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Farm women's adaptation to climate change: A technology adoption study in northern Odisha

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ABSTRACT

Indian agriculture is vulnerable to the adverse impact of climate change due to poor socio-economic and demographic adversaries. Climate change effects have heightened existing gender disparities by contributing to greater vulnerability. The adaptation and coping mechanisms to climate change are critical in developing countries like India. Keeping in view these issues, the present study was carried out on farm women's perceptions, adaptation of improved technologies in Keonjhar district of Odisha. Two hundred farm women were selected covering 20 villages from seven minor irrigation projects (MIPs) in three blocks of Keonjhar district. Majority of the farm women were found to have medium (84.5%) adoption. Among different technologies, maximum adoption was observed for adapted cultivars with an adoption index of 86.7. The output of regression model demonstrated that the age of farm women has a negative association with technology adoption. The impact of skill development on technology adoption had a significant positive (0.17) association with its adoption. Pre and post project yield of crops manifested greater difference and increase in crop yields of beneficiaries' farmers over years was found significant. An increase in average yield for rice; maize, ragi and groundnut with yield of 40.50, 26.38, 12.55, 13.44, 2.73, 3.34 and 10.46 q ha^{-1}, respectively in comparison to pre-project yield.

1. INTRODUCTION

Climate change describes a change in average conditions like temperature and rainfall in a region over a long period of time. Agriculture is vulnerable to climate change; the statement holds more significance particular to India, where a large population (65%) depends on agriculture for their livelihood. India is vulnerable to the adverse impact of climate change due to poor socio-economic, demographic, and institutional adversaries (Dupdal and Patil, 2019). Climate change affects different dimensions of food security *viz.* food availability, its accessibility, utilization, food systems stability and sustainability. In agricultural livelihood, women and men experience climate change impacts differently due to their socially constructed roles and tasks assigned. The adaptation and coping mechanisms to climate change are critical in developing countries like India. Earlier studies have revealed that with adaptation, the risk to climate change is reduced or minimized to a greater extent in the agricultural sector. The changes or modifications in agricultural practices act as adaptation strategies in agriculture to climate change (IPCC, 2014). Empowerment of farm women is vital for the effectiveness of climate change projects and policies implementation. Studies have demonstrated that gender equality and women's empowerment are central to development, environmental sustainability and achievement of the millennium development goals. There is an urgent need to explore suitable adaptation strategies, which make production system more resilient to mitigate the impacts of climate change (Aiswarya *et al.,* 2023) in which one must consider local community's understanding of climate change. For the global phenomena of climate change, adaptation needs to be local. Hence, better understanding of farmer's perceptions about climate change, its impact on agriculture production, existing adaptation technologies and factors influencing in adopting them is crucial (Chaudary *et al.,* 2011). Keeping in view of these issues, the present study was carried out on farm women's perceptions and adoption of improved technologies in Keonjhar district of north Odisha.

2. MATERIALS AND METHODS

Locale of the Study

The study was conducted in Keonjhar district of Odisha, which was selected purposively, as the Odisha

Integrated Irrigation Project for Climate Resilient Agriculture (OIIPCRA) has been implemented in the district since its inception (2020). The details of locale are given in Table 1 and Fig. 1. Keonjhar district represents north-central and eastern plateau with rainfed agro ecosystem and mostly affected by climatic variability like cyclone, intermittent droughts, and poor soil health. Two hundred farm women were selected covering 20 villages from seven minor irrigation projects (MIPs) in three blocks of Keonjhar district. Farm women associated with the project since inception were interviewed for socio-economic data and pre-project record were used for comparison of the yield and technology impact study.

Research Design and Data Collection

To analyse the impact of climate resilient interventions made under different MIPs, *ex-post-facto* research design with treatment and control group was used. Before-after comparison was made possible with the help of baseline data and recall memory of respondents. Data was collected from the respondents using personal interview method with the help of structured interview schedule designed for the purpose. Concurrently, secondary sources like Agriculture Department Annual Reports and KVK data were used to supplement, triangulation, and cross checking of primary data. The data was collected using various tools including Focus Group Discussions, gender analysis, key informant, and individual household interviews.

