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Farmer's perceptions on climate change and adaptation strategies in Nalgonda District of Telangana, India

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Abstract
This study is aimed at analyzing farmers' perception and adaptation to climate change in the Nalgonda district of Telangana State, India. It is based on analysis of data collected from 150 farmers selected randomly substantiated with Focus Group Discussions and field observations. Perception of farmers towards climatic change indicated reduction in annual rainfall, delayed onset of rainfall and early withdrawal of rainfall. Poor crop yield, reduced irrigation and drinking water availability, reduction in forest area and low availability of fodder for livestock were perceived as the changes in agricultural activities due to climate change. Adaptation strategies followed by farmers to face climate change varied from changing cropping pattern, crop diversification, and reduction in livestock to growing low input and crops requiring low water. Support of extension services is crucial for disseminating knowledge of new Climate Smart Agricultural Practices and climate-change adaptation plans to rural farmers to enable them to face adverse effects of climate change.

Keywords: Farmer's perceptions, climate change, adaptation strategies, Telangana, India

Introduction
Farming activities rely on favourable climate conditions and are at risk under a changing climate (Porter *et al*., 2014) [30]. Several studies have examined farmer perspectives of climate change and its risks, as well as the potential adoption of adaptation and mitigation behaviors (Arbuckle *et al*., 2013; Niles *et al*., 2013; Niles *et al*., 2015; Prokopy *et al*., 2015) [4, 27, 28, 31]. Climate change affects agriculture in two ways direct and indirect. Changes in climatic factors (for example, temperature, and rainfall) affect agricultural productivity through physiological changes in crops (Chakraborty *et al*., 2000). In addition, climate change also affects other factors of production agriculture, such as water availability, soil fertility, and pests (Porter, 2014) [30]. The overall effect of climate change on agriculture could be positive or negative; the magnitude of impact can also vary from very low to very high, depending on regional or geographical location and status of socioeconomic development (Mendelsohn *et al*., 2006 and Tripathi, 2016) [3].

The adverse impact of climate change on Indian agriculture has been elucidated upon by several researchers (Auffhammer *et al*., 2012; Gupta *et al*., 2014; Jha and Tripathi, 2017; Lobell *et al*., 2011; Pattanayak and Kumar, 2014; Bapuji Rao *et al*., 2014) [22, 8, 21, 7].

According to the Economic Survey of India 2018, around 52% (73.2 million hectares area of a total 141.4 million hectares net sown area) of India's total land under agriculture is still unirrigated and rain-fed, thus the farm sector could be in trouble due to climate change. The change in agricultural productivity patterns as a result of climate change could reduce annual agricultural incomes by between 15% and 18% on average, and between 20% and 25% particularly for unirrigated areas. Temperatures in India are likely to rise by 3-4 degree Celsius by the end of the 21stcentury (Pathak, Aggarwal and Singh, 2012) [29]

Adaptation to climate change is a two-step process, which initially requires the perception that climate is changing and then responding to changes through adaptation. Adaptation is an efficient and friendly way for farmers to reduce the negative impacts of climate change (Füssel and Klein 2006) [13]. According to IPCC (2007) [18], adaptation to climate change refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or its effects, which moderates harm or exploits beneficial opportunities. Moreover, adaptation decision is location-specific and influenced by key drivers such as socio-economic, environmental, and institutional factors.

This study is aimed at analyzing farmers' perception and adaptation to climate change in the Nalgonda district of Telangana State, India. It is based on analysis of data collected from 150

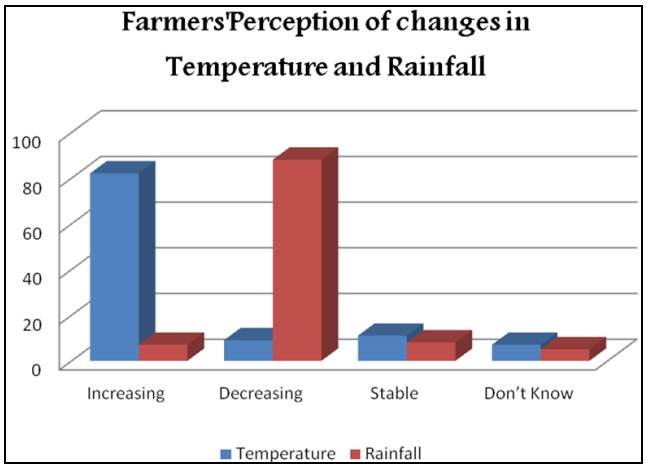
farmers selected randomly substantiated with Focus Group Discussions and field observations.

