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Determinants of vulnerable group of Madhya Pradesh developing climate change strategies for Sustainable Agriculture practices: Discrete Analysis using Logit Model

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ABSTRACT

The present study has focused to analysed determinants at field level climate resilient practices adopted by the vulnerable community in Madhya Pradesh. The model used data of a cross-sectional survey of 681 farm beneficiaries who have benefited under the Sustainable Livelihood for Adaptation and Climate Change (SLACC) project. The SLACC project was carried out in two districts of Madhya Pradesh (Central-India). The 13 logit models were performed which impacts the decision making of the farmers to enhance the exiting farming practice at the field level. Independent variables used for this study are socio-economic variable, credit accessibility, farmland holding, gender etc. which attracts farmers towards sustainable practices. The major finding of this exercises shows a positive relationship between the adoption of 'line sowing' of rice and 'SRI' (System of Rice Intensification), and the number of years of farming experience The credit accessibility results are positive significant where farmers have to adopt major farm activities like deep ploughing, seed replacement, zero tillage etc. combat the climate change vagaries. More interestingly, organic manure has been adopted by the vulnerable groups higher than the others where results are also validated from the ground level information. The promotions of above interventions require more focus policy driven steps to bifurcate different vulnerable groups under a cluster approach for effective credit diffusion to address Climate Resilient Practices.

Key words: Climate Change, Impacts, Adaptation, Sustainable Agriculture, Climate resilient.

India has seen exponential growth in agriculture post the 1960s, where India went from a persistent food grain production shortage to self-sufficiency and surplus food grain production. However, this growth has slowed down in the past two decades accruing to new problems one of which is climate change and climate variability. The importance of dealing with climate change becomes even more important in India's case as Indian agriculture is predominantly rain-fed with 58% of the total area under cultivation-dependent on seasonal rains for irrigation (Venkateswarlu and Prasad, 2012). Increasing population means there is a pressure on the agriculture sector to produce enough grains to feed everyone, this further aggravates the impact of climate change. According to the Inter-Governmental Panel on Climate Change (IPCC) 4th assessment report clearly outlined the global and regional impacts of projected climate change on agriculture, water resources, natural ecosystems, and food security. Almost every region of the world will be impacted by climate change but countries like India where large populations are dependent on agriculture for a living are more vulnerable. In India, the existing mechanisms for coping with and mitigating the impact of climate change are not properly developed. Several studies indicate that the role of increasing temperatures are significant in agricultural production (Lobell *et al.*, 2012; Aggarwal *et al.*, 2008), similarly, changes in rainfall patterns (Prasanna, 2014; Mall et al., 2006), variations in frequency and intensity of extreme climatic events such as floods and droughts (Brida and Owiyo, 2013; Singh *et al.*, 2013) are also triggering factors. The impact on different crops is not uniform and many crops are more severely affected than others. (Sinha and Swaminathan 1991) concluded that a 2^{o}C increase in mean air temperature could decrease rice yield by about 0.75 t/ha in the high yield areas and by about 0.06 t/ha in the low yield coastal regions. Further, a 0.5^{o}C increase in winter temperature would reduce wheat crop duration by seven days and reduce yield by 0.45 t/ha. An increase in winter temperature of 0.5^{o}C would thereby translate into a 10% reduction in wheat production in the high yield states of Punjab, Haryana and Uttar Pradesh. There are many impending adaptation options to reduce climatic risks in agriculture sectors where adoption of climate-smart agriculture (CSA) technologies is well-accepted method in many countries. FAO launched the concept of CSA in 2009 to draw attention to linkages between achieving food security and combating climate change through agricultural development, and the opportunities for attaining large synergies in doing so. As suggested practices by FAO, the CSA approach involves assimilating the need for adaptation for local context. And also looks into the potential for mitigation into the different strategies suitable for local context and finally, implementation of agricultural policies, planning, and investments. In this paper, however, we consider any technology that improves resilience to climate stresses, productivity or reduces greenhouse gas emissions to be a CSA technology. Notable studies address the practical applicability of adaptation of CSA practices in Madhya Pradesh. Mall et .al, 2006 addressed the impact of climate change in agriculture for specific crops like wheat, rice, and soybean in Madhya Pradesh in which he concluded there is a progressive reduction on the crop yield due to climate change if there is no adaption is followed in the state. The present paper is part of a pilot intervention by the government project “Sustainable Livelihoods and adaptation to Climate Change” implemented by Madhya Pradesh Dhindayal Anthothaya Yojana (MP Day-SRLM), Madhya Pradesh, India (MP-DAY SRLM). The aim of this project is to have a special focus on multiple, locale-specific interventions on production, ecological, knowledge and financial systems that address the specific climate-related vulnerabilities identified in livelihood. The present study tries to estimate the factor determinants adaption of climate-smart agricultural interventions by the government to the vulnerable group in Madhya Pradesh.

