Original Research Article

Climate-Resilient adaptation strategies in potato production and factors influencing it in Karnataka, India

ABSTARCT

The World is already experiencing climate change and it has profound effects on both agriculture and horticulture. Hence present study attempts to identify climate resilient adaptation strategies in potato production and factors influencing it in Karnataka, India. For the study Kolar and Hassan districts were considered based on their vulnerability status and potato crop was selected for the analysis. Primary data for the study were collected from 160 sample respondents through well structure, pre-tested interview schedule during 2021-22. To achieve the proposed objectives, descriptive statistics such as percentage and binary logistic regression was employed. The study identified six major climate-resilient adaptation strategies adopted by the respondents in potato cultivation such as early sowing, more than the recommended dose of pesticide application, preventive plant protection measures (in advance), improving water captures, drying of seed tubers before sowing and adapting heat/drought resistant varieties. Among six strategies, majority (92.50 % of Kolar and 72.50 % of Hassan) of the respondents adopted improving water captures as a major adaptation strategy. Binary regression revealed that education, family size, organizational participation, farming experience, access to weather alerts, and awareness of climate change had positive and significant impact on adaptation behavior of the sample respondents.

***Key words**: Climate resilient, adaptation strategies, potato cultivation, binary regression, weather alerts*

1. INTRODUCTION

According to Intergovernmental Panel on Climate Change (IPCC) report, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global and/or regional atmosphere and which is in addition to natural climate variability observed over comparable time periods [1]. Climate change includes major changes in temperature, precipitation, or wind speed patterns that occur over several decades or longer. Climate change results from carbon dioxide (CO2) and other greenhouse gas (GHG) emissions viz. methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, etc., and also due to anthropogenic activities like deforestation, burning of fossil fuels, etc. Climate change substantially defines agricultural productivity as it influences several input balances, which support the entire agricultural system. The impacts of climate change are manifested in many ways, which include periods of moisture stress, high incidence of pests and diseases, increased salinity, high temperature, and floods [2].

All India average annual temperature in 2021 is 26.5 degree Celsius and which is 24.4 degree Celsius in 1901 and temperature is increasing at the rate of 1.9 per cent during 2001-2020. In 2010 southwest monsoon was delayed by 1 day to onset and 27 days to withdrawal, whereas in 2019 it delayed -7 days to onset and 39 days to withdrawal. In 2017 India faces 10 extreme weather events such as floods, heat waves, drought etc., [3] these are the shreds of evidence for rapid climate change in India. The national clean energy fund, Paris agreement, international solar alliance, and national action plan on climate change are some of the actions taken by the Government of India to tackle ongoing climate change.

Karnataka is located in the southwest region and eighth largest state in India with a geographical area of 1,91,791 km^2 which is about 5.83 per cent of the total geographical area of India (32,88,000 km^2). It is located between 11^0.50' and 19^0.00' N latitude and between 74^0 and 78^0 E longitude in the southern plateau. Meteorologically Karnataka is divided into three zones - coastal, north interior, and south interior, of these, the coastal zone receives the highest rainfall with an average rainfall of about 3,638.5 mm per annum. The state receives rainfall from both south-west and a north-east monsoon with an average annual rainfall of about 1,140 mm, Agumbe of Shivamogga district is the rainiest city in Karnataka state. The state experiences the lowest temperature during the month of January and then decreases. The average high temperature during summer is 34 ^{0}C, monsoon season is 29 ^{0}C and 32 ^{0}C in the winter season. Till date, the highest temperature recorded was 45.6 ^{0}C at Raichur and the lowest was 2.8^0 Celsius at Bidar. Agriculture is the primary source of income for the majority of Karnataka's rural population.

Climate change vulnerability is the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change. As days go on the world is facing extreme climatic events such as drought, tornadoes, heavy downpours, etc., Somalia, Eritrea, and Sudan are the top three countries that are more vulnerable to climate change. India is not exempted from extreme climatic events, in 2020, Assam, Andhra Pradesh, and Maharashtra are the three more vulnerable states with vulnerable scores of 0.616, 0.483, and 0.478 respectively [4]. Out of 31 districts in Karnataka, Bidar district is more vulnerable to climate change followed by Kolar and Yadgir [5].

