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Comparative assessment of farmers' perceptions on climate change: Experiences from semi-arid tropics of India

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The present study was conducted to assess farmers' perceptions of the effects of climate change on their livelihoods. The aim was to compare these perceptions regarding climate trends, related effects, and adaptation options among rural communities in three Semi-Arid Tropical (SAT) villages located in Maharashtra and Andhra Pradesh, representing different agro-ecological regions. This study employed both quantitative and qualitative research methods to elicit farmers' perceptions, including farm household surveys, focus group discussions, and key informant interviews. The results of the study indicate that farm households are aware of climate change and are particularly concerned about changes in rainfall patterns and increased frequency of drought events, both in inter-seasonal and intra-seasonal distribution. Among the studied villages, Dokur experienced the most severe impacts from these changes. Furthermore, farmers perceive that natural resources such as land, water, and biodiversity have been affected due to the variations in the climate. In response to these challenges, farmers have adopted a set of adaptation options, including changes in crop selection, land management, water usage, socio-economic strategies, and collective actions. However, the study found discouraging trends in the adoption of these adaptation options, primarily due to a range of barriers that hinder their ability to adapt efficiently to climate change. This study underscores the critical need for region-specific strategic research and development programs aimed at enhancing the biophysical and socioeconomic conditions of these rural areas. Such efforts would enable these communities to improve their adaptive capacity and livelihood resilience in the face of climate-related risks and impacts. Future policies and programs should prioritize the upliftment of these fragile SAT communities, with the goal of enhancing their resilience to climate change and improving their overall quality of life.

Keywords: Climate change and variability (CCV), Semi-arid tropics, Rain-fed farming, Farmer's perception, Adaptation, Vulnerability

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Adversities of climate change are challenging humanity; consequently, the adverse and most vulnerable population is immediately at risk[1]. Rise in the atmospheric temperature and carbon dioxide (CO_2) and variability in rainfall together with a considerable rise infrequency of extreme events *i.e.*, drought and flood etc. do have a significant impact on agriculture and the rural population that primarily depends for their livelihood and nourishment. For the sustainability and development of the community engaged in agriculture focused attention and optimization are required on different dimensions *viz.*, social, economic and environmental, to ensure better livelihood. The importance lays in the fact that nearly 30% of the world population lives in semi-arid regions, which accounts for about 20% of the total world population[2]. In India, the semi-arid tropical (SAT) region assumes a prime importance as it provides a home for 45% of the total population. There is a consensus that rural populations who live in arid or semi-arid tropics are relatively more vulnerable to climate change and variability (CCV). Even though CCV is only one among many other factors posing immediate risk and hindering socio-economic development of rural communities in the SAT region. The region is also recognized as a region of low soil productivity, water shortage or scarcity, high population pressure, poor development of rural infrastructure, institutions and markets[3,4]. Moreover,it has been argued that increased degradation of available natural resources by over-exploitation has further

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exacerbated and increased the vulnerability in SAT-India[5]. Several studies have been carried out to gain insight on how the farmer perceives CCV and its associated impacts and the extent of resilience; farmers possess to cope with it; in different SAT regions of the world *viz.*, West Africa[6], and Eastern Africa[7]. Most of these research studies have been carried out on an aggregated scale. Contrarily, relatively less work was carried out for the SAT regions of the Indian sub-continent. It assumes prime importance, to gain insight into how farmer perceives the CCV, its impacts, and the extent of resilience. Further, this enables to enumerate the constraints and the capacity they possess to adapt efficiently to climate threats.

This paper attempts to capture farmers' perception on climate, impacts, trends and there by understanding micro level capacity to cope. The objective is to have a comparative analysis among differently endowed villages on a) farmers' perception about CCV,2) perception of trends in socio-economic indicators and 3) changes in the resources to adapt to CCV in the semi-arid tropical region of India.