MATERIALS AND METHODS

Study Area

The study area was conducted in 32 sampled villages (out of 100 intervention villages) in two districts (Mandla and Sheopur) of different diverse climatic risk zones (drought and flood) in Madhya Pradesh in India (Figure 1). The Sheopur District is located in the north of Madhya Pradesh State and is located in between 25^{0}-15‟ to 25^{0}-45‟ N Latitude and 76^{0} 22‟ to 77^{0} 02‟ E Longitude and covers an area of 6660.81 sq. km. and elevation 251.60 metre above the sea level (DDMP Sheopor-2016) and having 687,952 population (Census 2011). While Mandla district is a tribal district situated in the east-central part of Madhya Pradesh situated in between 22^{0} 2' and 23^{0} 22' N Latitude and 80^{0} 18' and 81^{0} 50' E Longitude almost entirely in the catchment of river Narmada & its tributaries and elevation 442m metre above the sea level(DDMP Mandla-2016). Mandla cover 8771 Sq. Km. area and consists a total population of 10, 53,522 (2011 census), comprises of numerous rivers and endowed with rich forests. The moderate drought probability in the selected districts Shopeur and Mandla have ranged in 15% to 20% and 10% to 15% (IMD Pune 2010) and Rainfed agriculture is very common in both the districts 28% and 50% respectively (SACP 2012) while Mandla has high frequency occurrence of flood affected district (MPSDMP). The major crops growing in the Kharif season (rainy season) are Maize, Rice, Minor millets (Kodo-kutki), Niger (Ram Till), Sesamum, Pigeon Pea and Soybean. The crops in Rabi (winter season) Wheat, Mustard, Chick Peas and Lentil are major cropping systems (Table 1). The study comprises 2 districts distributed across two livelihood zones (FAO 2012). Livelihood zones group together people who share similar options for agricultural production, securing cash income, accessing markets, and exposure to production risks, which is related to geographical location. (Table 2). The study has assessed a distribution rainfall for last 46 year in the Mandla district is 1305mm/year with 18-20% coefficient of variation (CV) Sheopur 795 mm/pear with 23 to 25 CV, this CV represent inter annual variation of rainfall; higher the CV the more variable in the year to year (A. Khatri-Chhetri et al.2017). 16 villages for each district were selected to assess the farmer's willingness to adopt the climate resilient agriculture (CRA) technologies in very low cost interventions by the extensive discussed with expert & subject qualified government officials, project qualified persons and other services organisations (state rural livelihood mission) & community resource persons (SLACC, 2014), both the Selected district having a high vulnerability to the climatic risk (High prevalence of Drought and Flood) categories (Rao *et al.*, 2016).

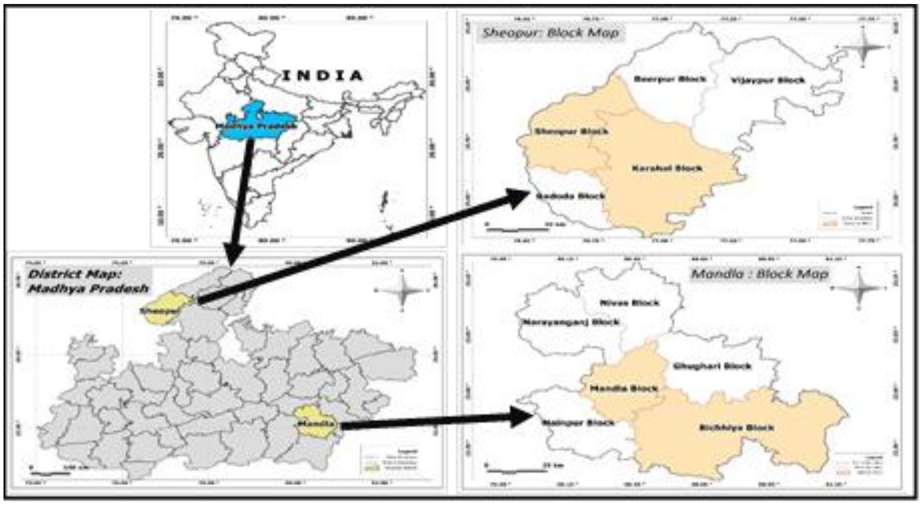

Figure 1. Map of the study area including Madhya Pradesh state of India and selected district with block maps.