Potatoes can be grown in both subtropical and tropical zones, such as in the highlands of Southeast Asia. Nonetheless, despite the wide distribution and adaptability of this plant to various environmental and climatic conditions, potato growth is not entirely unaffected by environmental problems. Water stress (drought and flooding), extreme temperature (low and high), and ion toxicity (salinity and heavy metal) are the abiotic constraints that potato plants face in their habitats. In Karnataka, potato production is mainly taken place in Chikkaballapura, Hassan, Kolar and Chikkamagaluru are the leading potato producing districts in Karnataka state, which together contribute about 70 per cent to the state's output [6].
With this background, the present research was conducted to identify climate-resilient adaptation strategies practiced by the farmers and factors influencing the adaptation behavior of the farmers in Karnataka.

2. MATERIAL AND METHODS

2.1 Study area and Sampling framework

The present study was conducted in Karnataka state, India. Multi-stage random sampling technique was employed for the selection of the sample. In the first stage, Kolar and Hassan districts were selected as Kolar is more vulnerable and Hassan is less vulnerable to climate change [5] among the major potato growing districts in Karnataka. This is the basis for the selection of the district. In the second stage, based on the contribution to total potato production in the district, two taluks Bagarpet (32.07 %) and Malur (28.90 %) from Kolar district and; Arkalagudu (26.02 %) and Hassan (22.47 %) taluks of Hassan district were selected purposively. In the third stage, major potato growing villages in each of the taluks were identified with the help of the Department of Agriculture, Government of Karnataka. From the list of identified villages, potato growing farmers were identified and grouped into small (≤ 2 acres of potato area) and large farmers (> 2 acres of potato area). In the final stage 40 farmers in each taluk were selected randomly for the present study and thus making up a sample size of 160. The study is purely based on primary data; required information on socioeconomic characteristics, adaptation strategies, and relevant data on variables required for evaluating the objectives of the study were collected from the sample respondents using pre-tested, well-structured schedule through personal interview method for the agriculture year 2021-22.

2.2 Analytical tools

To reach the proposed objective descriptive statistics such as percentage and binary logistic regression was employed, the details of the model is explained below;

$$\frac{\hat{y}}{1-\hat{y}} = \propto + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots + \beta_i X_i + u$$

Here the dependent variable (Y) presents the climate-resilient adaptation strategies adopted by the farmer and where ŷ is the probability that the number of adaptation strategies adopted by the sample potato respondents. The dependent variable is divided into 2 categories, namely 0 as a notation of low adopters (adapting ≤3 adaptation strategies) and 1 as a notation of high adopters (≥4 adaptation strategies). 11 independent variables were considered for the analysis such as age of the respondent (X_1), education (X_2), family size (X_3), organizational participation (X_4), operational land holding (X_5), per cent of irrigated area (X_6), farming experience (X_7), access to weather alerts (X_8), distance between farm and field (X_9), frequency of extension visits in a year (X_{10}) and awareness of climate change (X_{11}).

3. RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of the sample respondents

In the present study, farmers with land holding less than 2 acres are categorized as small and more than 2 acres as large farmers. Nearly 48 per cent of farmers in Hassan were large and 55 percent were small in Kolar district. The mean age of the respondents was found to be 47.35 with no statistical differences between categories between distinct study areas. 30 per cent attained primary education. Large farmers were found to be more educated than small farmers in both districts. It was observed that, the average family size was 5.42 and was higher for the large category (6.01) than the small category (4.83); the average family size in Kolar (5.60) was significantly higher than Hassan (5.17). Majority (59.37%) of the sample respondents participated in one organizational activity. The average farming experience was found to be 26.93 years for large farmers and 27.68 years for small farmers; there is no significant difference between farming experience between Kolar (25.50 years) and Hassan (25.12 years). The average size of the operational holding was 1.68 acres for small and 3.36 acres for large in Kolar district, while 1.54 acres for small and 4.21 acres for large in Hassan district. More than 50 per cent of the potato cultivated area was rainfed in Hassan, while 65 per cent was irrigated in Kolar.

