

Farmers' Perceptions, Attitudes and Adaptions towards Climate Change in Selected Semi-Arid Districts of India: Implications from an Adaptation View

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Authors' contributions

This work was carried out in collaboration among all authors. All authors contributed the intellectual input and assistance to this study and manuscript preparation. Author KRS is the PI of the research project. Authors KRS, KN, GN, CNAB and JR selected variables and developed the questionnaire based on study objectives. Authors KRS, KN, GN, SVK and KS collected data. Authors KRS, BMKR and PKP performed data analysis and tabulation. Author KRS wrote the paper with editing done by author CARR, IS and CSR. All authors read and approved the final manuscript.

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ABSTRACT

The effects of climate change on agriculture are being witnessed all over the world. Rainfed agriculture is likely to be impacted severely in view of its' high dependency on monsoon, the likelihood of increased extreme weather events due to aberrant behavior of south west monsoon. Anantapur, Akola, Solapur and Bijapur districts in India were selected for the study because, rainfed area is more than irrigated area and rainfall is the most critical factor affecting crop production in

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these districts. Major perceptions of climate change in the four rainfed study districts were prolonged dry spells, rise in temperatures, and delayed and shorter rains. Major adaptation measures towards climate change in four study districts were insurance, change in planting dates and cropping pattern. Majority of farmers positively agreed with attitude towards climate change statements which augurs well for current and future adaptation actions. As farm-level adaptation becomes an increasingly important across the world, policies at all levels will need to be accounted for appropriate factors, including perceptions and how perceptions affect human behavior and adaptive actions. Adaptation through transformation (in the present study diversify to livestock and work as labor) has the potential to become an inclusive, engaging and empowering process that contributes to alternative and sustainable development pathways which needs to be encouraged. The present findings contribute to research on climate change adaptation decision making both as a function of intra-individual processes such as knowledge, attitudes; and extra-individual factors like policies, infrastructure, information, forecasts etc. along with socio-economic contributory factors which deserve due attention in the light of scaling up adaptations.

Keywords: Adaptions; infrastructure; population; rainfed area.

1. INTRODUCTION

Global climate change is widely viewed as one of the most significant challenges society is facing today. Agriculture, upon which society depends for the food, feed, and fiber that enable sustainable livelihoods, is one of the sectors that is most vulnerable to shifts in climate [1,2]. In particular, arid and semi-arid areas are often challenged by the demands of existing climatic variability, and it is expected that climate change will have significant implications for water resources in these areas [3,4].

Countries especially like India are highly vulnerable in view of the large population depending on agriculture and excessive pressure on natural resources. Bapuji Rao et al. [5] found a decline in paddy yield by about 411–859 kg/ha due to a rise in 1°C temperatures. The studies conducted by the Indian Agricultural Research Institute (IARI) and other institutions shows the possibility that for every 1°C rise in temperature annual wheat production would decrease by 3% whereas production of rice would decrease by 10% [6]. Further Pathak et al. [7] concluded that negative trends in solar radiation and an increase in minimum temperature has resulted in declining trends in productivity of rice and wheat in the Indo-Gangetic plains of India. According to National Rainfed Area Authority of India [8], about 60% of the total cultivated area in India still relies on natural rainfall (rainfed agriculture) and hence changes to rainfall patterns are a significant threat to India's agrarian economy. In addition, drought increases the chance of food insecurity, shortage of drinking water, health problems, migration for work, and debt etc.

Udmale et al. [9] reported that recurring drought is a major challenge in Maharashtra State, Central India.

The vulnerability of communities to climate change is influenced by the ways in which they are affected by climate conditions and by the manner in which they can moderate effects or risks through adaptive strategies [10,11,12]. Although, the choice of adaptation interventions depends on a country's peculiar circumstances, Vincent [13] identified the main factors constituting the adaptive capacity of a country to include, economic well-being and stability, demographic structure, global interconnectivity, institutional stability and well-being, and natural resource dependence. Woods et al. [14] explained on Model of Private Proactive Adaptation to Climate Change (MPPACC) and found a positive correlation between Danish farmers' concern about climate change and intended adaptation to negative impacts. According to Smit & Pilifosova [15], "Adaptive capacity is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change." Adaptive capacity is determined by various factors including recognition of the need to adapt, willingness to undertake adaptation, and the availability of, and ability to deploy, resources [16].