Data Collection and Sample Design

The Sustainable Livelihoods and Adaptation to Climate Change (SLACC) program has been implemented in only two districts (Mandla and Sheopur), jointly by MP SRLM and World Bank (World Bank; MPRLM 2014). The data for the performance evaluation and impact study were obtained through the primary survey at the village level by selecting 20-25 farmers for each village. This exercise had mixed research questions (in digital tab-based format) based on the Three major components *Productions* (cropping systems, seed variety, livestock and new farm practices), *Ecology* (irrigation, organic manure, bio-fertilizers, bio-pesticides and soil) and *Technology & Knowledge* (New farm machinery and weather based agro advisory services). Further to the survey we randomly selected 680 farm households (Table 2 – 10% of the total sample size) and conduct survey were necessary to be a member of program beneficiary who participated in the self-help group (SHG) at the Village Organisation (VO) level (MPRAF 2014). We used a CAPI system of data collection whereby enumerators directly captured information by mobile tab phone during the data collection. The mobile Tab application (ODK collect) is a data entry application was loaded with a research-based questionnaire with in-built range and reliability checks to ensure good quality data information. We collect the information on household characteristics, cropping activities, farmer's perception on climate variability (occurrence of climate extreme effect on cropping systems), reason to adopt climate resilient agriculture (CRA) technology for sustainable and reliable recycle use of farm mechanisms to make resilience itself . During the discussion the detail information about the new climate smart agriculture technologies suitable for the local socio-ecological condition were introduced by the SLACC program to all the farmers (Table 3). This discussion helped to identify the influencing factor for adaptive capacity to adopt these interventions can minimise the climatic risk at the village level. The methods for analyse expected outcomes on the basis of two analytical frameworks.

Theoretical framework

Several approaches imply to build the farmers' capacity to understand the new innovative and improve adaptive technology introduced by the program's resource persons and they were tried to convince to make resilience determined by the socio-ecological approaches. This study consequently applies the combination of socio-ecological systems to adopt the low cost interventions that really make farmers resilient to fight with diverse climate conditions impact on agricultural practice. Resilience refers to the amount of disturbance a system can absorb without shifting into an alternate regime (Walker et al. 2006). Two aspects are integrated to make resilience; adaptability of new farm practices (i.e. how factor and systems play role to manage resilient), and transformability (i.e. ability to create a complete new system if old one is unattainable) (Khatri-chhetri et. al. 2016). We tested the assumption that farmers' socio ecological characteristics influence their decision about the type new farm practice and mechanisms that they use.

Analytical framework

The low-cost intervention analysis involves the assessment of availability and utilization by the farmers as either formal or informal. We assess the farmer's reason for adopting the new climatic smart technology in both the stress periods and which kind of farmers category of the farmers are ready to use them in a longer time. We also assess the important indicator of the farmer's preferences to choose the technology in entire agriculture practice.

Imperial Model

The dependent variable used in empirical estimation is the farmer's adoption of a climate smart technology from the list of technologies listed in the table (Table 3). The explanatory variables used for this study are the several socio-economic factors that influence the farmers' adoption of the climate smart technologies in agriculture. Age and gender (Nhemachana and Hassan, 2007; Maddison, 2006), income and poverty and the size of land they hold (Deressa et al., 2011; Knowler and Bradshaw, 2007). Furthermore, adoption patterns vary widely across different locations (Taneja et al., 2014), thus a location variable has been introduced into the model to capture the effect of prevailing rainfall in the different areas. The logit model is used to analyse the determinants of the farmer's adoption of climate resilient technologies. The implementation of SLACC programme resulted in farmers adopting various new technologies as an adaptation to climate change. Dependent variables are discrete and binary, thus a logit model was used for the study.