3.2 Climate resilient adaptation strategies adapted by potato farmers in Karnataka

Potato farmers adopted a variety of climate-resilient adaptation strategies in the study area. The study identified six major climate-resilient adaptation strategies followed by farmers in potato production to mitigate the adverse impact of climate change. The strategies are not implemented in isolation as farmers can use two or more strategies simultaneously. Among the identified strategies early sowing is one of the climate-resilient adaptation strategies which help to better adapt to changes in rainfall pattern and temperature similarly parmeshwar et al 2014 [7,8]. More than the recommended dose of pesticide application (i.e. 3) adaptation strategy protects the crop from pests and diseases arising from climate change. A preventive plant protection measure is another adaptive strategy; where farmers take decisions prior to its occurrence e.g. advance application of pesticides. Hydrological and metrological drought is one of the effects of climate change, which has detrimental effects on potato production, hence improving water capture adaptive strategy helps to mitigate drought. Drying of seed tubers before sowing makes potato seed tubers free from microbial, pests and disease attacks.

The results of Table 1 show that in Karnataka, among the six identified adaptation strategies, the majority (82.50 %) of the respondents adopted improving water captures (rainwater harvesting practices) followed by early sowing (75 %), more than the recommended dose of pesticide application (71.87 %), preventive plant protection measures (57.50 %), adapting heat/drought resistant varieties (43,16 %) and drying of seed tubers before sowing (25 %). In the more-climate vulnerable district of Kolar, all farmers (100 %) adopted preventive plant protection as a major adaptation strategy for potato production followed by improving water captures (92.50 %), more than the recommended dose of pesticide application (86.25 %), early sowing (83.75 %), adapting heat/ drought resistant varieties (53.75 %) and drying of seed tubers before sowing (23.75 %). While, in the less-climate-vulnerable district of Hassan, the majority (72.50 %) of farmers adopted improving water captures as a major adaptation strategy for potato production followed by early sowing (66.25 %), more than the recommended dose of pesticide application (57.50 %), adapting heat/ drought resistant varieties (33.75 %), drying of seed tubers before sowing (26.25 %) and preventive plant protection measure (15 %). Based on the number of adaptation strategies adopted by the potato farmers and with the guidance of subject experts, sample farmers were broadly classified into two categories viz., low adopters (≤ 3 adaptation strategies) and high adopters (≥4 adaptation strategies) for better understanding.

Table 1. Adaptation strategies adapted by farmers in potato production in climate vulnerable districts of Karnataka

Sl. No.	Adaptation strategies	Kolar (MCVD) n_1=80	Hassan (LCVD) n_2=80	Pooled n=160
1	Early sowing	67 (83.75)	53 (66.25)	120 (75.00)
2	More than recommended dose of pesticide application (i.e. 3)#	69 (86.25)	46 (57.50)	115 (71.87)
3	Preventive plant protection measures (in advance)	80 (100)	12 (15.00)	92 (57.50)
4	Improving water captures	74 (92.50)	58 (72.50)	132 (82.50)
5	Drying of seed tubers before sowing	19 (23.75)	21 (26.25)	40 (25.00)
6	Adapting heat/drought resistant varieties	43 (53.75)	27 (33.75)	70 (43.16)

Note: 1. Figures in the parenthesis indicates percentage to the respected column
2. MCVD: More-climate vulnerable district, LCVD: Less-climate vulnerable district
3. # Package of practices recommended by University of Agricultural Sciences (UAS) Bengaluru.

Before executing the binary model, all independent variables were tested for the existence of a multicollinearity problem. VIF (variance inflation factor) and correlation matrix were used for testing the association between the variables. To address the possibilities of heteroskedasticity, the study estimated a robust model that computes a robust variance estimator.

The binary logistic regression was employed to study the variables influencing the adaptation behavior of the respondents and the results are presented in Tables 2 and 3. The model explained around 61 per cent of the total variation in the climate-resilient adaptation behavior of the sample respondents as indicated by negelkerke R square value. Among the eleven independent variables in the model, six variables were significant at various levels concerning adapting climate-resilient adaptation strategies in the study area (pooled). In the case of Kolar district six variables while in Hassan district 5 variables were significant. The significant explanatory variables on adapting adaptation behavior in the study area are discussed below.