The objectives of the present study are to identify farmers perceptions/ knowledge, attitudes towards climate change (here we focus on one of the implications of climate change in semi-arid areas, i.e. water scarcity leading to droughts), to find out their major farm-level adaptation measures, to find out the relationship between different socioeconomic characteristics of

farmers with their adaptation strategies and, suggesting appropriate research/policy issues which can help in facilitating farmers adaptation to climate change. Drought (in this study) is considered to have set in when rainfall and soil moisture availability to plants has dropped to such a level that it adversely affects the crop yield and hence agricultural profitability. Farmers perceptions are the most important predictor of adaptive action. Risk perceptions are an important predictor of adaptive intentions given that researchers have found strong relationships between positive attitudes towards adaptation and higher levels of perceived climate risks [17,18,19]. Therefore, a higher perception of climate risks will influence an individual's decision to adopt adaptation strategies [20,21]. It is essential to know how perceptions and actions influence one another, to understand what physical changes in climate may prompt a change in farmers' opinion, and by extension, a change in action. Beyond understanding opinions regarding the concept of climate change, understanding perceptions of climate change is of particular importance because it will influence the adaptive behavior that individuals are likely to take. Opinions are views or judgement formed about something (here climate change), not necessarily based on facts, whereas, perceptions are becoming aware through involving senses which results in action/behavior. Identifying the knowledge, attitude, and farmers' adaptation behavior to climate change is vital in order to facilitate a societal response to the changes in climate that scientists have predicted. Hence, the present study is planned to understand whether or not all factors i.e. farmers internal, external, socioeconomic help adaptive actions towards climate change.

2. METHODS

The study was conducted in the three different states of India viz., Andhra Pradesh, Karnataka and Maharashtra where All India Coordinated Research Project for Dryland Agriculture (AICRPDA) centers are located duly reflecting chronic drought conditions in red and black soils. The selected AICRPDA centers (districts) are Anantapuramu in Andhra Pradesh, Bijapur in Karnataka, Akola and Solapur in Maharashtra (Fig. 1). These districts were selected for the study because, here rainfed area is more than irrigated area and rainfall is the most critical factor affecting crop production. The average annual rainfall is 560 mm, 553 mm, 800 mm and

545 mm in Anantapuramu, Bijapur, Akola and Solapur respectively. Climate is semi-arid in Anantapuramu and Bijapur; Akola has a tropical savanna climate bordering humid subtropical climate, while, Solapur has an arid and semi-arid climate. Major crops grown in Anantapuramu are groundnut; sorghum, maize, bajra and wheat are the major crops in Bijapur; cotton, soybean and sorghum are the essential crops grown in Akola; major crops grown include sorghum, wheat and sugarcane in Solapur. The average landholding size in all the districts is less than 2 hectares. The common characteristic across the four locations are farmers are resource poor with low education, meager land holdings, low incomes and low risk taking capacity. These characteristics are similar to any semi-arid dry region farmer and is widely quoted in literature review across the world.

A sample of 240 households at the rate of 60 from each center was selected randomly for data collection representing a minimum of 20% of the population of selected area. One district was selected under each center. From each district one mandal (a mandal is a unit of administration above village and below district level in a state and comprises several villages) and from each mandal two villages were selected. From each village, thirty farmers were selected for data collection. Simple random sampling was followed for selection of villages and farmers. Data was collected using a structured and pre-tested interview questionnaire from the farmers. Focus group discussion (FGD) and interviews were conducted to elicit data from farmers. These tools were helpful in collecting both qualitative and quantitative data. Two FGDs were conducted in each village and each group had ten farmers'. The FGDs were not mixed gender. Thirty household interviews were conducted in each village. The main theme on which data collected was about farmers' knowledge on climate change and its' impacts on agriculture. *Eguvapalli* and *Chakraipet* were the villages selected from Anantapuramu, while, *Varkhed* and *Kajaleshwar* were the villages from Akola. *Mangrul* and *Mundewadi* were the villages selected from Solapur, while, *Honnutagi* and *Hadagali* were the villages from Bijapur. Frequency, Percent analysis, correlation and regression coefficients and adaptation indices were used for data analysis. Likert method of summated ratings procedure was used for constructing attitude scale. The attitudes in the study are ordinal scales viz., Agree (A), Undecided (UD) and Disagree (DA) on a three-

point continuum with scoring of 1, 2 and 3 assigned to A, UD and DA respectively. Since attitudes precede actions, this component is important in predicting farmers' behavior. In this study, it was found that majority of farmers positively agree with attitude towards climate change statements which point to current and future positive adaptation actions towards climate change.