Materials and Methods

Under this project data was collected from farmers of three villages, Chelma Reddy gudem, Hazari Gudem and Naidu Palem of Anumula Mandal of Nalgonda district of Telangana State, India, on perception of farmers towards climatic change and adaptation strategies followed by farmers to face climate change. Data was collected from farmers on their perception of weather changes in the past 20 years, causes of climate change, changes in agricultural practices adopted by farmers, factors affecting decision to grow crops and adaptation strategies being adopted by farmers to face climate change. The survey was conducted in the 2016-17 agricultural production year through semi- structured interview schedule.

Results and Discussion

The farmer perceptions of long-term temperature and precipitation changes indicated that 82% of them felt temperatures have risen, followed by decreased temperature, no change and don't know respectively. Temperatures have increased steadily over the years as reported by the farmers, with both average maximum and minimum temperatures increasing. With regard to rainfall, 88% perceived that rainfall has decreased, 7% reported it has increased followed by no change and don't know (Figure1). Climate change is altering temperatures, rainfall patterns, regional climate variability and the incidence of extreme event incidence (IPCC 2013) [17].



Source: Primary study

Fig 1: Farmer perceptions of long-term temperature and precipitation changes

Changes in climatic conditions

Changes were also observed in total annual rainfall amount as reported by 78 percent farmers, delayed onset of rainfall, early withdrawal of rainfall by 67 and 53 percent farmers respectively (Table 1). Moreover, the farmers reported that the number of rainy days showed a decreasing trend, especially during the critical months of crop growth (April - June and September – November). Rainfall intensity has become more variable and erratic impacting negatively on soil moisture content and availability, thus leading to either reduced crop yields or total crop failure as reported by 63 percent farmers. Rainfall patterns within and between seasons are highly variable. The erratic onset and cessation of rains makes it difficult for farmers to plan for their cropping activities and increased incidences of insect pest attack and monkey menace were reported by 46 and 29 percent farmers respectively.

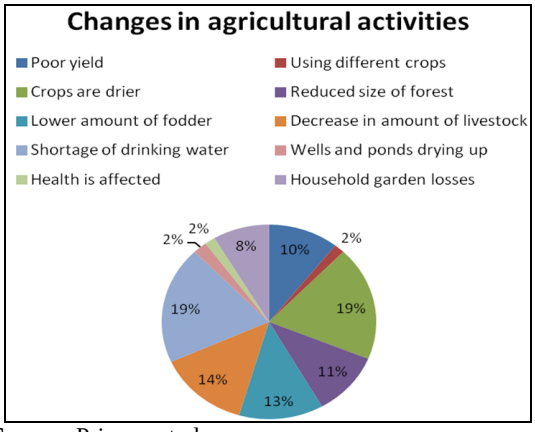
Table 1: Changes in climatic conditions as perceived by farmers

S.no	Climatic conditions	Percentage
1	Reduction in amount of rainfall	78.0
2	Delayed onset of rainfall	67.0
3	Early withdrawal of rainfall	53.0
4	Rise in temperatures	81.0
5	Crop loss	63.0
6	High incidence of insect and pest attack	46.0
8	Monkey menace due to deforestation (unable to grow fruit trees and vegetables)	29.0

Source: Primary study

Changes in agricultural activities

Farmers of the study area reported the following changes in agricultural activities due to climate change (figure 2). Poor crop yield, reduced irrigation and drinking water availability, reduction in forest area and low availability of fodder for livestock were perceived as the changes in agricultural activities due to climate change. Studies to examine the effects of extreme weather have found that the increased variability of temperature decreased crop yield (McCarl *et al.* 2008). A number of econometric studies have shown that changes in precipitation and temperature have altered agricultural yields (Chen, C. 2004, Attavanich, W 2014, McCarl, B.A. 2008, Schlenker, W 2009) [10, 5, 33]. Climate change also alters water supply (Bates, B. *et al.* 2008) drying of wells and shortage of drinking water has been reported by farmers of the study area and many studies have shown that climate change regionally reduced river flows, as well as diminished ground water recharge (IPCC 2014 and Gurdak, J.S. et.al.2009) [19, 15].



