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Assessing Farmers' Vulnerability to Climate Change: Insights and Adaptive Strategies

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Vulnerability of farmers to climate change is intimately related to poverty, as the poor are least able to respond to climatic stimuli. Further, certain regions of the world are more harshly affected by the effects of climate change than others. With this background the study was conducted to know the vulnerability of farmers to climate change and their suggestions to overcome its ill effects. The data was collected from the Central Dry Zone (Zone - IV) of Karnataka. Tiptur and Chiknayakanahalli *taluks* from Tumakuru district, Kadur from Chikmagalore district, Arsikere from Hassan district and Challakere from Chitradurga district were selected purposively for the study. Totally, the data was collected from 150 respondents. With respect to exposure of farmers to climate change, rainfall and

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temperature were selected and majority of farmers in the study area were severely exposed (0.822) and sensitive (0.894) to climate change with lower adaptive capacity (0.576) between the year 2013-2017. Climate Vulnerability Index (CVI) of Arsikere, Kadur, Tiptur, Chiknayakanahalli and Challakere *taluk* was 0.186, 0.226, 0.224, 0.220 and 0.241, respectively. The overall CVI value of all selected *taluks* of Central Dry Zone of Karnataka was 0.218. The data revealed that, the majority of the farmers suggested, Government has to take necessary steps to fill the water bodies in villages (I) followed by Providing more number of drip/ sprinkler irrigation facility to cover maximum farm families (II), Subsidies/compensation has to be given for the crops to make up the cost of cultivation due to weather aberrations (II), Development department should ensure supplying of production inputs at appropriate time in the villages (III), Support price has to be given to all the crop produce based on cost of cultivation (IV), Creating awareness to the farmers about appropriate adaptation measures against climate change (V) etc.,

Keywords: Farmers; climate change; vulnerability; suggestions.

1. INTRODUCTION

Vulnerability to climate change is intimately related to poverty, as the poor are least able to respond to climatic stimuli. Further, certain regions of the world are more harshly affected by the effects of climate change than others. Generally speaking, vulnerability and ill effects of climate change are major issues for concern. For this reason, there is need for provisions to aid those countries which are thought to be most vulnerable and least competent to adapt.

"The concern over the shocking effects of climate change, particularly in the agriculture sector, has become very severe now a days. These climate variability impacts on agriculture sector have been severely harmful. For instance, sporadic impacts such as droughts and floods make threats to the livelihood of rural people who are dependent on agriculture" [1]. "A decrease in the availability of water for irrigation is likely due to rainfall deficits caused by the intensity of droughts, reducing the amount of irrigated food production" [2]. "Crop losses may raise due to increased climate variability, and this impact will be one of the deciding issues that manipulate future food security" [1].

Climate change is affecting India in a big way and its impacts are many such as erratic monsoon, spread of infectious diseases, change of agricultural zones, raise in sea level, floods, droughts, storms, non-availability of fresh water etc. Unexpected climate change could make the country unfit to live. Analysis of different meteorological data in the country illustrates that, there is increase trend in monthly temperature and downward trend in annual rainfall, relative humidity, and number of wet days in a year. Some areas in India obtain more than normal rainfall while some of the areas receive less rainfall. The various studies show the overall loss in the crop production in the country in the last few years was due to the climate change. It is expected that in the near future, India is likely to face the challenges that includes unnecessary pressure from the growing population.

"Assessing the sector wise vulnerability to climate change may be necessary to increase the different sector's resilience. Vulnerability to climate change is referred as the degree to which a system is susceptible and unable to cope up with adverse effects of climate change, including climate variability and extremes. Sensitivity to climate change is referred as the degree to which system is affected, either adversely or beneficially by climate change" [3]. "In the context of the agriculture, sensitivity to climate change refers to the threshold reaction of crops to climate affecting their growth, development and yield" [4]. "Exposure is referred as degree to which a system is exposed to significant climatic variation" [5]. "Adaptive capacity defined as the ability of a system to adjust to climate change to moderate potential damages or to take advantage of opportunities or to cope with the consequences. There were several forms of adaptation to climate change in the circumstance of agriculture such as policies, access to climate information and new cropping patterns and technologies. Policies meant to encouraging successful climate change adaptation measures for the agricultural are driven by considering the following factors: farmers' perceptions of climate change, ongoing adaptation measures and the decision making process" [6]. "Crop diversification and enhancement of cropping patterns are also common adaptation strategies in the farm level. In terms of access to climate information, seasonal climate forecasts provide