The steps followed for constructing the Likert type of scale to measure the attitude of farmers towards climate change was as follows [22]:

- i) Collection of statements: As such, 60 statements representing the attitude of farmers towards climate change were collected randomly after consulting with scientists, experts in the area and review of available literature.
- ii) Editing of the statements: These statements were edited according to the criteria laid down [23]. Finally, out of 60, 49 statements, which satisfied the criteria, were selected.
- iii) Selection of statements and scoring technique: The selected 49 statements were administered to a group of 60 respondents from the non-sample area. The respondents were asked to indicate their degree of agreement or disagreement with each on a three-point continuum i.e. Agree (A), Undecided (UD) and Disagree (DA). The scores for positive statements were assigned as 3, 2 and 1 for A, UD and DA respectively. For negative statements, the scoring was reversed. The scores were then summed up to find out the total score of each respondent for all statements. The subjects were then arranged in an array based on the total score obtained by them. The top 25 percent of the subjects with highest score (high group) and 25 percent of the subjects with lowest score (low group) were used as criteria groups.
- iv) Critical ratio (t value): The critical ratio i.e. t-value which is a measure of the extent to which a given statement differentiates between the high and low groups of respondents for each statement was calculated. Finally, 22 statements were selected whose t-values were equal to or greater than 1.75. In order to avoid agreement bias, positively and negatively worded statements were included interchangeably.
- v) Reliability: The reliability of the scale was found out by using split-half method which was 0.82, which was high. Split-half reliability is determined by dividing the total set of items (e.g., questions) relating to a construct of interest into halves (e.g., odd-numbered and even-numbered questions) and comparing the results obtained from the two subsets of items thus created.
- vi) Validity: As all the possible items covering the universe of content were selected by discussion with experts, resource personnel and available literature on the subject, the present scale satisfied the content validity.

3. RESULTS AND DISCUSSION

3.1 Farmers Perceptions towards Climate Change

Perception of climate change is a necessary prerequisite for adaptation. From Table 1, it is evident that prolonged dry spells, rise in temperatures and rainfall outside rainy season are the major farmers' perceptions towards climate change in all the selected study locations. The focus group discussions suggested that farmers perceive the rainy period to be shorter now, coming at random compared to the previously longer and more reliable periods with heavy rainfall. Farmers perceived the late onset and less frequent more intense rainfall as 'shorter duration rains'. Farmers perceived that the signs for forecasting rain like clouds, wind movement etc. has lost accuracy in recent years, a possible explanation of climate change. It has been observed by the researchers in this study that prolonged dry spells has become a recurrent phenomenon year after year. Therefore, farmers are unsure of when the next rain would occur. In this context, adaptation by water harvesting and storage assumes significant importance for providing critical and supplemental irrigation to the crops as and when required. Another disturbing characteristic of the south west monsoon in the kharif season is heavy rains towards the end of the crop growing period and subsequent damage to the crop produce coinciding with harvesting period. This is untold misery for farmers' after toiling hard for the entire season. Similar studies in Ethiopia and South Africa revealed that farmers experienced increased temperature and decreased rainfall [24]. Similar observations of rise in temperatures and decreased rainfall were reported in their

studies by Vedwan and Rhoades 2001 [25]; Hageback et al. 2005 [26]; Dejene 2011 [27]. Results of a study conducted in Bundi district of Rajasthan, India revealed farmers' perceptions to climate change as increase in temperatures, decreased rainfall and long dry spells. Studies in several other developing countries indicate that most farmers perceive temperatures to have become warmer and rainfall reduced over the past decade or two [28,29,30,31].

3.2 Farmers Adaptations towards Climate Change

The present study revealed the following adaptations practiced by the farmers towards climate change in the four study locations.

Table 2 indicated that buying insurance, changing planting dates and cropping pattern, diversify to livestock and work as labor were the major adaptation measures followed by farmers towards climate change in the selected four study locations. Usually, farmers in Anantapuramu sow groundnut during July last week every year. But recent trend shows that if one rain occurs during summer month of May or early June, some of the farmers are going for sowing to reap some benefit thinking the worst case scenario may occur during that year i.e., drought. This finding is consistent with similar study by Swanson et al. [32] which reported that crop insurance was widely used by farmers in foremost region of Canada (which is under similar agro-ecological conditions) and the common feeling was that even though it might not provide sufficient returns for losses incurred it does offer some protection. It has allowed them to continue farming. Agricultural insurance can help people to cope with the financial losses incurred as a result of weather extremes. Insurance supports farmers as one of the adaptation processes and prevents them from falling into absolute poverty. Apart from stabilizing household incomes by reducing the economic risk, insurance can also enhance farmers willingness to adapt, to make use of innovations and invest in new technologies [33]. Changing crops has been demonstrated in the literature as a common adaptive behavior by farmers in the face of changing circumstances [34,35,36]. In a study in the Ejura-Sekyedumase district of Ghana, it was found that 93% of farmers were of the opinion that the timing of rains is now irregular and unpredictable [37].

Some of the values in the Table 2 show '0' because these are the absolute values showing absolute percent. Zero means no farmer had adopted that particular adaptation measure in question. Hence, no mean and error values are presented here. Large values are because these are multiple responses taken from farmers.