Table: 1
Details of sampling in Keonjhar district of Odisha

S.No.	Block	MIP	Sample size (nos.)
1.	Anandpur	Chakratirtha	25
2.	Anandpur	Taradia	30
3.	Ghasipura	Sindhei	40
4.	Harichandanpur	Jaunria	35
5.	Harichandanpur	Kureijodi	20
6.	Harichandanpur	Kusei	30
7.	Harichandanpur	Mushal	20
		Total	200

Data Analysis

The demographic characteristics were analysed and explained using descriptive statistical analysis. The selected dependent and independent variables were analysed using regression model in SAS program to estimate factors influencing the adoption of different climate resilient technologies. Table 2 describes different technologies adopted under the project. The data collection was done on the interventions already implemented. Impact was studied using several variables and then the values were compared and tested with suitable test statistics. The obtained data was quantitative in nature; hence it was tested with t-statistic to find the significance of differences. Thus, total 200 respondents were randomly selected for this study.

Adoption index refers to degree of adoption of climate resilient technologies. It was measured on three-point continuum as high (full adoption), Medium (partial adoption) and low (non-adoption) by assigning the score of 3, 2 and 1,

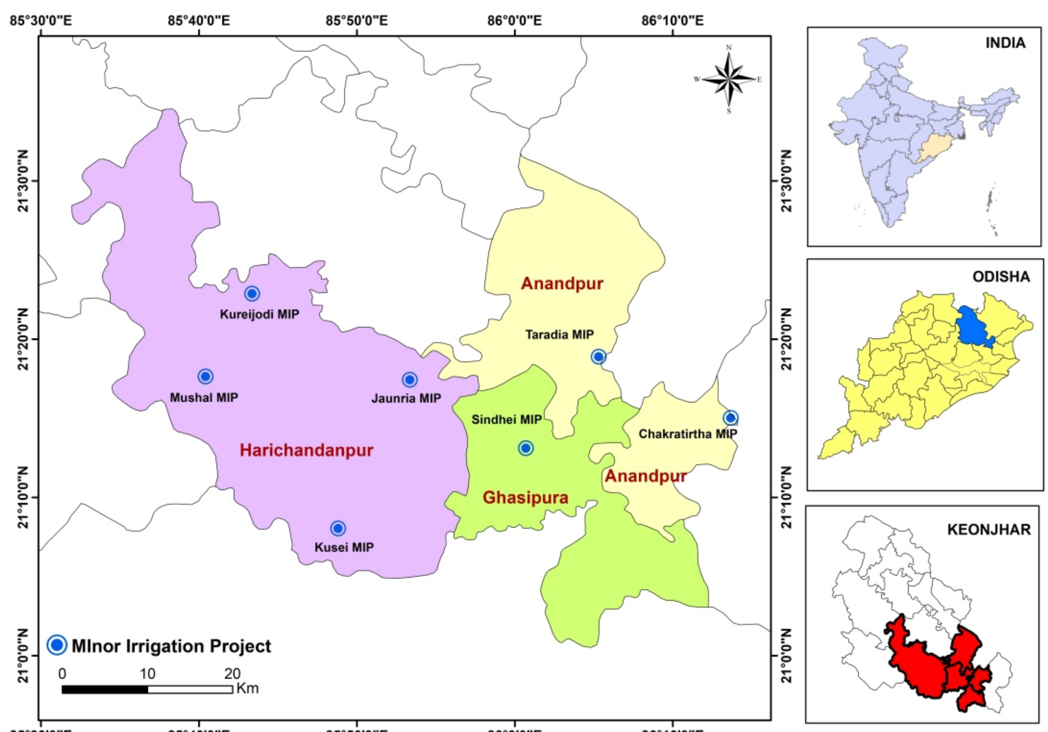

Fig. 1. Location of the study

Table: 2
Details of technologies adopted in project village area

S.No.	Technology (Interventions)	Climate Resilient characterises
1.	Adapted varieties	Resilient varieties of rice were grown *viz.,* Swarna sub-1, MTU 1009 (Flood tolerant), Shabhagi Dhan (Drought tolerant) MTU 7029 (terminal water stress).
2.	Stubble mulching	Stubble of *kharif* season paddy were used as mulching material in *rabi* season pulses and sunflower crop for moisture conservation.
3.	Live bunds	Broom grass and lemon grasses were raised on bunds for moisture conservation and retain eroded soil.
4.	Rainwater harvesting	*In-situ* as well as *ex-situ* measures *viz.,* restoration of farm ponds, recharge wells were used for enhanced water availability.
5.	Contour farming	On mild slopes, *kharif* season maize and millets were sown to control erosion and restore fertility.
6.	Weather agro-advisory	Farm women used weather-based customised agro advisory from *Grameen Krishi Mausam Seva.*
7.	Contingent crop plan	To cope up the climate variability the contingency plan was followed for optimum yields.
8.	Compositing pits	Biodegradable waste composting was done in village area for manures as mitigating GHG emissions.
9.	Crop diversification	20% Paddy crop area was diverted to millets and oilseeds (Sesamum and Groundnut).
10.	Direct seeding of rice	DSR was followed in *kharif* season paddy by women farmers used 30-50% less water.