The model in used in the study can be written in the following general form.

$$P_n (Y_i = 1) = f(X_{i1}, X_{i2}, X_{i3}, \ldots X_{iM})$$

Where Y_i is the dependant variable where Y_i=1 for adoption and Y_i=0 for non-adoption and X_i are the explanatory variables.

Logistic function which is central to the logit model can be represented by as follows

$$P_n(y_i=1) = P_n = \frac{1}{1+e^{-W_i}} \quad i = 1, \ldots, N$$

Where $W_i = b_0 + \sum_{j=0}^{M} bjxij$ is a linear combination of the independent variables (Table 4) and a set of coefficients which are to be estimated.

Table 1: Percentage of rainfed agriculture and major crops in study areas

Districts	% of rainfed agriculture	Major Kharif crops (based on total area under the crop)	Major Rabi crops (based on total area under the crop)
Sheopur	28	Maize*Zea mays*, Jwar, Urad, Sesame, Moong (vigna radiata), Paddy, Kodo, Kutki	Wheat, Gram,Mustard, Lentil
Mandla	50	Maize, Jowar, Urad, Sesame, Moong, Paddy, Minor millets (Kodo, Kutki), Nizer (Ramtil	Wheat, Gram,Mustard, Lentil

Source: MP state agriculture contingency plan 2012

Table 2: Characteristics of areas selected for the study and sample size

Livelihood Zone	Key Characteristics	Sample District	Respondents
Sheopur Zone 7- Northern Chambal Ravines Zone - Irrigated mustard predominant.	Alluvial (Light) soil. A population density of 100/km2. The average annual temperature in Sheopur is 25.8 °C, the climate is warm and temperate in Sheopur, Traditional farmers and landless	Sheopur & Karahal	311 Females 32 Males
Mandla Zone 16- Mahakaushal Maikal Hill Zone water rich, subsistence (millet) tribal zone	Red & Yellow Medium black & skeletal soil. A population density of 120/km2. Traditional farming methods are used widely. The average annual temperature in Mandla is 24.4 °C. There is much less rainfall in Mandla than in summer, Traditional Tribal farmers	Mandla & Bichhiya	327 Females 11 Males

Source: MP ENVIS, FAO

Table 3: Climate smart technologies

Technology	Adaptation/Mitigation Potential
Water - resilient	Technologies that improve water use efficiency
Lift irrigation (well canal, river, dam)	Reduces water loss
Rechargeable bore well	Vertical drilled wells which are recharged from rain water.
Drip Irrigation	Application of water to the roots of the crops to minimise water loss.
Sprinkler	Saves water by spreading water out to a larger area.
Rain gun	Rain guns are high performance impact sprinklers. Can cover up to 4 hectares of land.
Check dam	Check dams are a highly effective practice to reduce flow velocities in waterways.
Farm Pond (In-situ Rain Water Harvesting)	Harvests and stores rainwater.
Energy - Resilient	Improve energy use efficiency
Direct sowing/Minimum Tillage	Reduces amount of energy use in land preparation.
Weather – resilient	Interventions that safeguard farmers from the weather change
Weather based advisory	Climate based advisories given to farmers.
Adoption of any improved seed varieties	Seed variety that are resilient to adverse climate conditions.
Crop insurance	Compensates for losses in fluctuating weather
Knowledge – resilient	Uses specific local knowledge and awareness
New farm machinery tools (Custom Hiring Centre)	Hiring tools and implements from local CHCs, significant reduction in transportation costs.
Climate Change adaptation Planning (CCAP)	Village level management plans for adoption to climate change that create awareness for available local resources to assess climate variability and

	how to tackle it.
Nutrient - resilient	Practices that improve nutrient profile
Organic Manure	Improves soil health by improving microbe count
Soil health card	Advisory based on current soil health
Carbon smart – resilient	Practices that reduce emissions
Bio - Pesticides (Neemashtra, Brhmashtra, Agnishtra, Amrit Khad)	Leaves no toxic residue.
Labour - resilient	Require less effort
Deep Ploughing	Maintains more moisture with less effort
Seed Treatment	Increases yield and resilience
Line Sowing	Higher yield
Contour bounding	Prevents soil erosion, promotes water retention
Seed Replacement	

