricultural systems. The world agriculture scenario is faced with a serious decline within this century due to global warming with an overall, agricultural productivity for the entire world projected to decline between 3 and 16 per cent by 2080 (Mahato 2014).

Even though climatic changes could affect agriculture in several ways, the nature of its biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms. An increase in the mean seasonal temperature can lead to reduced crop duration and hence reduce the yield. A more immediate impact of increased temperature on yield is expected to be witnessed in the areas where temperatures are already close to the physiological maxima for crops (Anon 2007). In the other hand, carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance the productivity of agro-ecosystems. Climate change may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion (Adams 1986).

Climate change is expected to cause changes in the climatic

scenarios of the world and manifest primarily in terms of higher temperatures, changes in precipitation, and higher atmospheric CO_2 concentrations. The plausible changes can have both positive and negative impact on agriculture. For example, an increased temperature has been found to reduce yields and quality of many crops, most importantly cereal and food grains due to higher respiration rates and shorter seed formation and grain filling period. On the other hand, an increase in precipitation may benefit semi-arid and other areas with shortage of water by increasing soil moisture. The same can however aggravate problems in regions with excess water, while a reduction in rainfall in some places can cause drought like scenario. The greenhouse effect is a natural process that plays a major part in shaping the earth's climate and is responsible for the relatively warm and hospitable environment near the earth's surface where life-forms have been able to grow. However the world is currently facing a rapid spike in the amount of Green House Gases (GHG) in the atmosphere as a result of uncontrolled anthropogenic activities which leads to an overall increase of the earth's temperature, leading to a global warming. The average global surface temperature has increased by 0.74 ^oC since the late 19th Century and is expected to increase by 1.40 ^oC to 5.80 ^oC by 2100 AD with significant regional variations Anon., 2012). There are three ways in which the Greenhouse Effect may affect agriculture. Firstly, an increase in the atmospheric CO_2 concentrations can directly affect the growth rate of crop plants and weeds. Secondly, CO_2 can induce changes in the earth climate that can alter the levels of temperature, rainfall and sunshine which can influence plant and animal productivity. Finally, rises in sea level due to global warming may lead to loss of farmland by inundation and increasing salinity of groundwater in coastal areas (Morton, 2007). An atmosphere with higher CO2 concentration would result in higher net photosynthetic rates (Cure, 1986, Adam *et al.,* 1998). Higher concentrations may also reduce transpiration as plants reduce their stomatal apertures with a reduction of about 30.00 per cent reported in some crop plants (Kimball 1983). The net change in crop yields is determined by the balance between these negative and positive direct effects on plant growth and development, as well as the indirect effects that can affect production. These indirect effects have been largely ignored in the assessment of climate change effects except for changes in water supplies (Yadav *et al.,* 2021). Indirect effects may arise from changes in the incidence and distribution of pests and pathogens (Sutherst *et al.,* 1995), increased rates of soil erosion and degradation, and increased tropospheric ozone levels due to rising temperatures (Gunho, 2006).

Climate change is also likely to affect the livestock sector in many ways, for example, there may be a change in the quantity and quality of feed in both open grazing condition as well as cultivated fodder. A rise in summer temperatures can cause suppressed appetite in livestock and hence lead to lowered weight gain (Bockel *et al.,* 2011). However, some studies of mid to high latitude grasslands found that climate change has led to higher productivity (Rina, 2020). Climate change also affects livestock by affecting the frequency and severity of extreme climate events. Even though the study of the impact of climate change on livestock quiet limited; livestock sector may be particularly vulnerable to the effects of climate change (Hoffmann, 2013).