Agricultural adaptation involves two types of modifications in production systems (this was observed both in the field sites and literature). The first is increased diversification that involves engaging in production activities that are drought tolerant and or resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing water and temperature conditions, among other factors. Crop diversification can serve as insurance against rainfall variability as different crops are affected differently by climate events [38,39]. The second strategy focuses on crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts. Crop management practices that can be used include modifying the length of the growing period and changing planting and harvesting dates [38]. Smallholder farmers can adapt to climate change by changing planting dates and diversifying crops [40]. Similar reports of planting different crops as an adaptation strategy by 74% of farmers in a study [41] in Oyo state of Nigeria.

Under diversify to livestock in these dryland regions usually means that the farmers would rear sheep and goat, and sell them as a contingent strategy to tide over the situation particularly, if monsoon fails and drought occurs. Small farmers usually migrate during the event of failure of monsoon to work as contract labour which also serves as one of the adaptation practices in rainfed areas [42]. Water harvesting is one particular practice that has proved to be climate resilient among farmers and reaped rich dividends to them. Farm ponds, percolation tanks and bunds across the slope are a common and welcome sight in the study villages to the researchers. Water harvesting along with the use of modern micro-irrigation practices such as sprinkler and drip irrigation as an adaptation strategy is well established and should be promoted aggressively in similar dry regions of the world. Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is one government program in India which has clearly made impacts in the lives of rural people by

providing 100 days of employment to poor people by way of labor and improving the groundwater resource of the area. Dry regions like Anantapuramu have been benefited enormously by constructing water harvesting pits/structures wherever possible with technical checks. "The rainwater harvested is helping us during periods of dry spell. Groundwater levels are increasing as well, providing us enough for irrigation and cattle rearing" said a farmer from Anantapuramu. These farm ponds are vital to increase storage of rain water, to improve recharge of bore wells, and to provide wage employment to agricultural labor. Rain Water Harvesting (RWH) increases the amount of water available for agriculture and livelihoods through the capture and storage of runoff, while at the same time reducing the intensity of peak flows following high-intensity rainfall events. It is therefore often highlighted as a practical response to dryness (i.e., long-term aridity and low seasonal precipitation) and rainfall variability, both of which are projected to become more acute over time in some dryland areas [43,44]. A global meta-analysis of changes in crop production due to the adoption of RWH techniques noted an average increase in yields of 78%, ranging from -28% to 468% [45].

MGNREGA: Mahatma Gandhi National Rural Employment Guarantee Act (a Government of India sponsored social security scheme in rural areas).

3.3 Trend analysis of Annual rainfall and Temperature over the Four Study Districts

The long-term meteorological variables viz., annual rainfall and temperature were subjected to trend analysis for the four study districts from 1976-2019 and it was observed that the average rainfall was 594 mm., 1046 mm., 590 mm. and 861 mm. for Anantapuramu, Akola, Bijapur and Solapur respectively. The average seasonal rainfall (from May to October) for the above four districts were 512 mm., 945 mm., 520 mm. and 786 mm. respectively in that order. The maximum temperature was the highest for Bijapur at 42°C and the minimum temperature showed highest for Akola at 14.6°C. Rainy days were highest for Solapur at 66, while least rainy days were observed in Bijapur at 36.4. After comparing this trend data with actual farmers' perceptions data (Table 1), results coincided on two parameters. First in Anantapuramu, average seasonal rainfall was lowest at 512 mm. which

was reflected in highest percent of farmers' (70%) among four study districts indicating delayed and shorter rains. Second, rainy days were least in Bijapur (36.4), which was reflected in highest percent of farmers' (52%) among four districts indicating rainfall outside rainy season.

3.4 Computation of Adaptation Index to Assess the Extent of Farmers' Adaptation to Climate Change

Adaptation was judged through assigning score of 1 for each practice/measure adapted. In the present study, total adaptation measures were 10, and hence maximum adaptation score that could be obtained is 10, while minimum adaptation score that could be obtained by a farmer is 0. The ten adaptation measures in the study were 'buy insurance', 'change in planting dates and cropping pattern', 'planting different crops, diversify to livestock', 'work as labor', 'construct water harvesting structures under MGNREGA', 'timely availability of inputs', 'drought resistant crops', 'contingency crop planning' and 'spray urea'. These were recommended after consulting with scientists, experts in the area and review of available literature. Since all the ten measures were considered under adaptation and analysis was done with this assumption, 'spray urea' in this study was considered as adaptation measure and not as a coping strategy. Adaptation index was computed for assessing the extent of adaptation.

$$\text{Adaptation index} = \frac{\text{Adapted measures}}{\text{Total recommended measures}} \times 100.$$

The index values were in decimals and were rounded off to the nearest number in the first place. Later, the decimal values were reinstated in Table 3. However, being an absolute measurement there is no point in indicating the error values. The mean adaptation index for the four study locations are presented in Table 3. Farmers in Anantapuramu showed high adaptation when compared with other three locations as they are more receptive (higher perceptions of climate change than other three districts) and already adapting to climate change when compared to other centers. Also, they are accustomed to perpetual droughts year in and out. A higher adaptation index in this study infers higher resilience to combat drought and vice versa.