Table 4: Description of independent variables

Variables	Descriptions
Land	Area of the land owned by farmer in Bigha.
Income	Annual Income in Rs
Experience	Farming experience, 1 = experience above 10 years 0 = otherwise
Age	Age of the farmer
Education	Farmer's education level
Location with rainfall	Average annual rainfall, High rainfall = 1 0 = otherwise

RESULTS AND DISCUSSION

The result section consists of two major classifications (I) Descriptive statistics of variables used in the regression analysis and (II) Parameter estimates of logistic models of the different interventions to the farmers in the state of Madhya Pradesh. The explanatory variables are consist of 9 major classifications including 13 major interventions namely, gender, educational qualification, social category, farming experience, economic information's, credit accessibility, other variables and study location. Out of 13 major interventions, agro advisories was the one of the wide spread intervention to the farmers, 65% of the farmers adopted the agro- Advisories in the study location. More interestingly, 59% of farmers were showing interest to adopt, the SRI and SWI in the agriculture land. 53% of the farmers in the selected villages were adopted the deep ploughing machinery from the Custom Hiring Centre (CHC) which is established in each intervention villages. Even though, 24% of farmers adapted line sowing, the adaption of weed control machinery like Cono-weeder in CHC center was limited to 4% from the study location. Soil enrichment interventions like usage of organic manure and bio-pesticide were adopted up to 37% of the farmers. The intervention program mainly designed to engage the women farmers in climate-smart agricultural practices in the state. In line to the program, 94% of the women farmers and 4% were the male farmer. More eventually, 69% of farmers were illiterate and 14% completed the primary education. The Scheduled Tribes and Other Backward Caste were the dominant communities located in both the district which constitute 50% and 31% of the farmers in the study sample. Farming experience of the farmers has been classified into 3 major classifications which were more than 20years of experience (71%), between 10 to 20 years (22%) and less than 10 years of experience (7%). It clearly shows that the climate-smart intervention was focused mostly on the experienced women farmers. The average annual income of the farmers is INR 60877 followed by the land holding of per farm household was 7.54 bigha (3.35 acres). The average age of the farmers in both districts was 38 years and the size of

Table 5. Descriptive statistics for the variables used in the regression

Variable	Description of variable used in regression	Mean	Std.dev.
Dependent variable			
Deep Ploughing	Dummy variable 1=Deep ploughing ; 0 otherwise	0.53	0.50
Seed replacement	Dummy variable 1=Seed replacement ; 0 otherwise	0.37	0.48
Seed treatment	Dummy variable 1=Seed treatment ; 0 otherwise	0.21	0.41
Line sowing	Dummy variable 1=Line sowing ; 0 otherwise	0.24	0.43
Seed Germination	Dummy variable 1=Seed Germination ; 0 otherwise	0.14	0.35
Organic Manure	Dummy variable 1=Organic Manure ; 0 otherwise	0.37	0.48
Bio-Pesticides	Dummy variable 1=Bio-Pesticides ; 0 otherwise	0.37	0.48
Direct sowing	Dummy variable 1=Direct sowing and zero tillage ; 0 otherwise	0.42	0.49
Weed control	Dummy variable 1=weed control and zero tillage ; 0 otherwise	0.04	0.20
SRI/SWI*	Dummy variable 1=SRI/SWI ; 0 otherwise	0.59	0.49
Soil testing	Dummy variable 1=Soil testing ; 0 otherwise	0.43	0.50
Agro Advisory	Dummy variable 1=Agro Advisory; 0 otherwise	0.65	0.48
Bore well	Dummy variable 1=Bore well; 0 otherwise	0.38	0.49
Gender			
Female	Dummy variable 1= Female; 0 otherwise	0.94	0.24
Male	Dummy variable 1= Male ; 0 otherwise	0.06	0.24
Educational Qualification			
Primary Education	Dummy variable 1= primary education (1-5 standard) ; 0 otherwise	0.14	0.35
Secondary Education	Dummy variable 1= Secondary education (6- 8 standard) ; 0 otherwise	0.10	0.29
Higher Secondary education	Dummy variable 1= Higher secondary ; 0 otherwise	0.06	0.24
Graduation & Above	Dummy variable 1= Graduation and above ; 0 otherwise	0.01	0.09
Illiterate	Dummy variable 1= illiterate ; 0 otherwise	0.69	0.46
Social Category			
Scheduled caste	Dummy variable 1= Scheduled Caste ; 0 otherwise	0.16	0.37
Scheduled tribe	Dummy variable 1= Scheduled Tribe ; 0 otherwise	0.50	0.50
Other Backward caste	Dummy variable 1= Other backward caste ; 0 otherwise	0.31	0.46
General/ Forward caste	Dummy variable 1=General caste ; 0 otherwise	0.03	0.18
Farming experience			
More than 20 years	Dummy variable 1= >20 years ; 0 otherwise	0.71	0.46