an occasion for farmers to adopt new technologies and to strengthen production or select lower risk, lower return strategies" [7]. The levels of sensitivity, exposure and adaptive capacity in a system determine its overall vulnerability. According to Fellman [5], these definitions from IPCC imply that, a system is vulnerable to climate change if it has a high sensitivity and exposure to the effects of climate change impacts and if it has an inadequate capacity to adapt. Vulnerability assessments often create policy courses that enhance the ability of communities to react to stressors and secure livelihoods, which in turn decrease their vulnerability to future climate change impacts [8]. In the context of agriculture, measurement of agricultural vulnerability should help to identify vulnerable agricultural regions and systems, resulting in proposal for specific adaptation measures [5].

2. METHODOLOGY

Selection of the study area: The study was conducted in the Central Dry Zone (Zone - IV) of Karnataka. Tiptur and Chiknayakanahalli *taluks* from Tumakuru district, Kadur from Chikmagalore district, Arsikere from Hassan district and Challakere from Chitradurga district were selected purposively for the study.

Selection of villages and respondents: Villages from each of the *taluks* were selected randomly and the list of the villages from each of the *taluks* so selected was collected from the Revenue Department and then the five villages from each of the *taluk* were selected randomly for the study. In each of the village so selected, 2 farmers belongs to marginal, 2 from small and 2 from big farmers were listed and then the respondents were selected by applying systematic quota sampling technique. Thus, totally 30 farmers from each Taluk and totally 150 respondents constituted sample for the study. The details on number of villages and farmers selected for the study were presented in Table 1.

Suggestions to overcome adverse effects of climate change were collected from the respondents and they were given in more and less important strategies to over come ill effects of climate change then they were framed rank wise based on importance.

Table 1. Study area and farmers selected for the study

Districts	Taluks	Villages	No. of Respondents selected
Tumakuru	**Tiptur**	Patrehalli	6
		Bannihalli	6
		Gowdanakatte	6
		Biligere	6
		Rangapura	6
	Chiknayakanahalli	Shettikere	6
		Kuppur	6
		Thamadihalli	6
		Honnebhagi	6
		Halugona	6
Hassan	**Arasikere**	Boranakoppalu	6
		Guthinakere	6
		Jaajur	6
		Belavathahalli	6
		Dasihalli	6
Chikmagalore	**Kadur**	Macheri	6
		Mallidevihalli	6
		Kodihalli	6
		Nagenahalli	6
		Biluvala	6
Chithradurga	**Challakere**	Doddachellur	6
		Obanahalli	6
		Kyadigunte	6
		Gouripura	6
		Mahadevpura	6
Total	**5**	**25**	**150**

3. RESULTS AND DISCUSSION

Exposure of farmers to climate change: Exposure index value was calculated based on the Exposure Index (EI) formula using scores obtained by each respondent to the individual statements under Rainfall and Temperature changes. The index value is between 0 and 1. As value near to zero reflects low level of exposure and towards one shows high exposure of farmers to climate change particularly Rainfall and Temperature changes. Data in the Table 2 reveals that, the mean exposure index value of farmers in all *taluks* was 0.822. Equal proportion of exposure index value was observed in Arsikere (0.823), Kadur (0.841), Tiptur (0.824), Chiknayakanahalli (0.813) and Challakere (0.812). Which implies that, the majority of the farmers were highly exposed to changes in rainfall and temperature. ANOVA technique was used to understand the significant difference among the *taluks* with respect to exposure, it shows that, there was a significant difference among the *taluks* with respect to exposure of farmers to severe climate change (Rainfall &Temperature) with the 'F' value 2.675 at 5 per cent level of significance. Result are in line with studies of Diana and Adrià [9], they reported that, overall LVI (Livelihood Vulnerability Index) is 0.106 (-1 low vulnerability to 1 high vulnerability) and exposure index value 0.696 is the factor that contributes most to the vulnerability of the community.