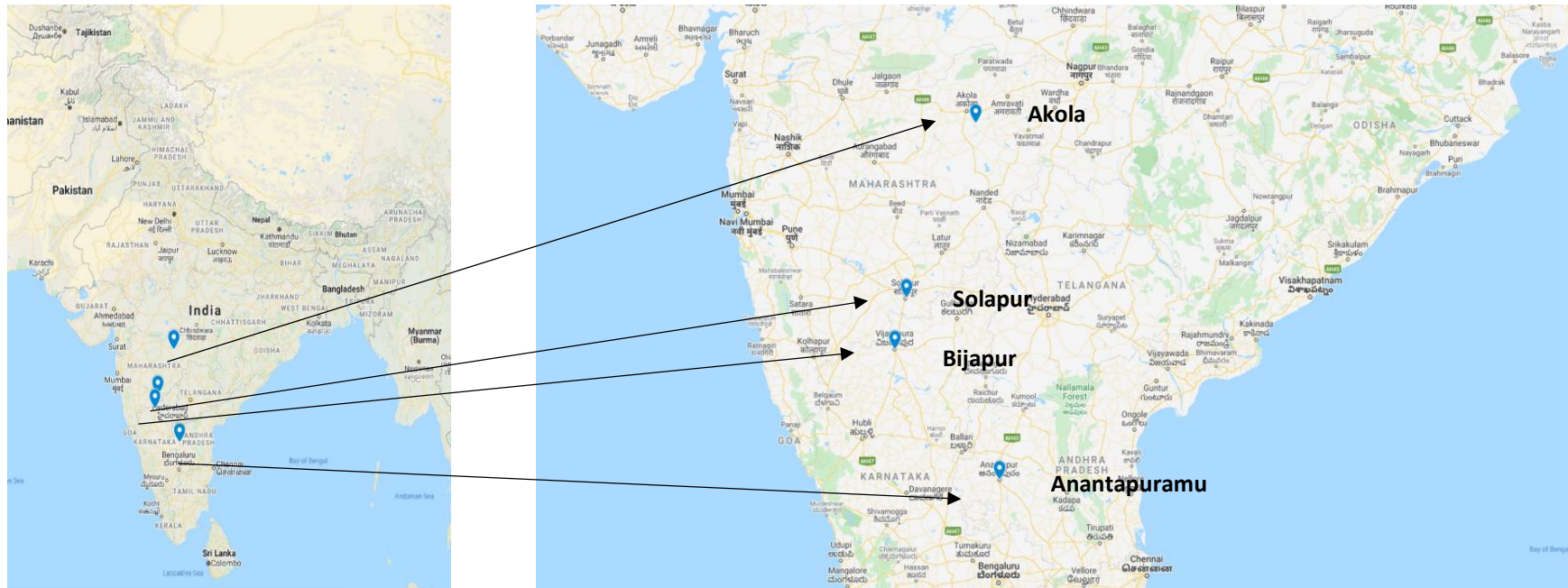


Fig. 1. Map showing selected study districts of India

Table 1. Farmers perceptions regarding climate change

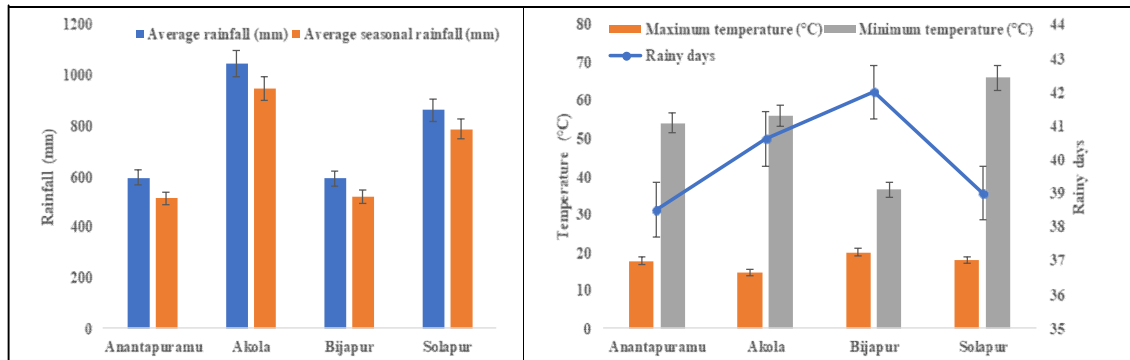
S. No.	Major farmers' perceptions	%*			
		Anantapuramu	Akola	Solapur	Bijapur
1.	Prolonged dry spells.	80	45	63	27
2.	Rise in temperatures.	78	92	50	28
3.	Delayed and shorter rains.	70	63	48	50
4.	Extended breaks in monsoon.	63	43	32	28
5.	Rainfall outside rainy season.	43	41	42	52