Between 10 to 20 years	Dummy variable 1=10> experience <20 years ; 0 otherwise	0.22	0.42
Less than 10 years	Dummy variable 1=<10 ; 0 otherwise	0.07	0.25
Economic variables			
Income	In INR	60877	50910
Agricultural land size	In Bigha (1 acre=2.25 bigha)	7.54	6.62
Credit Accessibility			
Loan taken	Dummy variable 1=Loan taken ; 0 otherwise	0.31	0.46
Other variables			
Age	Age in years	37.94	10.03
Size of the household	Household size in numbers	5.40	2.01
Study location			
Mandla	Dummy variable 1= Mandla; 0 otherwise	0.50	0.50
Sheopur	Dummy variable 1= Sheopur; 0 otherwise	0.50	0.50

Table 6. Result of parameter estimates on intervention using logistic model.

Variables	Deep Ploughing		Seed Replacement		Seed Treatment		Line Sowing		Seed Germination		Organic Manure		Bio-Pesticides		Direct Sowing and Zero Tillage		Weed Control	
	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E	C.E	S.E
Gender (Male as reference variable)																		
Gender-Female	-0.58	0.45	-0.77**	0.36	-0.86**	0.39	0.08	0.42	-0.03	0.48	0.04	0.41	0.01	0.41	-0.25	0.38	-1.42**	0.65
Educational Qualification (Illiterate)																		
Primary	-0.24	0.32	0.16	0.28	0.23	0.36	-0.06	0.40	0.20	0.43	0.16	0.37	-0.56	0.37	-0.07	0.30	0.42	0.75
Secondary	-0.45	0.39	-0.08	0.34	0.13	0.45	-0.06	0.49	0.59	0.47	-0.29	0.46	-0.53	0.45	-0.28	0.36	1.38**	0.76
Higher secondary	-0.13	0.44	0.47	0.39	-0.05	0.62	0.38	0.68	0.38	0.68	0.01	0.58	0.17	0.53	-0.08	0.43	2.34**	1.00
Graduation above	-0.21	1.20	0.06	0.99	1.50	1.11	2.52**	1.11	1.57	1.20	1.44	1.18	0.67	1.12	1.61	1.00	2.51	1.99
Social Category (General Caste)																		
Scheduled Caste	-0.22	0.64	-0.82	0.51	0.13	0.55	-0.27	0.57	2.38**	1.08	1.27***	0.61	0.06	0.55	-0.31	0.53	14.91	767.22
Scheduled Tribe	0.39	0.62	-0.91*	0.49	0.04	0.52	-0.12	0.53	1.90**	1.07	2.09***	0.59	-0.12	0.51	-0.34	0.51	14.07	767.22
Other Backward Caste	-0.51	0.60	-0.52	0.48	-0.79	0.51	0.16	0.51	1.27	1.06	1.09*	0.56	-0.10	0.50	-0.68	0.50	13.54	767.22