Source: Primary study

Fig 2: Changes in agricultural activities due to climate change as reported by farmers

Adaptation strategies in agricultural sector

The adaptation to climate change necessitates the development of practices and management systems that maintain a productive agriculture for avoiding food security issues and the adaptation needs to be continual as climate change proceeds. However, the ability to adapt is limited in places by financial, human, and physical capital, as well as by lifestyle and culture barriers (Chambwera, M *et al.* 2014) [9]. Moreover, many farmers learn farming practices and potential adaptations from their elders, but additional forms of learning will be needed if climate change alters the best enterprise mix. IPCC, 2014 [19], has listed the following adaptations in agricultural sectors to face climate change.

List of adaptation strategies in agricultural sector as identified by IPCC, 2014

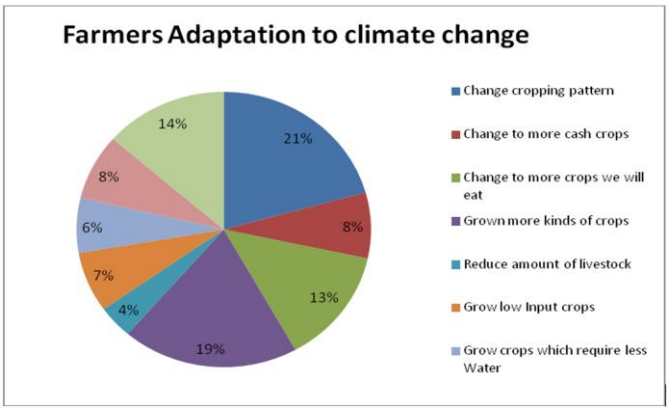
1.	Modifying planting, harvesting, and fertilizing practices for crops
2.	Changing amount or area of land under cultivation
3.	Using different varieties (e.g. early maturing, drought-resistant)
4.	Diversifying crops and/ or animal species
5.	Commercialization of agriculture
6.	Water control mechanisms (including irrigation and water allocation right)
7.	Shading wand wind breaks
8.	Conservation agriculture (e.g. soil protection, agroforestry)
9.	Modifying grazing patterns for herds
10.	Providing supplemental feeding for herds/ storage for animal feed
11.	Ensuring optimal herd size
12.	Developing new crop and livestock varieties (e.g. biotechnology and breeding)

Source: IPCC (2014) [19].

Farmers' adaptations to climate change

Agriculture and farmers are adapting to climate with locally specific adapted systems across the world. The most discussed and reported climate change adaptations for crops are changes in crop timing, crop mix/production locations and input usage. These adaptation strategies vary from region to region and depend on the exposure of the region to climate change, and the socio-economic background of the people in the region. Majority of the farmers in the study (figure 3) reported adaptations in crop management ranging from changing cropping pattern (21%), growing cash crops (8%) and growing crops for own consumption (13%). Similar findings of farmers adjusting their farming activities have been reported by Naresh Chandra Sahu and Diptimayee Mishra (2016) and Amarnath Tripathi and, Ashok K. Mishra 2017.

Several researchers' have reported similar results; Reilly *et al*. (2003) [32] documented changes in the weighted centroid of U.S. crop production for corn, soybeans and wheat. Park, McCarl and Wu (2016) examined how crop mix changes in response to temperature and precipitation through econometric analysis. Adams *et al*. (1990) [1] found climate change caused crop mix to change in a modelling study. Moving to a more diversified production system is an identified adaptation practice (Howden, S.M *et al.* 2007) [16] and farmers (19%) reported growing more diverse crops as an adaptation measure in the study area. Strategies like adjusting the stocking rate of livestock has been reported by farmers with similar results from studies of Mu *et al*. and Joyce, L.A *et al.* 2013 [20].



Source: Primary study

Fig 3: Farmers' adaptations to climate change

Conclusion

Agriculture is quite vulnerable to climate change and a wide array of adaptation activities are needed to reduce the negative effects of climate change. Perception of farmers towards climatic change indicated reduction in annual rainfall, delayed onset of rainfall and early withdrawal of rainfall. Poor crop yield, reduced irrigation and drinking water availability, reduction in forest area and low availability of fodder for livestock were perceived as the changes in agricultural activities due to climate change. Adaptation strategies followed by farmers to face climate change varied from changing cropping pattern, crop diversification, and reduction in livestock to growing low input and low water requiring crops. Successful implementation of CSA requires considerable efforts from a variety of stakeholders. Moreover, achieving the objectives of CSA requires changes in the behaviour, strategies and agricultural practices of farming households by improving their access to climate resilient technologies and practices, knowledge and information for increasing productivity, inputs and market information; information and assistance with income diversification; as well as organizing themselves better for collective action.

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