Climate change and its perception by the farmers

Climate change is very real and has a direct or indirect environmental, economic and social impacton several sectors, including agriculture. However, the extent of impact it has on agriculture depends on greatly on farmers' awareness and their capacity for adaptation in response to changes in the climate (Foguesatto *et al.,* 2020). Earlier studies conducted in Africa have shown that the farmers' perceptions of change relate more to the increased variability and uncertainty of specific weather parameters rather than long-term climate change (Gune, 1986; Thomas *et al.,* 2005; Osman *et al.,* 2006; Mertz *et al.,* 2009;). Studies also found that socioeconomic and psychological factors shape farmers' perception of climate change (Mozhui and Sharma, 2020). Farmers often perceive climate change in the forms of changes in rainfall intensity, duration and pattern, changes in the onset and duration of the seasons, change in temperature. Some farming communities are perceptive to the change and follow various adaptive and mitigation measures in order to ensure good yield and farm income. Some of the most commonly observed adaptive measures followed by the farmers are: the use of plant protection chemicals, improved varieties, increasing frequency of irrigation, land fallowing, off-farm works and improved management practices. Findings such as these are important towards the identification and formulation of an integrated sustainable and climate-proof farming support system (Chhogyel *et al.,* 2020).

Materials and Methods

A study was conducted in the East Siang and Lohit districts of Arunachal Pradesh in order to identify the various problems faced by the rice (*Oryza sativa* L.) and maize (*Zea mays* L.) farmers of the state due to climate change, their observations, and mitigation and adaptive measures taken up by them to overcome the problems. The study was conducted in the state of Arunachal Pradesh wherein the districts East Siang and Lohit were selected purposefully due to them being the districts with highest productivity in terms of rice and maize respectively. Two blocks each from each district were then purposefully selected following which two villages from each block were then randomly selected.

In order to make sure that the sample drawn for the study is a proper representation of the population from which the sample is drawn, it is required that the sampling method followed be efficient and as unbiased as possible. For that, the total numbers of households in the selected villages were obtained by contacting the village elders out of which,

three percent of the total village households were selected from each village by following the simple random sampling technique. The research work was based on the primary and secondary data wherein the primary data was collected from the farmers with the help of structured and pre-tested questionnaires through personal interview method and the secondary data was collected from the meteorological department and other concerned organizations functioning in the state (Tangjang and Sharma, 2018).

Collected data was scrutinized, tabulated and processed systematically according to the objectives laid down for the study. Tabular and functional analysis was used to meet the objectives of the study as and where needed. In order to evaluate the problems faced by the farmers, the Henry Garrett's ranking technique was used. The orders of merit given by the respondents were converted into rank by using the formula. To find out the most significant factor which influences the respondent, Garrett's ranking technique was used. As per this method, respondents were asked to assign the rank for all factors and the outcomes of such ranking were converted into score value with the help of the following formula:

$$\text{Percent position} = \frac{100(Rij - 0.5)}{Nj}$$

Whereas: Rij = Rank given for the ith variable by jth respondents

Nj = Number of variable ranked by jth respondents

With the help of Garrett's Table, the percent position estimated was converted into scores. Then for each factor, the scores of each individual are added and then total value of scores and mean values of score was calculated. The factors having highest mean value is considered to be the most important factor.

RESULTS AND DISCUSSION

The farmers of Arunachal Pradeshregion mostly practices organic method of cultivation of crops with minimum usage of chemical input in the farms. The farmers of the state have cultivated rice and maize since a long time ago and have a number of local varieties grown in the fields for various purposes. Some of the local varieties of rice grown in the state include Itanagar, Deku, Amka, Neori, Yagrung, Katum, Kayong, Mosina, Raling, Kolom dhani etc. The farmers have also started to grow introduced varieties like CAU R1, IR8 and Ranjit in their farms. Maize is grown in both kharif and rabi seasons. Farmers prefer to grow local varieties of maize during the winter season where as during the summers, farmers usually plant introduced varieties of maize like DKC 9165, DHH77, DHH107 and DURGA. The farmers were quiet aware of climate change and 76 percent of the respondents perceived a change in the amount of annual rainfall while 89 percent perceived a change in the timeliness, distribution and duration of rainfall. The villagers also exhibited basic awareness regarding the causes of climate change like deforestation and Green House Gases and cited various problems that it has caused in agriculture in their area.