Farm experience (>10 years)																		
>20 years	0.20	0.42	0.07	0.36	0.16	0.46	-0.94**	0.45	-0.67	0.49	0.40	0.45	0.29	0.44	0.85	0.42	1.17	0.96
<10 years and >20 years	0.55	0.43	0.01	0.37	0.11	0.46	-0.40	0.44	0.15	0.48	0.76*	0.44	-0.13	0.43	1.33***	0.42	0.43	1.00
Economic variables																		
Household Income	0.00	0.00	0.00*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00**	0.00
Agricultural Income	-0.09	0.34	-0.57*	0.31	0.19	0.54	0.82	0.64	-1.13***	0.43	0.54	0.50	0.96*	0.54	0.36	0.36	-1.90**	0.86
Farm Landholding																		
Size of the land	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.00	0.02	0.02	0.02	0.02	0.02	-0.01	0.02	0.08***	0.03
Credit Accessibility																		
Loan Taken	1.01***	0.24	0.71***	0.19	-0.08	0.23	0.46**	0.23	0.16	0.26	1.02***	0.24	1.19***	0.23	1.46***	0.21	0.57	0.45
Other variables																		
Age	0.01	0.01	0.00	0.01	-0.01	0.01	0.00	0.01	0.04***	0.01	0.00	0.01	-0.01	0.01	0.00	0.01	0.00	0.03
Household Size	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Location (Sheopur as a reference variable)																		
Mandla District	-3.23***	0.32	-1.54***	0.29	-2.64***	0.36	-3.15***	0.45	-2.02***	0.42	-4.00***	0.38	-3.19***	0.34	-1.65***	0.27	-4.72***	1.06
Constant	1.41	0.97	2.09**	0.84	0.39	1.01	-0.86	1.08	-3.08**	1.41	-2.08**	1.05	-0.56	1.01	-0.52	0.88	-13.98	767.22
Pseudo R Square	0.366		0.119		0.189		0.285		0.141		0.396		0.366		0.231		0.268	
Log Likelihood	-298.2		-396.0		-284.9		-267.8		-234.9		-270.6		-285.1		-356.6		-87.8	
No of Observation	681		681		681		681		681		681		681		681		681	

*, ** and*** represents 99%, 95% and 99% significance level.

Table 7. Parameter estimates of the logistic model.

Variables	SRI/SWI*[1]		Soil Testing		Agro-Advisory		Bore well	
	C.E	S. E	C.E	S. E	C.E	S. E	C.E	S. E
Gender (Male as reference variable)								
Gender- Female	0.03	0.44	-0.28	0.53	-0.16	0.56	0.81**	0.41
Educational Qualification (Illiterate)								
Primary	0.54*	0.29	0.44	0.38	0.26	0.33	0.03	0.33
Secondary	0.41	0.34	1.59***	0.44	0.87**	0.37	0.37	0.37
Higher secondary	0.51	0.39	0.11	0.61	0.89**	0.40	0.15	0.46
Graduation above	1.37	0.95	1.59	1.00	2.38**	1.19	1.02	1.06
Social Category (General Caste)								
Scheduled Caste	0.02	0.69	0.64	0.62	-1.09	0.93	-1.17**	0.55
Scheduled Tribe	-0.29	0.66	-0.23	0.58	-0.17	0.90	0.29	0.51
Other Backward Caste	-0.79	0.66	0.49	0.57	-0.18	0.91	-0.18	0.49
Farm experience (>10 years)								
Farming Experience >20 years	0.95**	0.40	1.49***	0.47	-0.14	0.49	-0.17	0.40
Farming Experience <10 years and >20 years	1.07***	0.41	-0.01	0.45	-0.53	0.52	0.09	0.40
Economic variables								
Household Income	0.00	0.00	0.00**	0.00	0.00*	0.00	0.00**	0.00
Agricultural Income	-0.40	0.30	0.93*	0.51	0.53	0.34	0.70*	0.41
Farm Landholding								
Size of the land	0.00	0.01	0.02	0.02	0.00	0.02	0.00	0.02
Credit Accessibility								
Loan Taken	0.66***	0.22	0.97***	0.26	1.25	0.28	0.88	0.21
Other variables								
Age	0.01	0.01	-0.01	0.01	-0.01	0.01	0.00	0.01
Household Size	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	0.04
Location (Sheopur as a reference variable)								
Mandla District	-2.69***	0.30	-3.71***	0.36	-3.51***	0.40	-2.20	0.30
Constant	0.65	0.95	-1.01	1.08	2.68**	1.27	-1.33	0.94
Pseudo R Square	0.258		0.449		0.416		0.256	
Log Likelihood	-341.6		-256.3		-257.1		-336.7	
No of Observation	681		681		681		681	