Limitations of the study

Every study, no matter how well it is conducted and constructed, has limitations[8].First, the perception studies basically assume that the information provided by the respondents is true to an extent and is near to the actual one perceived by them. There exists abias/ propensity towards certain prolonged and disastrous events *viz.*, flood and drought, which tend to remain in the memory of farmer-respondent. However, in this study we observed not more than two percent of respondents show such propensity (by looking at farmer's responses to questions) and anything beyond that is purely out of reach. Second, farmer's perception pertaining to the livelihood impact again had an inclination to the most affected factor say it reduced yield or area among others. Third, as for trends in adaptation measures, each farmer may differ over a period and might give a chance to change based on its effectiveness and reliability.

Data and Methods

This empirical study was carried out in the semi-arid tropical (SAT) region of India. The primary objective was to investigate the periodic changes in climate and their corresponding effects on farming, natural resources, and socioeconomic conditions within village communities. Three distinct villages were selected, each situated in different districts, representing diverse agro-climatic characteristics within SAT-India. These villages, originating from various districts in Andhra Pradesh and Maharashtra, are Kanzara (located in Akola district, Maharashtra), Shirapur (in Solapur district, Maharashtra), and Dokur (in Mahabubnagar district, Andhra Pradesh) (refer to Fig. 1). Notably, these villages differ from one another in terms of their agro-ecological and socioeconomic attributes (Table 1).

To initiate the study, comprehensive data were gathered from the villages to create inventories and to characterize these areas based on micro-level resources and conditions[9]. The classification of these villages was determined based on the existing resources and developmental indicators, as outlined in Table 2.

For the survey portion of the study, a set of 30 respondents were randomly selected from the study villages and interviewed using a well-structured survey schedule. Additionally, key informant interviews were conducted with extension service personnel, and farmers' group discussions (two discussions per village) were organized. These interviews and discussions, which are commonly employed approaches to assess farmers' perceptions of various shocks and events[10,11], provided deeper insights into farming practices, the natural resource base of the villages, farm management, changes in cropping patterns, and the socioeconomic status of the communities.

Methodology

Descriptive statistics

The farmer's perceptions were analyzed using descriptive statistics such as frequency and percentages.

Chi square test

One of the most common sets of statistical analyses in the evaluation and social science research is the Pearson family of chi-square [12]. It is generally used to test whether there is any significant association between the two variables. Here first we test any significant association in the farmers' perception on impacts of climate change on rural livelihood across selected villages in SAT region. Second, a test was applied to know whether there is any significant difference among the farmer-respondent's perception across the villages in adaptation strategies/options. The test statistics are as follows,