*Multiple responses

Table 2. Farmers adaptations towards climate change

S. No.	Major farmers' adaptations	%*			
		Anantapuramu	Akola	Solapur	Bijapur
1.	Buy insurance.	93	0	15	25
2.	Change in planting dates and cropping pattern.	87	68	77	45
3.	Planting different crops.	0	0	65	35
4.	Diversify to livestock.	65	0	27	23
5.	Work as labour.	60	0	0	0
6.	Construct water harvesting structures under MGNREGA.	58	0	50	0
7.	Timely availability of inputs.	0	60	0	0
8.	Drought resistant crops.	0	60	0	0
9.	Contingency crop planning.	0	53	0	0
10.	Spray urea.	0	52	0	30

*Multiple responses



Average long-term rainfall characteristics (1976-2019) Average long-term temperature and rainy days characteristics (1976-2019)

Fig. 2. Long term meteorological variables trend in selected semi-arid districts of India
(Source: Author's own compilation)

Table 3. Adaptation index of farmers

Statistic/Category	Anantapuramu (n=60)	Akola (n=60)	Solapur (n=60)	Bijapur (n=60)
Mean Adaptation index	67.3	38.2	32.6	28.9

3.5 Attitude of Farmers towards Climate Change

Attitude in this study means the degree of positive or negative feelings, beliefs of farmers towards climate change in agriculture and allied fields. Since attitudes precede actions, this component is important in predicting farmers' behavior in the present study. Logically farmers' awareness, perceptions, attitudes and adaptation measures are correct in that order. However, to emphasize more on attitudes which predicts adaptation behavior of farmers' it was presented after adaptations in a detailed manner in this study.

Attitudes of farmers towards climate change provide feedback to the research for developing tools for the decision support systems. Farmers attitudes towards climate change are likely to be affected by their opinion about acceptable adaptation strategies. A majority of the farmers (more than half of the sample population) agreed with all the attitude statements in the four study locations as given above in Table 4. Of particular interest is the way with which farmers echoed similar response about the rise in temperatures, decrease in total amount of rain, incidence of pests and diseases and that human activity is responsible for climate change. It is known that some people strongly believe that climate change is occurring and attribute it to human activity, others do not believe that it is happening, and still others are uncertain [46]. While majority of farmers believe that local or traditional knowledge systems can offer solutions to climate change, they, also acknowledge to the fact that of late traditional knowledge/indicators for rain prediction are failing. This is one area which spurs research interest. Majority of farmers from Table 4 acknowledge that God has provided for every one's need and not to every one's greed. Farmers from three out of four study locations in statement no. 11 disagreed to the fact that they do not take climate change into account while thinking about their future. Farmers were eager to have more information on options or choices to respond to climate change. Simultaneously, adaptation to other problems is more important than adaptation to climate change for farmers. This suggests that climate change is one of the many problems (not the foremost) that farmers are facing in their daily decision matrix like availability of inputs, credit, government support mechanisms and markets

etc. Farmers felt that government support to adapt to climate change is inadequate and needs to be further accelerated like by conducting awareness campaigns, trainings and education etc. Farmers have put tremendous responsibility upon scientists to solve the climate change threat and scientists should live up to the responsibility in providing good crop varieties that should possess drought tolerant and flood resistant characteristics. In this analysis, it was found that majority of farmers positively agree with attitude towards climate change statements which augurs well for current and future adaptation actions. It is critically important to understand what factor shape attitudes toward responses to climate change [47].

3.6 Correlation and Regression Analysis

Coefficient of correlation between farmers' adaptation to climate change and six selected socio-economic variables was computed and compared (Table 5). In this study, relationship analysis was not done between farmers' perceptions, attitudes with adaptation because they were adequately discussed and their interrelationship was well established. Here the authors objective is not undertaking any modelling analysis. Some of the essential socioeconomic contributory factors such as age, education, farm size, farming experience etc. were subjected to correlation and multiple linear regression to confirm their relationship with farmers' adaptation to climate change. Age was negatively significant at 0.01 level of probability while, education, family size, farm size and annual income were positively significant at 0.01 probability level. The relationship of farming experience with farmers' adaptation to climate change was negative though not significant.

Further, in order to determine the combined effect of all the socio-economic variables in explaining variation in farmers' adaptation to climate change, multiple linear regression analysis was carried out and the results are presented in Table 6. Family size, farm size and annual income were found to be contributing positively and significantly at 0.01 level of probability with farmers' adaptation to climate change. Education was found to be contributing positively and significantly with farmers' adaptation while, age was contributing negatively and significantly with farmers' adaptation at 0.05 level of probability.