respectively. The adoption score was then converted into adoption index by applying following formula: Adoption index = Obtained Adoption score / Maximum Obtainable Adoption score*100. This provided adoption index (for all components of climate resilient technologies) for each farm women. The composite index thus obtained in the process lie in between 0 and 1. The composite score was then classified as low-level adoption (below 60%) medium level (61-80%) and high level of adoption (above 81%).

3. RESULTS AND DISCUSSION

Extent of Technology Adoption

The adoption level of different climate resilient technologies by farm women is elucidated in Table 3. It signifies that the majority (90 nos.) of farm women (45%) had a medium level of adoption. About 32.5% of respondents showed low adoption. Whereas, a small proportion of farm women (22.5%) had a high rate of adoption. These findings indicate the social scenario of the region where farmers in general and farm women in particular are accepting a new technology at a very slow pace. Farm women have poor access to the extension services, social institutions, credit etc. which hinders the new technology transfer pace. In some developing countries, access to credit is gender biased where farm women are discriminated by credit institutions, and they are unable to finance yield-raising technologies, leading to a low adoption rate (Mwangi and Kariuki, 2015).

The adoption level of specific climate resilient technologies was analysed amid farm women in different villages. Farmers' feedback was categorised into low, medium, and high group based on the score followed by overall adoption index for each technology (Table 4). Among different technologies, maximum adoption was observed for adapted cultivars with an adoption index of 86.7. Farm women expressed that adapted cultivars use is the most basic and easy method for combating climate change. Direct seeding of rice is another very important

Table: 3
Distribution of respondents on adoption of climate resilient technologies

S.No.	Technology adoption	Frequency	Percent	Mean	Stand Dev.
1.	Low	65	32.50	4.53	2.06
2.	Medium	90	45.00		
3.	High	45	22.50		
	Total	200	100.00		

Table: 4
Adoption level of individual technology by farm women

S.No.	Climate resilient technology	High	Medium	Low	Adoption index	Adoption rank
1.	Adapted varieties	130	60	10	86.7	1
2.	Direct seeding of rice	80	100	20	76.7	2
3.	Crop diversification	90	60	50	73.3	3
4.	Compositing pits	70	80	50	70.0	4
5.	Weather agro advisory	40	135	25	69.2	5
6.	Stubble mulching	30	150	20	68.3	6
7.	Contingent crop plan	20	130	50	61.7	7
8.	Contour farming	40	60	100	56.7	8
9.	Rainwater harvesting	30	40	130	50.0	9
10.	Live bunds	20	30	150	45.0	10