$$X_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

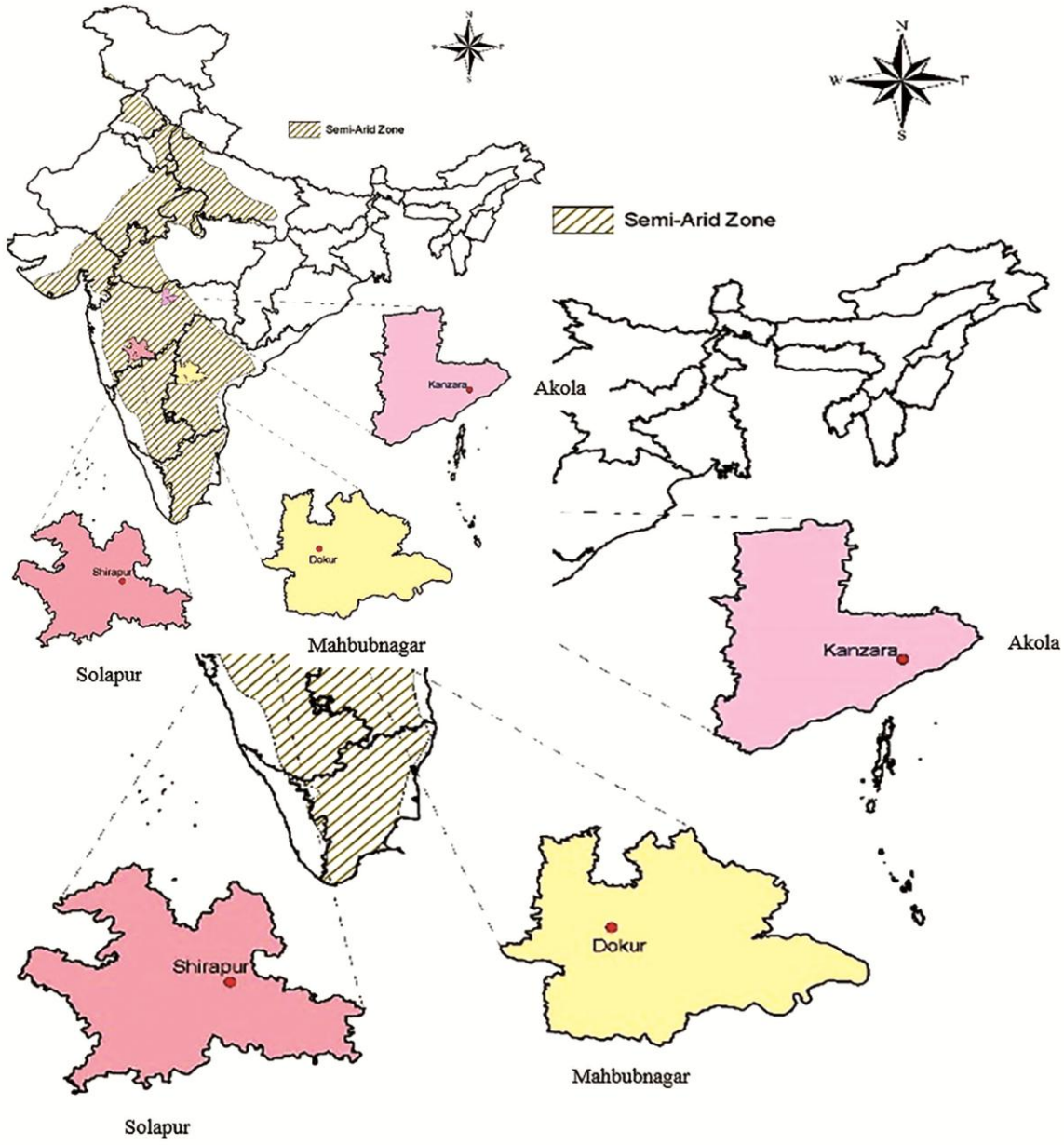

Fig. 1 — Geographical map of the study area

Table 1 — General characteristics of the study villages

Criteria	Kanzara (Better endowed)	Shirapur (Medium endowed)	Dokur (Poorly endowed)
Population/Irrigated land	2.78	3.45	9.33
Ratio of poor HH to total HH*	0.68	0.77	0.85
Sex Ratio	922.3	916	862.4
Average Total Income/HH	130.3	81.9	70.0
Cultivated area per HH	1.6	1.3	0.6
No. of tube well per cult. Area	0.05	0.38	0.53
Average Education (Yrs per individual)	5.90	4.69	3.41
Total livestock unit/HH	2.31	7.06	6.79
Open dug well per cultivable Area	0.17	0.06	0.01

* HH- Households; Poor HH includes landless, marginal and small farmers

Table 2 — Categorization of the study villages based on socio-economic indicators