Sensitivity of farmers to climate change: Sensitivity index value was calculated based on the components wise scores obtained due to adverse effects of socio demographic factors and other activities on crop production practices, livestock production and Human health. The index values obtained was presented in the Table 3 and it implies that, the index value is between 0 and 1. As value near to zero reflects low level of sensitivity and towards one explains the high level of sensitivity of farmers to climate change. Data in the Table 2 reveals that, the mean Sensitivity Index values for five *taluks* was 0.894 and maximum Sensitivity Index value was observed in Kadur (0.951) followed by Challakere (0.933), Tiptur (0.923), Chiknayakanahalli (0.922) and Arsikere (0.742). Which implies that, the majority of the farmers were highly Sensitive *i.e* adversely effected due to climate change. Among 5 *taluks* except Arsikere other four *taluks* are closely near to value one, it indicated that, they were severely affected by climate change. The ANOVA test result reveals that, there was significant variation among the *taluks* with respect to sensitivity of farmers to climate change with "F" value 725.4 at 1 per cent level of significance.

Result were in similar with the studies of Mohan and Sinha [10], they used the LVI-IPCC approach to assess farmers' vulnerability to climate change in Uttar Pradesh. The results shows that, LVI value was 0.072 and sensitivity index value was 0.509. Diana and Adrià [9] reported that, sensitivity index value of Berambadi watershed livelihoods towards climate change impacts was 0.535. This value indicates a moderate sensitivity to climate variations.

Adaptive capacity of farmers to climate change: Adaptive capacity index value was calculated based on the components wise scores obtained under adaptive capacity of farmers in crop production, livestock production and Human health. The index value obtained was presented in the Table 4 and it implies that, the index value is between 0 and 1. As value near to zero reflects low level of adaptive capacity and towards one explains the high level of adaptive capacity of farmers to climate change.

Data in the *Table* 4 reveals that, the mean Adaptive Capacity Index value of the study area is 0.576 and the *taluks* Arsikere (0.572), Kadur (0.603), Tiptur (0.581), Chiknayakanahalli (0.574) and Challakere (0.554) having more or less moderate level of Adaptive Capacity Index. Which implies that, majority of the farmers are moderately adapted to adverse effect of climate change even though they are highly exposed and severely sensitive to climatic variations. ANOVA test result shows that, there was a highly significant variation among the *taluks* regarding adaptive capacity of farmers to climate change with "F" value 4.311 at 1 per cent level of significance. Parallel studies were also conducted to know the adaptive capacity of farmers to climate change and they reported that, LVI-IPCC approach to assess farmers' vulnerability to climate change in Uttar Pradesh, a state located in the North India. The results obtained in this study gave an overall result of 0.072. The partial results for each contributing factor of adaptive capacity score of 0.349 [10]. Suresh et al. [11] worked out the scores of ACI of all the districts and reported that, Bengaluru (Urban), Kodagu, Belgaum, Bengaluru Rural, Dakshin Kannada, Bellary and Udupi emerged as districts having high degree of Adaptive capacity with their Adaptive capacity scores

being 0.768, 0.580, 0.579, 0.568, 0.559, 0.514 and 0.500, respectively. Bengaluru (urban) secured first rank in terms of adaptive capacity on account of very high per capita income, which was the highest among all the districts, high literacy rate, substantially sound on health parameters coupled with higher life expectancy and lesser infant mortality rate than that other districts. Wide range of Adaptive capacity scores, ranging from 0.334 to 0.282, shows that, there are perceptible inter-district disparities among the districts. Uttar Kannada, Yadgir, Bidar, Mandya and Chamrajnagara were placed under the 'low adaptive capacity' category since all these districts scored an Adaptive capacity value of < 0.367 which was the minimum criteria value as per quartile analysis.

Table 2. Exposure index values (n=150)

Sl. No	*Taluks*	Exposure Index value	ANOVA test - "F" value
1	Arsikere	0.823	2.675*
2	Kadur	0.841	
3	Tiptur	0.824	
4	Chiknayakanahalli	0.813	
5	Challakere	0.812	
Mean		**0.822**	

** Significance level @ 5 %*

Table 3. Sensitivity Index values (n=150)

Sl. No	*Taluks*	Sensitivity index value	ANOVA test - "F" value
1	Arsikere	0.742	725.4**
2	Kadur	0.951	
3	Tiptur	0.923	
4	Chiknayakanahalli	0.922	
5	Challakere	0.933	
Mean		**0.894**	

*** Significance level @ 1 %*

Table 4. Adaptive capacity index values (n=150)

Sl. No	*Taluks*	Adaptive capacity index value	ANOVA test- "F" value
1	Arsikere	0.572	4.311**
2	Kadur	0.603	
3	Tiptur	0.581	
4	Chiknayakanahalli	0.574	
5	Challakere	0.554	
Total		**0.576**	