technology for mitigating greenhouse gases. It got an adoption index of 76.7 and was found to be easily adoptable by diverse land type beneficiaries for its multitude advantages. Crop diversification though raising oilseeds and pulses in rice fallow is an important intervention for soil health as well income (Singh and Tomar, 2023). It scored an adoption index of 73.3 with majority of farm women showed medium adoption. A medium level of adoption was observed for composite pits (70.0 adoption index), followed by Agro advisory services (69.2%). Rainwater harvesting and live bunds scored minimum in adoption index adoption in comparison to other practices as farm women reported difficulty in execution by them. From this analysis it can be concluded that farm women are sensitive for climate change and its effects. They have adopted some of the practices and it has boosted confidence level of the cultivators in the area. Similar studies on adoption of different climate resilient technologies are done by Kumar and Sidana (2018) and Dupdal *et al.* (2022).

Regression Analysis

To study the factors responsible for adoption of technologies, variable based information from 200 farm women from different MIPs was collected. The multiple regression model was employed to establish the relationship between dependent (technology adoption) and independent variables (demographic and socio-economic factors) affecting women's adoption of technologies. For this purpose, 12 explanatory variables were selected to explicate the dependent variable (technology adoption). Among different variables, five variables namely age (X_1), education (X_2), risk bearing (X_6) social participation (X_7) and skill development (X_{10}) were determinant factors that influenced the dependent variable (Table 5). The detailed explanation of each variable is given below:

Age: The output of regression model demonstrated that the age of farm women has a negative association with technology adoption. The result was statistically significant (at P<0.01) with r value of -0.045. This signifies that with increasing age, women have shown decreasing interest in trying and adopting new technologies. The young farmers largely adopt the technologies due to increased technological exposure and educational levels than the older community (Berkowsky *et al.,* 2018). However, some studies have also reported a positive relationship. Melesse (2018) and Chuang *et al.* (2020) also supported the fact that older farmers have more resources than young farmers that help in adoption of new technologies.

Education: This variable for farm women was analysed in terms of number of schooling years completed. Education level had a positive significant impact on the adoption of technology with r value of 0.196. It might be due to change in the knowledge, attitude, and skills of a farm women through higher level of education. Egge *et al.* (2012) and Dileso (2017) reported that farmers who had higher education level were more interested in adoption of high yielding varieties

Table: 5
Multiple regression analysis between technology adoption and selected independent variables

S.No.	Variables	Reg. Coef. (b)	SE of b	t-value for b
1.	Age (years)	-0.045	0.010	-4.34**
2.	Education (years)	0.196	0.025	7.98**
3.	Farm experience (years)	0.005	0.008	0.60
4.	Monthly household income (₹)	0.000	0.000	0.74
5.	Available land holdings (Acres)	-0.000	0.023	-0.015
6.	Risk bearing$^+$	0.299	0.089	3.37*
7.	Social participation$^+$	0.386	0.094	4.10**
8.	Weather advisory$^+$	0.179	0.104	1.73
9.	Market information$^+$	0.003	0.089	0.04
10.	Skill development$^+$	0.176	0.169	1.045*
11.	Institutional credit$^+$	-0.245	0.153	-1.59
12.	Cost effectiveness$^+$	0.116	0.166	0.70
	Constant	2.767		
	R-square value	0.802		
	Multiple R-value	0.89		

$^+$*Qualitative variables response converted on scale*

*Note: ** and * denotes significance level at 1% and 5%, respectively*

Risk bearing: Risk bearing in present study signifies the no. of new technologies tested on farm women field. The risk bearing of farm women got positive association with adoption (0.29). The farm women who were already adopting improved agricultural practices *viz.,* vermicomposting, organic farming, new variety, etc., were able to bear risks of adopting new climate resilient technologies. Risk-averse people are generally small farmers, who are resistant to adopting new technologies due to less availability of capital and low income (Gwara *et al.,* 2022). Positive association of risk bearing with adoption is also associated with other factors like social participation, technology exposure, etc.