Education has a positive and significant impact on the adaptation behavior of the respondents. The education status of the respondents has a greater influence on the adaptation behavior of the sample respondents. Holding other variables constant, a change in the education level by one unit will increase the odds of being adapting climate resilient adaptation strategies in potato cultivation by the factor of 0.5893 in pooled and 0.1936 in Kolar district. The possible justification was that educated respondents has a greater knowledge of adaptation strategies than illiterates. The obtained results are similar to the findings by Bekabil 2015 [9] which found that the higher the education level higher the participation in conservation agriculture. Family size was found to be positive and significant indicating that a unit increase in the family size, will increase the odds of being adapting climate resilient strategies by the factor of 0.0973 in Hassan and 0.7592 in pooled which means an increase in the family size will increase the labour power which influences the adaptation behavior of the sample respondents. Positive influence of family size on adaptation behavior, which was also observed by chandra and vijay 2021 [10]. It is clear from Table 2 that organizational participation is positive and significant which reflects that a unit increase in organizational participation will increase the odds of being adopting adaptation strategies by the factor of 1.8302 in Kolar and 0.2282 Hassan district. Participating in organizational activities will enrich the knowledge of climate change and measure to tackle its impacts such as adapting climate resilient adaptation strategies in potato production. Per cent of the area under irrigation was positive had

Table 2. Factors influencing adaption behavior of the sample farmers to adopt climate resilient strategies in potato production

Sl. No.	Independent variables	Kolar (n_1=80)		Hassan (n_2=80)		Pooled (n=160)	
		Odds ratio Exp (β)	S.E	Odds ratio Exp (β)	S.E	Odds ratio Exp (β)	S.E
	Constant	17.03	0.1021	24.23	0.0220	13.84	0.0829
1	Age	0.0243	0.0012	0.0397	0.2039	0.4638	0.1609
2	Education	0.1936*	0.0210	0.2382	0.0102	0.5893*	0.0029
3	Family size	0.2832	0.1374	0.0973*	0.1299	0.7592**	0.2801
4	Organizational participation	1.8302**	0.2083	0.2282**	0.0029	0.9274	0.1129
5	Size of land holding	0.0473	0.0478	0.9374	0.0392	0.9238	0.1020
6	Irrigated area (%)	1.1028***	0.2910	0.5368**	0.8290	0.6538**	0.0238
7	Farming experience	2.0297***	0.3798	1.0394*	0.9823	1.0938**	0.3909
8	Access to weather alerts	3.5483**	0.7342	2.0349	0.0101	2.0914*	0.3748
9	Distance between farm to field	0.1293	0.2303	1.7483	0.3920	0.2239	0.2038
10	Frequency of extension visits in a year	1.0293	0.0293	0.9934	0.3744	0.8393	0.2929
11	Awareness of climate change	1.3048**	0.2823	1.0393*	0.3038	1.3409**	0.2203

Note: 1: * significance at 10 %, ** significance at 5 %, *** significance at 10 %
2: Figures in the parenthesis represents standard error
3: MCVD: More-climate vulnerable district, LCVD: Less-climate vulnerable district, S.E: Standard Error
4: Exp (β) is odds ratio

Table 3. Statistical value of likelihood ratio test

Step	-2 Log likelihood	Cox & Snell R square	Negelkerke R square
1	48,293	0.498	0.610

significantly influences the adaptation behavior of the sample respondents, a unit change in the area on irrigation will increase the odds of being climate resilient adopters by the factor of 1.1028 in Kolar, 0.5386 in Hassan and 0.6538 in pooled which reflect the more the area under irrigation will improve the adaptation behavior of sample respondents. Present findings were corroborative with the findings of Kanesh et al 2015 and Nancy and Bhardwaj 2015 [11,12] who reported that the irrigated area had positive influence on adaptation behaviour. Framing experience had a positive impact on the adaptation behavior of the sample respondents, a unit increase in the farming experience will improve adaptation behavior by the factor of 2.0297 in Kolar, 1.0394 in Hassan, and 1.0938 in pooled Asfik and Ratur 2017 [13] have reported positive relation between farming experience and adaptation strategies. Access to weather alerts was found to significantly influences the adaptation behavior of the sample respondents. A unit increase in the weather alerts will increase the odds of adaptation behavior by 3.5483 in Kolar and 2.0914 in pooled. This meant that respondents who receive weather alerts were more likely to adopt climate-resilient adaptation strategies in potato cultivation. Awareness of climate change was found to positive and significant factor which influences the adaptation behavior of sample respondents, a unit increase in awareness of climate change (years) will increase the odds of being climate resilient adopters by 1.3048 in Kolar, 1.0393 in Hassan and 1.3409 in pooled indicating respondents who aware more of climate change will adopt more of climate resilient adaptation strategies in potato production in the study area [14, 15].