Both the rice farmers as well as maize farmers reported a declining yield of their crops throughout the study period and the particular constraint was ranked the highest according to Garrett's ranking with an average score of 66.00 per cent and 64.62 per cent for the rice and maize farmers respectively. The constraint that was ranked second by both the rice and maize farmers was increasing pest and disease infestation in their fields. Some farmers also reported that some insects which were considered as minor pest with negligible damage to the crops had lately been the cause of major infestations causing major losses in yield and income if the farm family. Various districts of Arunachal Pradesh including East Siang, Upper Siang, Siang and Lower Siang reported a massive infestation of the rice fields by white-blacked plant hopper, brown plant hopper, green plant hopper and spiny beetle. These pests were initially had been previously seen and observed to be localized. However, the recent years had witnessed a sudden multiplication and quick spread of the pests going beyond the threshold level up to fifty per cent (Tangjang and Sharma, 2018).

Various constraints faced by the rice and maize farmers of arunachal pradesh

The rice farmers ranked unpredictability of weather condition as the third, increasing weed infestation as fourth and degrading quality of produce as fifth most important problems faced by them. In case of the maize farmers, increasing weed infestation was ranked third, followed by unpredictability of weather and degrading quality of produce.

Various mitigation and adaptation measures followed by the farmers in view of the problems faced by them due to climate change

1. Change in the timing and intensity of rainfall during various stages of crop growth.

According to the rice growing families from East Siang, about three to four decades ago, the sowing of rice was done around the month of May as it was during this month that the region witnessed the onset of monsoon. The farmers pressed on the requirement of rain during various stages of crop growth especially during the active tillering stage for a higher yield and the detrimental affect delayed rainfall has on the yield. However the farmers of the region have reported witnessing delayed monsoon since the past two decades which had caused reduced yield for the local varieties.

Keeping in view the need for proper rainfall during the active tillering stage of crop growth, the farmers have now adjusted their agricultural calendar and shifted the sowing time of the concerned crops from the month of May to June-July.

The farmers also observed improper filling of grains (*amiang*) and thus low yield whenever there is heavy rainfall during the flowering and grain-filling stages of the crop (August). Other phenomenon reported was that heavy

Table 1. Garrets Ranking of the major concerns faced by the rice and maize farmers of Arunachal Pradesh

Factor no.	Factors / constraints	Ranking by rice farmers		Ranking by maize farmers	
		Average score	Rank	Average score	Rank
F1	Decreasing yield	66	1	64.62	1
F2	Degrading quality of the produce	29.2	5	27.31	5
F3	Unpredictability of the weather	52.4	3	43.08	4
F4	Increasing Pest and disease infestation	65.8	2	61.92	2
F5	Weed infestation	36.6	4	53.08	3

rainfall during maturing stage of the crop (late September to October) leads the filled grains to germinate while it is still on the plant, before it is even harvested. Such seeds then become unfit for consumption and hence cause losses to farm family.

Since different varieties of rice have different crop durations, the farmers have hence accordingly adjusting the sowing time as well as harvesting time of the particular clops to tally along with the crop duration of various varieties grown in order to avoid undesirable weather conditions during the various stages of crop growth and harvest period.

Reduced volume of water in the mountain streams.

The paddy farmers rely on mountain streams to irrigate their rice fields along with the annual rainfall. They claim that the fields irrigated with mountain stream water produced crops with higher yield with better tasting grains. They have also observed a reduction in the volume of the stream water in the past decade along with rapid felling of trees in the mountain forests. The village communities then soon came to a conclusion that the two phenomenon were interconnected

The villagers have since collectively decided to avoid unnecessary and extensive chopping down of trees to avoid drying up of the river streams which is regulated by the village elders.

Heavy and untimely rainfall during sowing season of maize.

The maize farmers of Lohit district have reported that the uncertainty in the amount and duration of rainfall has caused farmers great distress in planning their farm activities. Though light rainfall is preferred and welcome during the sowing seasons for maize, the crop can't stand heavy rainfall and flooding of fields causing great losses to the farmers.