Particulars	Kanzara[∞]	Shirapur[∞]	Dokur[∞]
Geographical locations	20.5° N lat 77.2° E long	18.32°N lat 76.15°E long	16.5° N lat 77°50'E long
Tehsil/Mandal	Murtizapur	Mohol	Devakadra
Geographical area (ha)	588.2	1472	1358
Gross cropped area (ha)	18.9	440.6	259.2
Gross Irrigated area (ha)	65	714	40.8
Average annual Maximum temperature (°C)	34.2	34.3	33.3
Average annual Minimum temperature (°C)	19.4	20.5	21.8
Rainfall (mm)	723	726	639
Soil Type	Medium black clay soil (Vertisols)	Deep Black soil (Vertisols)	Shallow to medium alluvial (Alfisols)
Cropping season		*kharif* and *rabi*	
Major crops	Pigeon pea, cotton, green gram, Soybean	Sorghum, Sugarcane, Pigeon pea, Sunflower and Chickpea	Paddy, sorghum, castor, cotton

[∞]Shirapur (Solapur); Kanzara (Akola); Dokur (Mahabubnagar)

Where, O_i stands for observed frequency and E_i stands for expected frequency. X^2 indicates Chi square. The obtained test statistic is compared against a critical value from the chi-square distribution with (r-1) (c-1) degrees of freedom.

Results and Discussion

As per designated methodology, data from sample respondents has been collected with respect to their perception of climate variables by them. This has been elaborately explained in two sections. The first section describes the farmers' perception of climate change and a variability impact on rural livelihood has been eloquently described. In the second section explains the trend in adoption strategies opted by farmers.

Farmers' perception of climate change and variability impacts on rural livelihood

Perception on climate variables

Precipitation and occurrence of extreme events are major climate parameters and were considered broadly in assessing farmers' perception (Table 3). During 1990-2018, farmers in general farmers perceived a reduction in the amount of rainfall over the years, and the reduction was largely perceived in all the study villages. In addition, the sampled farmers collectively established the fact that in recent decades there has been continuous delayed arrival of monsoons and an increased erraticness in the distribution of rainfall. The rise in delayed arrival and erraticness of rainfall brought considerable influence on taking key farming decisions critically affecting crop planning, income sources, other alternatives, etc. The degree of severity of climatic parameters was experienced high in Dokur particularly during the last three decades (~100% of respondents). Among various concerns, changes in the annual rainy days and sizable rainfall quantum with minimum assurance of average rainfall quantum are major concerns among villagers. Further, during summer months farmers observed rising events of extreme temperature and are akin to the fact of increased atmospheric temperature in recent years. Temperature rise fuelling to rise in acute water shortage and resulting in reduced farming activities. Household perceptions corroborated with results on climatic trends observed during the focus group discussions. The rural population has commonly agreed that erratic weather events have often considerably disturbed the growth of village economy and is an important element in distressing socio-economic stability and sustainability[13,14].

Further, the rise in temperature has significant bearing on level of crop yield, which is further reducing productivity and inducing pressure on water sources. Also, the nature of drought occurring is becoming intra-seasonal and thereby coincides with the crop's critical growth negatively affecting the crop yield. However, the crop stresses resulting in lower crop yield is found to be from multiple factors such as moisture stress, pests and diseases and including input constraints. The crop loss resulting from these abnormalities makes farmers to invariably land in vicious web of debt/loans, high expense and income. Among climatic stresses, moisture stress faced by farmers is considered predominant. Frequency of occurrence of drought is perceived to rise in these villages, majorly in Dokur and Kanzara. The observed

Table 3 — Farmers' perception on changes in precipitation and extreme events (1970-2018)