Table 4. Farmers agreement with attitude towards climate change in Anantapuramu, Akola, Solapur and Bijapur

S. No.	Attitude statement	Agree (%)				Undecided (%)				Disagree (%)			
		An	Ak	S	B	An	Ak	S	B	An	Ak	S	B
1.	Climate change is a serious problem.	92	93	97	97	3	4	0	0	5	3	3	3
2.	Climate change is affecting my farming.	95	92	98	95	5	2	0	3	0	6	2	2
3.	Average temperatures are increasing.	95	88	92	94	5	5	5	3	0	7	3	3
4.	Human activity is responsible for climate change.	95	87	67	87	5	0	13	7	0	13	20	6
5.	Climate change affects small and marginal farmers more.	93	67	75	82	7	0	5	3	0	33	20	15
6.	Climate change impacted food production of my farm.	97	97	90	90	3	3	2	3	0	0	8	7
7.	Climate change affected incidence of pests and diseases.	75	93	95	93	23	7	2	3	2	0	3	4
8.	Cropping seasons in my village are changing.	85	50	72	87	12	12	2	3	3	38	26	10
9.	Local knowledge system of the area can offer solutions to climate change problems.	83	13	72	65	12	27	3	20	5	60	25	15
10.	Climate change is the anger of God for the avarice and ill ways of humans towards nature.	77	78	72	80	15	9	0	2	8	13	28	18
11.	I do not take climate change into account when thinking about my future.	73	25	32	25	15	17	10	25	12	58	58	50
12.	I am uncertain about the ability of my farm to cope with climate change.	83	75	68	55	12	15	10	27	5	10	22	18
13.	I would like more information on options to respond to climate change.	80	92	92	87	5	8	3	3	15	0	5	10
14.	I think adaptation to other problems is more important than adaptation to climate change.	53	58	60	56	2	5	15	13	45	37	25	31
15.	Prolonged dry spells experienced during kharif are part of natural climate variability.	80	70	90	92	15	13	3	3	5	17	7	5
16.	I will be more interested in climate change when I know how it will affect rainfall distribution in my farm.	85	72	95	83	12	11	0	10	3	17	5	7
17.	Rainfall patterns are changing.	92	90	95	97	8	10	2	0	0	0	3	3
18.	In response to change in rainfall patterns, I	87	63	97	82	11	0	2	8	2	37	1	10

S. No.	Attitude statement	Agree (%)				Undecided (%)				Disagree (%)			
	have changed the time of planting/harvesting in my farm.												
19.	Farmers have much bigger challenges to deal with than climate change.	90	47	85	75	8	16	2	5	2	37	13	20
20.	Government should do more to help farmers adapt to climate change.	82	95	85	88	15	0	0	2	3	5	15	10
21.	Scientists can solve the problems of climate change.	90	83	80	87	10	0	5	3	0	17	15	10
22.	The seriousness of climate change has been exaggerated.	85	45	42	51	15	22	25	29	0	33	33	20

An: Anantapuramu; Ak: Akola; S: Solapur and B: Bijapur

Table 5. Correlation coefficients between major socio-economic variables and farmers adaptation to climate change (pooled sample) n=240

S. No.	Socio-economic variables	'r' value
1.	Age	-0.318**
2.	Education	0.265**
3.	Family size	0.323*
4.	Farming experience	-0.196
5.	Farm size	0.388**
6.	Annual income	0.592**

*Significant at 5% level of significance; **Significant at 1% level of significance

The more the age, the lesser would be the farmers' adaptation to climate change. With age, farmers become fixed in their thinking patterns and hence the less inclination towards adaptation. The more the farmers are educated, the greater would be the chances of adaptation. This was due to the fact that educated farmers' does not rely on one source of information and would refer to multiple sources and take the best course of action, their adaptation to climate change would be higher. Farmers with higher level of education are more likely to adapt successfully to climate change than those with lower level of education, as high level of education has a link with access to information on improved technologies and production challenges [48]. The relationship between family size and adaptation was positively significant. As members in a family increase, their risk orientation also increases and, hence the higher the adaptation to climate change. Increasing household size increases the likelihood of adaptation. This finding is in line with the argument, which assumes that a large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks, especially during peak seasons [49]. Farming experience was found to be positive though, not significant. The R^2 value was less than 50 in the study and

non-significant farming experience contributed in part to this result. Higher farming experience accounts for increasing the likelihood of taking up adaptation strategies. This is because experienced farmers have more knowledge and wisdom about changes in climatic elements, and on best agricultural practices to adopt. The same understanding holds good for relation between annual incomes with farmers' adaptation to climate change which was positively significant. The greater the farm size, the higher the adaptation of farmers to climate change due to more adaptive capacity. With increase in acreage, the adaptation process hastens and even if some decisions go wrong, the farmer can as well compensate by the large holdings. Gbetibouo [40] found a positive relationship between farm size and the adaptation to climate change. The author also argued that adoption of an innovation tends to take place earlier on larger farms than on smaller farms. The relative importance of these socio-economic variables reflects both the economic environment and external social relations of farmers that pave the way for collective nature of enhanced adaptation towards climate change. The identified variables help policy makers to provide targeted extension and advisory services to enrich climate change understanding and support appropriate farm-level climate change adaptations.