*, ** and*** represents 99%, 95% and 99% significance level. *[1] SRI/SWI including line sowing

the farm household was 5 per house. In the present study, the logistic regression consists of the several explanatory variables which constituting the socio-economic variables like age, sex, social category, household income and farm experience, land holding, credit accessibility. Initially, total 21 logistic regressions were performed, due to under fit model the result was dropped in table 6. The results were divided into 2 major divisions namely, production activities and other supporting activities of the production processes. In production activities, interventions involve 9 activities namely, deep ploughing, seed replacement, seed treatment, line sowing, seed germination, organic manure, bio-pesticide, direct sowing & zero tillages, and weed control. These interventions were performed by the farmers either directly or through a custom Hiring center (CHC) established by the government in each village organisations. The activities like seed treatment, deep ploughing machinery, seed germination, weed control machinery were hired from CHC. When comparing with male farmers, female farmers are not adopting the advanced machinery for the activities like seed replacement, seed treatment and weed control which clearly shows that it is negatively affecting these activities with 95% level of significance (Table 6). More interestingly, the activities like seed germination and the use of organic manure are positively significant to social groups like scheduled caste and scheduled tribes. More importantly, the farmers experienced more than 10 years and less than 20 years are positively significant (Table 7) to organic manure and direct sowing & zero tillage when compared with less than 10 years of experience. When comparing agricultural income with seed replacement, seed germination, biopesticide and weeds control shows that the seed replacement and seed germination are negatively impacting since it takes a long time to recover whereas; use of bio pesticides is positively significant to weed control. In credit accessibility (loan taken for production activity), the activities using with machinery are positively significant which is 99% level of significance. The Pseudo R-square value ranges from 12% to 39% for 9 models which clearly shows that the dependent variables correlated with the independent variable. The logit model results of supporting interventions are represented in Table 7. The SRI/SWI term includes the adaptation of line sowing activity by the farmers. When comparing with illiterates, farmers who educated are highly interested to adopt the agro- advisory services provided to the farmers in the locality. More interestingly, when compared less than 10 years experienced farmers and the farmers have more than 10 years of experience found that experienced farmers are highly adapting the SRI technology which is statistically significant and farmer has more than 20 years of experience are testing soil in the farmland which was statistically significant at 99% level of significance. Soil testing was positively influencing the agricultural income. It has been establish in data that soil testing adopted by the farmers in the district that has increased their farm income**.** Loan accessibility positively influences the SRI/SWI activities and soil testing. Taneja *et al.*, 2014 explored the preference of farmers on Climate Smart Agriculture in which the study concluded with interventions like zero tillage, crop insurance and water interventions was highly preferred by the farmers in the study region. Survey data also established the fact that farmers who are taking the loan for the agricultural purpose; have more adaptive towards SRI/SWI and soil testing in their agricultural land. When comparing with SRI/SWI, soil testing and agro-advisory in both the districts that results are more effecting in Sheopur district compare to Mandla district. The Pseudo R-square value ranges between 25% to 44% for SRI/SWI, soil testing, Agro advisory and Bore well.

CONCLUSION

In general, our results suggest that line 'sowing' in general and 'SRI methods' in paddy fields are adopted highly by farmers, where deep ploughing, seed replacement, zero tillage were the other most important agronomic practices impressible under climate resilient adoption practices by farmers in Sheopur and Mandla, Madhya Pradesh. In other words, adoption of SRI and Line sowing are critical for enhancing the yield. Furthermore, farmers supplemented that it will enhance their farm income. Also, since a climate resilient practice requires timely farm inputs (Agro advisory), affordable technologies such as organic manure pit and farm credit and promotions of it have improved the participation in agriculture by vulnerable groups. The gender results indicate that a female farmer is likely to adopt almost all promoted farm practices relative to a male farmer. So, improving farm participation across farmers in Sheopur and Mandla and related or similar geographical locations in Madhya Pradesh or other parts of India can focus on improving women's access to credit, land, education, and training and additionally, provide information on market prices to motive female farmers into sustainable agriculture. Finally, this study provides detailed information about the impact of different independent variables of the individual farmers and economic aspects. This is one of the few studies analyzing short-term credit model for adopting climate resilient practices. These empirical results are critical from a policy perspective in semi-arid regions. However, due to the lack of information about actual benefits by individuals for two seasonal crops, we could not estimate the credit demand elasticity. The inclusion of this financial information would contribute to future farm credit research. The promotions of such interventions require more focus policy driven steps to bifurcate different vulnerable groups under cluster approach for effective credit diffusion to address Climate Resilient Practices.

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