Social participation: Participation in social organization like SHG, FPO, society etc. make women more exposed to new avenues and confident in daily life. Formal linkage or association of farm women to number of institutions was considered for this variable. During data collection among farm women the low adoption of technology for women were those with no participation in social organization or local institutions showed less probability of adopting new technologies. Social participation had a positive association with the adoption of technology with a value of 0.39 at 1% level of significance. This suggests that women who take an active role in discussions, meetings, and various community dialogues have a higher likelihood of participation compared to those who are not engaged in any discussions (Ren *et al.*, 2022).

Skill development: Technology plays a significant role in influencing the personality and technology adoption across various sectors. Farm women undergone no. of capacity building programme were considered for this variable. The impact of skill development on technology adoption had a significant positive (0.17) association with its adoption at 5% level of adoption. The R^2 value of 0.80, expressed the idea that six variables jointly contributed towards 80% of the variation in the level of adoption. Education and training can benefit the agri producers which will help to farmers, effective use, and maintenance of mechanization of farming, awareness of credit facilities and its utilization in technology adoption (Saran *et al.,* 2022).

Crop yield

To unveil the impact of improved varieties and other climate resilient technologies on yield of major crops, the yield data of respective crops before the project intervention (2020) and at the time of the study (2023) were equated. The yield data during *kharif* season was taken for comparison, since the cultivation during *rabi* and summer were negligible before project inception. Table 6 depicts an increase in average yield for rice; maize, ragi and groundnut with yield of 40.50, 26.38, 12.55, 13.44, 2.73, 3.34 and 10.46 q ha^{-1}, respectively in comparison to pre-project yield. The paired t-test values were found to be significant for the differences in all the crops. A multitude of factors including drought tolerant, high yielding, pest-resistant varieties, timely sowing and transplanting, high moisture content in soil, increased frequency of irrigations, improved soil and water management practices would have dovetailed in realization of better yields (Sharma *et al.,* 2023).

Information on crops grown before (2020) and after (2023) was obtained based on interaction with the respondents. No major change in crops cultivated was found but changes occurred to the varieties of the crops grown. Before the project intervention, the farmers cultivated the traditional and conventional varieties, which were more prone and susceptible to crop damage. But after the project interventions farm women started growing drought tolerant and flood tolerant varieties *viz.,* Swarna Sub 1, Shabhagi, etc., but no significant change in varieties was noticed in case of non-beneficiaries. The scenario prevailed because of resistance and fear of farmers to leap into a new list of crops, given their adaptation and marketability under question. However, the new varieties of conventional crops are offering them quite good alternative to the existing situation of climate variability Jasna *et al.* (2017).

Table: 6
Before-after comparison of crop yield (q ha^{-1}) with climate resilient technologies

Crop	Year	Farm Women*	Mean	Std. deviation	t-value
Paddy	Before 2020	60	26.51	1.64	33.8
	In 2023		40.50	2.84	
Maize	Before 2020	40	23.93	2.02	4.10
	In 2023		26.38	3.19	
Finger millet	Before 2020	40	10.73	0.58	6.71
	In 2023		12.55	1.75	
Groundnut	Before 2020	40	10.38	0.20	12.38
	In 2023		13.44	1.53	
Greengram	Before 2020	40	2.35	0.44	13.33
	In 2023		2.73	0.53	
Blackgram	Before 2020	30	2.88	1.22	7.61
	In 2023		3.34	1.10	
Sunflower	Before 2020	30	8.15	2.70	9.84
	In 2023		10.46	2.66	

**Indicates the sample of farm women taken for particular crop*

4. CONCLUSIONS

Climate resilient technologies are promising tool to guard a farming system from climate variations. Impact study of these technologies is a prerequisite for guiding the adaptive research for better customization, upscaling, and out scaling them. Adoption of adapted cultivars and other technologies by farm women is one of the positive impacts of climate resilient technologies dissemination in the villages. Increased awareness on land management practices, training, timely availability of inputs and right technologies, machineries for agricultural operations contributed favourably to the project. Pre and post project yield of crops manifested much difference and increase in crop yields of beneficiaries' farmers. All these findings displayed a positive impact of the technologies in farm women's life.

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