Table 6. Regression coefficients of major socio-economic variables with farmers adaptation to climate change (pooled sample) n=240

S. No.	Socio-economic variables	Regression coefficient	Standard error	't' value
1.	Age	-0.487	0.232	-2.09*
2.	Education	0.984	0.477	2.06*
3.	Family size	0.215	0.092	2.33**
4.	Farming experience	0.349	0.288	1.21
5.	Farm size	1.733	0.347	4.99**
6.	Annual income	0.076	0.014	5.34**

$R^2 = 0.41$; *Significant at 5% level of significance; **Significant at 1% level of significance

3.7 Barriers to Climate Change Adaptation

The major barriers to climate change adaptation identified from the study locations were lack of access to credit, labor and access to water. From farmers point of view, awareness about adaptation practices is by itself not sufficient, but has to be supported with capital and labor for successful adaptation. Measures which need attention by policy makers regarding climate change adaptation that were expressed by farmers were pollution control, afforestation and development of irrigation projects. Limits to adaptation are dynamic, site specific and determined through the interaction of biophysical changes with social and institutional conditions. Exceeding the limits of adaptation will trigger escalating losses or result in undesirable changes, such as forced migration, conflicts, or poverty.

4. CONCLUSION

Present study suggested major perceptions of climate change among farmers were prolonged dry spells, rise in temperatures, and delayed and shorter rains. Major adaptations towards climate change were insurance, change in planting dates and cropping pattern, diversify to livestock and work as labor. These identified adaptation (crop management) strategies along with those that aim at soil management like conservation tillage, mulching, nutrient recycling etc. and water management like irrigation scheduling, water harvesting etc. too should be promoted and supported by governmental and non-governmental agencies if, farming situations in India has to be made resilient to climate change impacts. Results of study conducted by Mwenda et. al. [50] in semi-arid Kenya points that sampled households employ a wide range of adaptations strategies, principally crop based practices such as cultivation of fast maturing crops and crop diversification. These practices aim at building resilience, taking advantage of new opportunities and can primarily reduce the unforeseen damage and losses resulting from extreme climatic events. Hence, emphasis should be given to crop-based strategies, value addition, forecast based action and financing and localization of water harvesting. Integrated crop, soil and water management measures can be employed to reduce soil degradation and increase the resilience of agricultural production systems to the impacts of climate change. These

measures include crop diversification and adoption of drought-resilient economically appropriate plants, reduced tillage, adoption of improved irrigation techniques (e.g. drip irrigation) and moisture conservation methods (e.g. rainwater harvesting using indigenous and local practices), and maintaining vegetation and mulch cover [51]. The numerical value of adaptation index was found to be a good indicator to suggest an area was climate resilient or not.

A better comprehension of farmers perceptions towards climate change, current adaptation decisions, is needed to promote effective futuristic agricultural adaptation policies. Here, even though difficult, we need to account for how the external factors (like policies, infrastructure, information, forecasts) influence farmers' expectations and actual experiences of rainfall. Results from Mitter et. al. [52] emphasize that not only climate change and adaptation appraisal affect the formation of agricultural adaptation intention and avoidance, but personal, farm and regional characteristics are also of importance as well. This finding supports conceptual and empirical literature proposing that adaptation is often a response to a mix of climatic and non-climatic factors [53]. Since attitudes precede actions, it can be safely assumed that the attitudes of farmers (here found positive) towards climate change precede their future positive adaptation actions.

Agricultural extension and education are crucial to farmers in providing climate resilient knowledge and practices for successful adaptation. Both extension and meteorological organizations should focus and pay attention to the socio-economic contributing factors to adaptation before they embark with their interventions that enhance the productivity and competitiveness of farmers. Emphasis should be given to water harvesting techniques to increase the extent of irrigation coverage. As farm-level adaptation becomes an increasingly important across the world, policies at all levels will need to be accounted for appropriate factors, including perceptions and how perceptions affect human behavior and adaptive actions. Policy responses to droughts based on proactive drought preparedness and drought risk mitigation are more efficient in limiting drought-caused damages than reactive drought relief efforts. Actions required for the enhancement of adaptive capacity are essentially equivalent to those that promote sustainable development and

equity. Adaptation through transformation (in the present study diversify to livestock and work as labor) has the potential to become an inclusive, engaging and empowering process that contributes to alternative and sustainable development pathways which needs to be encouraged.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

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DECLARATION

All the authors state that none of the material has been published or is under consideration for publication elsewhere, including the Internet.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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