*** Significance level @ 1 %*

Vulnerability of farmers to climate change: After assessing the Exposure, Sensitivity and Adaptive Capacity Index of farmers with respect to marginal, small and big farmers, a cumulative index value for all farmers of each *taluk* on above dimensions were worked out and presented in the Table 5. It shows that, farmers of Arsikere had 0.823, 0.742 and 0.572, Kadur *taluk*: 0.841, 0.951 and 0.603, Tiptur: 0.824, 0.923 and 0.581, Chiknayakanahalli: 0.813, 0.922 and 0.574, Challakere: 0.812, 0.933 and 0.554 and in overall: 0.822, 0.892 and 0.576 of Exposure Index, Sensitivity and Adaptive Capacity Index, respectively. In general sense, irrespective of *taluks*, all farmers had more or less equal level of exposure, sensitivity and adaptive capacity Index. But with respect to sensitivity the farmers of Arsikere had the Index value of 0.742, where, this value was less compare to over all and also *taluk* wise Sensitive Index value. And also in Adaptive Capacity, farmers of Kadur had 0.603 which is better than others marginally. These deviations in both *taluks* might be because of their level adaptation strategies, resources and some socio economic factors influenced them in sensitivity and their adaptive capacity to climate change. The level of farmers Exposure, Sensitivity and Adaptive Capacity to Climate

Change would reflect in their Vulnerability to Climate Change.

Finally by using the index value of Exposure, Sensitivity and Adaptive Capacity of farmers of each *taluk* Vulnerability Index was worked out and presented in the Table 5. It shows that, 0.186, 0.226, 0.224, 0.220 and 0.241 was the Climate Vulnerability Index (CVI) of Arsikere, Kadur, Tiptur, Chiknayakanahalli and Challakere *taluk,* respectively. The overall CVI value of all *taluks* was 0.218. As per the result, all *taluks* were severely vulnerable to climate change. Since, the index value was nearer to 0.25. Few studies are in comparable with the present study.

Diana and Adrià [9], reported that, the overall of the Livelihood Vulnerability Index (LVI) for the studied Berambadi watershed villages was found to be 0,499 (in a range from 0 to 1 where 0 represents low vulnerability and 1 high vulnerability).

Suresh *et al.,* [11], reported that, in Karnataka, nearly 51 per cent of the state's geographical area has 'high' to 'very high' degree of vulnerability.

Omid *et al.,* [12] report on vulnerability assessment reveals that, the majority of small holder farmers are relatively or highly vulnerable to climate change. Highly vulnerable indicates the households which are sensitive and exposed to climate change and do not have adequate adaptive capacity. Low vulnerable means that households which are in a vulnerable situation are still able to cope without external assistance. And also less vulnerable refers to those households which need urgent, but temporary external assistance to recover after a hard shock.

Suggestions to overcome ill effects of climate change: Farmers were facing many constraints while initiating the adaptation measures in their farm to resolve these constraints farmers have offered their suggestions. The valuable suggestions given by farmers to overcome adverse effects of climate change were furnished in the Table 6. The data revealed that, the majority of the farmers suggested, Government has to take necessary steps to fill the water bodies in villages (I) followed by Providing more number of drip/ sprinkler irrigation facility to cover maximum farm families (II), Subsidies/compensation has to be given for the crops to make up the cost of cultivation due to weather aberrations (II), Development department should ensure supplying of production inputs at appropriate time in the villages (III), Support price has to be given to all the crop produce based on cost of cultivation (IV), Creating awareness to the farmers about appropriate adaptation measures against climate change (V), Early warning has to be given to the farmers about environmental changes (VI), Creating awareness/Support for adoption of organic farming technologies (VII), Insurance has to be extended to all crops (VIII), Incentives/support for increasing the green manuring (IX), Government has to take strict action on deforestation and should more focus on afforestation (X) and Providing financial support for soil nutrient enrichment (XI) were the major suggestions offered by the farmers to mitigate ill effects of climate change. These were the important suggestions expressed by farmers based on their experience in farming over a long period. Government and development departments should think over all these suggestions of farmers in order to fulfill their needs to cope up with adverse effects of climate change to reduce the level of vulnerability which was caused due to climate change. the present study results are in par with the studies of Makoka and Kaplan [13], they argued that, vulnerability is caused by a broad range of political, institutional, economic, environmental and socio-cultural factors such as insufficient knowledge, organizational gaps, lack of personal and financial resources and inadequate legislation. As a result, vulnerability must not be restricted to a simple cause-effect relationship. Therefore, in the planning and designing of adaptation programs and strategies, considering aforementioned variables help to increase the efficiency of efforts. Consequently, adopting different adaptation strategies such as utilizing modern irrigation systems, changing crop patterns to less water needed plants, cultivating drought resistance varieties, changing planting dates and soil and water conservation will help farmers increase their resilience. Deepa and Shiyani, [14], the major suggestions which emerged from the study were that in the dry land areas like Kutch, there is a need for strategies unique to their system that takes into account their uncertain dynamics. Strategies such as rainwater harvesting, livestock development and techniques to enhance dry land agriculture can help overcome many of these constraints. Policies for promotion of efficient irrigation systems must be implemented. As a part of water management strategies there is a need to