The farmers have hence shifted the maize fields to highland areas where there is less chance of flooding in order to mitigate the problem. Also, in case the farmers are halfway through sowing the maize in their fields and the place witnesses sudden heavy rainfall with high risks of flood, they sow the rest of the field with leguminous crops like black eyed beans, soyabeans, rice bean and hyacinth bean.

CONCLUSIONS

The study showed that 76.00 per cent of the respondents perceived a change in the amount of annual rainfall while 89.00 per cent perceived a change in the timeliness, distribution and duration of rainfall. In a Garrett's ranking analysis of the various constraints faced by the paddy and maize farmers, decreasing yield was ranked first with an average score of 66.00 per cent and, 64.64 per cent by the paddy and maize farmers respectively. Increasing disease and pest infestation was ranked second scoring an average of 65.8 per cent and 61.92 per cent by the rice and maize growers respectively. Other problems included increasing weed infestation, unpredictability of weather and degrading quality of the produce. The paddy and maize farmers have adapted to the various challenges faced by them due to the change in climatic condition by adopting new cultivation practices like changing their agricultural calendar, introduction of climate resilient varieties, and switching to other crops with low risks and higher returns. Understanding the fact that Climate change has created challenges for the agricultural sector, and will continue to do so it is necessary that Policy reforms be made within and beyond the agricultural sector to strengthen farmer incentives to achieve sustainable productivity growth without sacrificing climate change mitigation and adaptation. Some of which can include improvement in extension services in order to ensure efficient dissemination of necessary and up-to-date information, adoption of risk sharing and transfer schemes, promoting community based risk management tools, developing crop monitoring system, climate forecasting as well as mapping of vulnerable areas, encouraging environment friendly agricultural practices, resource use efficiency, shift to sustainable agriculture, crop diversification etc.

Policy measures

It is well accepted fact that Climate change has created challenges for the agricultural sector, and will continue to do so. However, the extent of affect it has is dependent on how we respond to the change. Climate change adaptation can be understood as the spontaneous or organized processes by which human beings and society adjust to changes in climate. It can be done by making changes in production systems and social and economic organization in order to reduce vulnerability to changing climatic conditions. Adaptation in agricultural sector is essential in order to enhance its capacity to deal with climate change conditions, improve the resilience and reduce its vulnerability to changing climate. Policy reforms are hence needed within and beyond the agricultural sector to strengthen farmer incentives to achieve sustainable

productivity growth without sacrificing climate change mitigation and adaptation.

Some of the policies that can help farmers with recognizing and understanding the affect that climate change has on agriculture as well as equip them with means to adapt to and mitigate the problems that is caused due to climate change are: -

a) The Government should improve extension services in order to ensure efficient dissemination of necessary and up-to-date information regarding climate changes, problems and various mitigation and adaptive measures to overcome them to the farmers. For example, conducting climate change awareness programmes

b) Government and agriculture related institutions can come up with means to encouraged farmers to adopt risk sharing and transfer schemes such as crop insurance, compensation and calamity funds. Promoting community based risk management tools like grain banks and self help groups can also help the farmers to lower the risks.

c) It is highly necessary that the concerned institutions concentrate on developing crop monitoring system, climate forecasting as well as mapping of vulnerable areas as well as timely transfer of the information to the farmers.

d) It is important to understand that it is the human activities that have caused accelerated climate change and it includes agricultural activities. The need to feed the ever-growing population of the earth has caused massive stress on agricultural lands leading to transformation of more forest lands into agricultural lands, intensive cropping, excessive use of chemical fertilizers and pest control which has led to soil, water and air pollution, which on the other hand contributes to climate change. It is therefore necessary to encourage the farmers to shift to more environment friendly practices without compromising their income or the environment. Farmers should be encouraged to use resources efficiently, shift to sustainable agriculture, crop diversification etc.

e) Introduction of climate resilient and pest resistant varieties.

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