Region		1970-1990		1990-18	
	A. Precipitation	Response	%	Response	%
Kanzara (*Akola district, Maharashtra*) (*n=30*)	Amount of rainfall	Decreased	73	Highly decreased	100
	Intensity of rainy days	Decreased	57	Decreased	100
	onset of monsoon	On time	97	Delayed	100
	Distribution of rainfall	Less erratic	92	Erratic	100
		B. Extreme events			
	Increase in Temperature	Increased	53	Increased	100
	Incidence of droughts	Increased	57	Highly Increased	83
Shirapur (*Solapur district, Maharashtra*) (*n=30*)	*A. Precipitation*				
	Amount of rainfall	Increased	97	Decreased	100
	Intensity of rainy days	Increased	97	Decreased	100
	onset of monsoon	On time	100	Delayed	100
	Distribution of rainfall	Less erratic	100	Erratic	100
		B. Extreme events			
	Increase in Temperature	No change	77	Increased	87
	Incidence of droughts	Increased	67	Increased	73
Dokur village (*Mahbubnagar district, Andhra Pradesh*) (*n=30*)		*A. Precipitation*			
	Amount of rainfall	Increased	100	Highly decreased	100
	Intensity of rainy days	Increased	93	Highly decreased	100
	onset of monsoon	On time	52	Delayed	100
	Distribution of rainfall	Less erratic	100	Erratic	100
		B. Extreme events			
	Increase in Temperature	No change	67	Increased	100
	Incidence of droughts	Increased	70	Highly Increased	87

Source: Authors own calculations

Table 4 — Farmers' perception of impacts onrural livelihood due to climate change

Factors[Ψ]	Kanzara (n=30)	Shirapur (n=30)	Dokur (n=30)	X^2
i. Crop factors				
Decline in gross cropped area	0	0	100	0.00**
Fall in proportion of area under cereal cultivation	13	0	57	0.02**
Decrease in irrigated area	0	0	100	0.00**
Decline in crop yield	2	73	70	0.00**
Rise in use of inputs (irrigation, fertilizer, etc.)	67	73	100	0.02**
Reduction in Land / soil fertility	47	63	73	0.04**
ii. Climate factors				
Rise infrequency of consecutive drought	50	57	73	0.03**
Decrease in availability of alternative water source	20	0	93	0.00**
Others				
Decrease in accessible common resource endowments	0	37	67	0.04**
Reduction in bio-diversity	37	67	70	0.05**

[Ψ] % of the respondents; **significant at 5% level; the chi-square test relates to significance of differences between three villages vis-à-vis perceptions.

climate trends amongst the percentage of sample households responding, the acuteness of the perception on climatic distress was experienced majorly amongst farmers in resource poorly endowed villages (Table 3).

Perception on impacts on rural livelihood option

Farmers' livelihood in rural area is linked to performance of climate crop factors. In addition, farmers'livelihood is also considerably influenced by resource endowments and rich local bio-diversity fuelling the growth. Nearly three-fourths of the farmers in the Dokur village clearly perceived an increase in occurrence of consecutive drought (Table 4). However, in the other two villages, the percentage of households' perceived relative changes *i.e.*, Shirapur (57%) to Kanzara (50%). This dichotomy across the villages is mainly attributed to two things. First the total irrigated area and gross cropped area has been increasing in these two villages (Shirapur and Kanzara) with the development of canals, tanks and other sources *viz.*, tube-well during 1970-'90 and are still in operation. Second, in Dokur, over the last

decade there have been drastic reductions in the water availability due to drying up of storage tanks, increasing dysfunctional tube-wells; dams etc. that in turn reduced the cultivated area. The occurrence of consecutive drought had resulted in forced abandoning of farm lands[15], which is true to in case of Dokur. Further, in Kanzara, water availability of irrigation is found to be moderate, however, canal water had been diminishing over the years and farmers are forced to rely on tube well irrigation as an alternative source. While Shirapur does have canal options and tube well irrigation enabling them to grow high value crop *viz.*, sugarcane. In fact, in Kanzara, the canal irrigation facility is restricted to Rabi season and is allowed to flow once in 2-3 years.