deepen wells, utilise water supply system properly, construct check-dams and focus on integrated watershed management and rainwater harvesting. Insurance coverage (crop, livestock *etc*) and micro financing facilities may also be strengthened. Apart from this, while making investments particularly on dry land agriculture, a specific component of climate change could also prove useful. Raju [15], opined that, urgent steps need to be taken to increase adaptive capacity. This would require increased support of adaptation research, developing regionally differential contingency plans for temperature and rainfall related risks, evolve new land use systems including heat and drought tolerant varieties of crops adaptive to climate variability and increasing food demand. Hence, greater attention is now needed on adaptation to climate change, which includes increased investment, adaptation and mitigation research, improved land use and natural resource management policies, improved risk management through crop insurance*, etc.*

Table 5. *Taluk* wise climate vulnerability index values (n=150)

Taluks	**Total**			
	Exposure Index value	**Sensitivity Index value**	**Adaptive capacity Index value**	**CVI**
Arsikere	0.823	0.742	0.572	0.186
Kadur	0.841	0.951	0.603	0.226
Tiptur	0.824	0.923	0.581	0.224
Chiknayakanahalli	0.813	0.922	0.574	0.220
Challakere	0.812	0.933	0.554	0.241
Total	**0.822**	**0.892**	**0.576**	0.218

CVI: Climate Vulnerability Index

Table 6. Suggestions to overcome adverse effects of climate change (n=150)

Sl. No	**Farmers suggestions**	**Response**		**Response (Ranking)**
		More Important	**Less Important**	
1	Government has to take necessary steps to fill the water bodies in villages	150 (100.00%)	0 (0.00%)	I
2	Providing more number of drip/ sprinkler irrigation facility to cover maximum farm families	149 (99.33%)	1 (0.67%)	II
3	Subsidies/compensation has to be given for the crops to make up the cost of cultivation due to weather aberrations	149 (99.33%)	1 (0.67%)	II
4	Development department should ensure supplying of production inputs at appropriate time in the villages	148 (98.67%)	2 (1.33%)	III
5	Support price has to be given to all the crop produce based on cost of cultivation	147 (98.00%)	3 (2.00%)	IV
6	Creating awareness to the farmers about appropriate adaptation measures against climate change	145 (96.67%)	5 (3.33%)	V
7	Early warning has to be given to the farmers about environmental changes	142 (94.67%)	8 (5.33%)	VI
8	Creating awareness/Support for adoption of organic farming technologies	138 (92.00%)	12 (8.00%)	VII
9	Insurance has to be extended to all crops	125 (83.33%)	25 (16.67%)	VIII
10	Incentives/support for increasing the	123 (82.00%)	27 (18.00%)	IX

Sl. No	Farmers suggestions	Response		Response (Ranking)
		More Important	Less Important	
	green manuring			
11	Government has to take strict action on deforestation and should more focus on afforestation	118 (78.66%)	32 (21.34%)	X
12	Providing financial support for soil nutrient enrichment	110 (73.33%)	40 (26.67%)	XI

**The value in the parenthesis indicates the percentile to the total*

4. CONCLUSION

As per the study its clearly observed that, farmers were highly exposed to climate changes and adversely affected due to ill effects of climate change but had moderate to low level of adaptive capacity. Hence, majority of the farmers and *taluks* in the study area fall in severely vulnerable category. To overcome these ill effects, farmers were also provided some suggestions. This is a lightning call for policy makers and development departments to take necessary activities and suitable programmes to build confidence among farming community and to improve their status by making farming as a profitable occupation.

CONFERENCE DISCLAIMER

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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