4. CONCLUSION

The study identified six major climate-resilient adaptation strategies in distinct climate-vulnerable districts of Karnataka. Among which improving water captures (rainwater water harvesting measures) was the major strategy followed in both districts. The research also examined the determinants of the adaptation behavior of respondents and employed binary logistic regression to identify the significant variables. Independent variables such as education, family size, organizational participation, farming experience, irrigated area (%), farming experience, access to weather alerts, and awareness of climate change were found to be positive and significantly influencing the adaptation behavior towards climate resilient adaptation strategies in potato production in the study area. Keeping climate change in view, government, NGOs, and concerned departments should play their role in promoting and implementing climate-resilient adaptation strategies in the agriculture and horticulture sector.

REFERENCE

1. Intergovernmental Panel on Climate Change (IPCC). Climate Change 2001: Impacts, vulnerability and adaptation. Contribution of working group III to the third assessment report on the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge 2001.
2. Khanal, U., Wilson, C., Hoange, V. N. And Lee, B. L. Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. *Ecological Economics.* 2018; **14** (4): 139-147.
3. Reserve Bank of India (RBI), Monetary policy statement, resolution of the monetary policy committee, April 5-7, 2021.
4. Mohanty, A. and Wadhawan, S. Mapping India's climate vulnerability-A district level assessment. Council on Energy, Environment and Water, New Delhi 2021.
5. Shivakumar, C. and Srikanthamurthy, P. S. Mapping a climate change vulnerable index: An assessment in agricultural, geological and demographic sectors across the districts of Karnataka (India). International Journal of Climate Change Strategy and Management, 2019; **9** (8): 447-456.
6. Anonymous. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India, 2022.
7. Parmeshwar, U., Yutaka, I., Sujata, M., Hiroshi, I. and Anthony, S. K. Farmers' perception of drought impacts, local adaptation, and administrative mitigation measures in Maharashtra state, India. International Journal of Disaster Risk Reductio*.,* 2014; **8**: 217-237.
8. Kumar and Baljinder, K. S. Farmers' perceptions and adaptation strategies to climate change in Punjab agriculture. Indian Journal of Agricultural Sciences, 2018; **88** (10): 93-101.
9. Bekabil, U. T. Dynamics of farmers' participation in conservation agriculture: binary logistic regression analysis. Journal of Poverty, Investment and Development, 2015; 13: 74-84
10. Chandra, K. J and Vijay, G. Farmer's perception and factors determining the adaptation decisions to cope with climate change: An evidence from rural India. Journal of Environmental Sustainability, 2021; **10**: 1-12.
11. Kanesh, S., Uttam, K., Clevo, W., Shunsuke, M., Annette, Q. and Samithamby, S. An economic analysis of agricultural adaptation to climate change impacts in Sri Lanka: An endogenous switching regression analysis. Land Use Policy, 2015; **10** (9): 1-9.
12. Nancy, L. and Bhardwaj, S. K. Farmers' response and adaptation strategies to climate change in low-hills of Himachal Pradesh in India. *Nat. Environ. Pollut*,, 2016; **15** (3): 895-901.
13. Asfika, B. and Ratul, M. Adaptation to climate change and factors affecting it in Assam. Indian Journal of Agricultural Economics, 2017; **72** (3): 446-455.
14. Paulos, A. and Belay, S. Farmer's perception of climate change and adaptation on strategies in the Dabus watershed, North-West Ethiopia. Asrat and Simane Ecological Processes, 2018; **7** (7): 1-13.
15. Mohammed, N. U., Wolfgang, B. and Jason, S. E. Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: A farm level study in Bangladesh, Climate*,* 2014; **2**: 223-241.