The proportion of area under cereal production and also pulses and oil seeds has reduced in these villages, especially in Dokur where rice used to be a major water intensivecrop[16]. Further cereals particularly rice used to be the major crop in these SAT villages, mainly rice in Telangana. The change in cropping pattern from cereals to drought tolerant (ex. castor) or short duration crops (ex. soybean) is mainly a result of a rise in demand for irrigation and perpetual drought. The general switch from cereals (Coarse and fine) to pulses and oilseed (having relatively less water requirement) was also evident and there exists a significant reduction in area in the later phase of analysis (Table 4). In addition, the multiple cropping systems with minimum addition of soil emoluments and rise in the use of inputs resulted in gradual degradation of the soil structure. Besides, there has also been a high propensity for the adoption of better performing improved varieties during the last three decades (1990-2018) that in turn powered increased input use. The diminishing soil fertility level and with increased application of inorganic fertilizers coupled with decreased micronutrient and input use efficiency of the soil eventually raised the cost of cultivation among other features commonly found in these villages.

Farmer's perception of the trends in quality, accessibility and availability of common property resources (CPRs), which were once equally distributed across the community have diminished widely owing to prolonged exploitation, improper management and population pressure. In addition, the conversion of more land into cultivation resulted from population pressure further fuelled the fragmentation of land holding. With reduced irrigation options, the area under fallow land increased significantly coupled with unreliable monsoon. Further, the instances of increased crop failure, fluctuations in produce price and lack of supplementary sources of irrigation forced farmers to skip cultivation by abandoning land. This was mainly evident in Dokur. Although all these impacts as it is perceived differ significantly among the study villages and the perception are at the higher end in resource-poor village than the better resource-endowed villages (Table 4). This implies the condition of village significant bearing on the farmers' perceptions on the impacts and climate-related risks.

Trends in adaptation strategies opted by farmers

Rural communities to avoid the risk due to increased climate variability adopt a number of potential adaptation/coping strategies[2]. The strategies were primarily to sustain livelihood by ensuring food security and minimum income flow. Identified strategies will benefit and strengthen their capacity to adapt against various risks *viz.*, climatic, price, etc. (Table 5). The villagers experienced a rise in yield and production over the years. However, the farmers from the Dokur (37%) have perceived a rise in production lower compared to their counterparts. However, livestock, as an alternative source of income is not popular among these villagers. They cite a number of reasons why livestock is not popular amongst the villagers. This includes unavailability of labour, improved cattle, common pastureland, feed, market issues etc. Among the villagers interviewed only 50% or less perceived livestock to be a good alternative other than crop income.

The land management options, soil conservation and tillage practices are followed minimally among the rural poor in the SAT region. Moreover, the green- manuring /organic manure incorporation is not common among the villagers and is mostly followed by rich farmers who have sufficient means to afford it. Diversifying income through non-farm activities like migration, business, and other services flourished as a strategy to ward off the risks associated with farming. These trends are highly pertinent in Dokur where repeated drought and unavailability of irrigational sources have hampered farming. All the villages have tried to adopt water conserving technologies *viz.*, sprinkler/drip irrigation systems. Of late, there has been extended support from the government as subsidies for implementing irrigation systems. However, minimum support from the

Table 5 — Major trends in adaptation strategies/options as perceived by the farmers

Category[Ψ]	Kanzara (n=30)	Shirapur (n=30)	Dokur (n=30)	X^2
Crop Production				
Increased crop production/yield	83	73	37	0.03**
Livestock rearing	53	37	33	0.27
Land and water management				
Increased adoption of soil conservation & tillage practices	33	47	97	0.01**
Increased soil enriching (Green manuring /organic manure} incorporation	57	20	27	0.01*8
Improved water conservation and efficient irrigation system	97	67	97	0.25
Socio-economic				
Rise in non-farm activities (Migration, Business, and Services etc.)	13	17	93	0.03**
Increased use of improved technology	66	93	53	0.18
Increased improvement in human development index	63	43	57	0.40
Collective actions				
Increased ability to cope with drought	33	97	100	0.01**
Maintenance of community Infrastructure (Roads, wells etc.)	0	43	50	0.00**
Increased efficient farmer's association/groups/societies	37	30	40	0.75
Increased effective Government programs/ Yojanas	100	97	100	0.86
Increased Information flow	100	100	100	0.89

[Ψ] % of the respondents; **significant at 5% level; the chi-square test relates to significance of differences between three villages vis-à-vis perceptions

government for implementing irrigation system through subsidies was availed by few and others could not afford to invest their share.

The rural infrastructure improved with input and output market accessibility, which was lower before than in recent decades[17]. Collective actions and social capital have weakened as society developed over the years. Social networks, formal and informal associations including self-help groups (SHG's) have helped the communities to control producer price, acquiring subsidy, availing loans etc. but are not efficient in these villages. However, the socio-economic status is highly diverse at the micro level characterized by several factors including communal, political, governance etc. Even though, government support programs are meant to support the socio-economically weaker section, there exists non-equity in availing and disbursing support distress to the poor and marginal. Information on farming, improved technologies, credits, subsidies, programs, etc. have increased over the years, nevertheless, where it is important that its efficiency need to be analyzed and how effectively it could convert into action.

Informant interview and focus group discussion with the farmers have emanated what prevents them from successful adaptation (barriers to adaptation) to minimize risks associated with climate variability. Absence of effective and efficient collective actions and linkages among the communities to adhere to *viz.*, adoption of soil and water conservation technologies, effectively regulated cooperatives, credit facilities etc. enables them to build resilience. Non-availability and access to risk-averse technologies ex. drought tolerant varieties, natural resource conservation technologies etc. that perform better in marginal conditions and ensure better productivity, increased input efficiency and minimize crop failure. Although, government programs are on the ground, definite program to encourage including income diversification, technology dissemination, credit support, agricultural development programs etc. However, these need to be properly placed and implemented in the rural set up. Limited access to alternative water sources and lacking resources to construct tubewell or dugwell are some other factors debilitate the resilient capacity of the poor[24]. Even though information flow and exchange have increased over the year, the efficiency with which it worked to cater the community equally is still a long way to go. Extension systems should be efficient for quick delivery of information to lower level of the rural population who has minimum access. There exists wide disparity among the villagers in sharing the common property resources tangled with socio-economic intricacies of village assemble. The majority of barriers to adaptation are complex in dynamics and it is spatially and temporally varied.

Farmer's perception on climatic variables and other socio-economic factors gives a proper analogue of trends. In addition, these observations are potentially useful to scientist in tracking bio-physical and socio-economic changes in the region[18]. However, quantitative analysis of observed climatic variables is must to confirm whether it corroborates with the

farmers experiential knowledge[18] and perceptions. Water, being the primary input for production, unavailability could hamper the livelihood that depends on it. Water scarcity is highly experienced in semi-arid tropical regions and is largely felt in these villages for example Dokur. Population pressure, over exploitation, low rainfall together with no conservation of received rainfall has made the situation from bad to worse. Conservation or maintenance of the resources opens the options to develop synergies to combat CCV among the farmers to adapt[19]. Importance on awareness and adoption of water conservation and management techniques/ optionsare very crucial in the region. Even though efficient irrigation systems *viz.*, sprinkler, drip etc. have had gained importance, however the partial subsidies are not sufficient to ensure wide adoption. Potential socio-economic factors important to downplay risks in the event of climate related shocks includes witch to non-farm activities, mechanization, Input & Output market access, improved infrastructure development etc. Trend in switching to non-farming activities was significant in these villages with migration[19] at the time of crisis for satisfying occupational needs[17]and where in Dokur being exceptionally high. Migration to nearby cities in search of work was evident during drought as a copying strategy to avoid distress during extreme weather conditions *viz.*, drought[20]. Mechanization, Input and output market accessibility, infrastructure *viz.*, schools, hospital/clinic, Anganwadis etc. comparatively improved in respect to two decades ago. However, most of the government supported infrastructure and activities are comparatively inefficient to cater the growing poor population size. Group initiatives to conserve natural resources *i.e.*, soil and water have increased minimally. Other collective actions *viz.*, maintenance of community infrastructure, use of improved farming techniques, efficient farmer's association/groups/societies, government association/ Yojanas, information flow etc. continues improvement at the micro level[20]. However, the questions are raised on how efficiently it could improve the resilience capacity of the rural poor. In the study village like Kanzara have been marginally improving in these conservations centered collective actions which can ameliorate better replication of synergies among the rural households.

Singling out climate as the major factor in change in these changes is a challenge with a number of factors spatially varied influencing this change. The current fallow and fallow plots decreased in Shirapur and Kanzara due to development of irrigational setup over the years. In SAT villages with high temperatures and frequent soil manipulation during cultivation, fertility status of the soil has diminished tremendously as perceived by the farmers. In these systems, livestock continues to be an important component providing subsidiary income and organic soil input for the farmers. However, one argues that cropping pattern change and crop diversification are mainly driven by major socio-economic factors *viz.*, profitability, labor availability, market price etc.[17], climate still persist as a hidden factor driving these changes. With technological intervention, alternate irrigational source availability will help in the intensification of agriculture more land was put to cultivation to suffice increasing population needs and by further fragmentation of the land ownership. Even though, farmers perceived an increased trend over the past over-exploitation of available sources have led to the drastic reduction in proportion of irrigated area and the majority abandoning winter (Rabi) crop[21].

In the future, research activities should be designed to understand multi-dimensional facets that limit socio-economic growth at different levels of interventions from micro to macro level impacting the poor. It also aims with the imminence of climate change impact, it is quite important not to ignore climate change adaptation measures as a developmental strategy[21] in minimizing the related danger that adversely affects different sectors *viz.*, agriculture, natural resources[22] and population dependent on for livelihood. It has been always confirmed that the capacity to adapt to climate change by the communities in the tropics is achieved through various bio-physical, socio-economic, demographic and policy trends[22]. This analysis could give a flavor of impacts, and adaptation at micro level, however, policies and action should be taken at multi-scales and understanding of the involvement of multi-stakeholders including government institutions, support programs and stakeholder beneficiaries. These policies should address minimizing micro-level barriers and the climate resilient policies should integrate into development agenda to ensure overall development[23-25]. These field level insights and findings could be an add-on to the policymakers in devising programs to mainstream target regions and, improving and developing cushions against climatic risk[24].

Conclusion

The analysis conducted in this study has revealed that farmers in the rain-fed semi-arid tract regions of India have perceptibly observed unfavorable climatic changes, particularly during cropping seasons. These changes manifest as delayed onset of rainfall, erratic precipitation patterns, variations in both the amount and intensity of rainfall, and an increased frequency of drought occurrences. These climatic risks, in conjunction with their associated impacts, have significantly altered the agro-socio-economic conditions in these regions, exacerbating the challenges faced by smallholder farmers over time. Consequences include dramatic reductions in crop yields, diminished soil fertility, alterations in agricultural inputs, shifts in cropping patterns and cultivated areas, reduced biodiversity, and an elevated frequency of drought events. It is worth noting that households in villages with limited infrastructure support for farming and livelihoods are more profoundly affected by and at tuned to the impacts of climate change. Regrettably, the potential adaptation options to counteract these climatic risks and their trends are diminishing across all the study villages. The current state of bio-physical and socio-economic conditions undermines the inherent capacity of impoverished farmers in the semi-arid tropics of India to adapt effectively to these challenges. In light of these findings, it is imperative to comprehensively understand the constraints faced by these communities and translate recommendations into actionable strategies. Transforming these regions into climate-resilient communities necessitates a concerted effort to address vulnerabilities and enhance adaptive capacities among the affected populations.

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Conflict of Interest

Authors declare that they do not have any conflict of interest.

Authors' Contributions

NPS has planned the research study, provided outline and set objectives RPC, BA and KK together engaged in data collection, compilation, writing inference and others. BA was involved in applying statistical tools in present study. While fine-tuning of the article was made by NPS and RPC.

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