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Farm Women Participation in Natural Resource Conservation: Technology Adoption Study in Semi-Arid Regions of India

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ABSTRACT

Background: Semi-arid regions (SARs) of India are characterized by limited rainfall and often prone to droughts. These regions typically receive moderate to low levels of precipitation, making agriculture and water availability significantly challenging. In India, 55% of population is engaged in agriculture and its allied activities. Despite making a significant contribution to livelihoods, the sector continues to face challenges as soil degradation and resource depletion have reduced crop and livestock outputs. To mitigate the effects of land degradation and conserve rainwater, government has taken significant measures to make natural resource conservation a priority throughout the country. To conserve the natural resources, women are always playing an important role as they are always involved in agricultural activities.

Methods: The study was undertaken to investigate the role of women in Soil and Water Conservation (SWC) in 3 SARs of India. The purposive sampling was done as watershed beneficiaries were selected as sample respondents.

Result: The results revealed that majority of women (55%) had a medium level of technology adoption. Multiple regression analysis revealed that women's age, education, farming experience, risk bearing, social participation and cost-effectiveness were influencing the adoption of SWC technologies in watersheds. The correlation analysis reflected that out of sixteen factors, eleven factors namely age, education, farming experience, land holding, risk bearing, social participation, agro advisory and weather advisory, skill development, ease of use and cost effectiveness significantly affected the adoption of SWC technologies.

Key words: Adoption, Farm women, Semi-arid region, SWC technology, Watershed.

INTRODUCTION

Agriculture is the backbone of rural India because it is the primary source of employment, employing half of the country's workforce (Singh *et al*., 2020). Although, soil degradation and replenishment of natural resources make Indian agriculture always on high risk (Choudhary *et al*., 2013). Government of India launched watershed programme in 1983-84 as a major scheme to conserve and utilize natural resources for higher crops productivity and more employment generation in addition to address the climatic variabilities (Ram, 2021). The success of these watershed programmes depended more on farm women compared to men, as they are closer to their environment and natural habitat. They play an important role not only in agriculture and decision making but also in activities such as non-farm operations, livestock and household duties (Choudhary *et al*., 2013). Their household chores are also affected with change in their natural habitat (Rawat *et al*., 2019).

In India, the semi-arid regions cover around 9.7 lakh km^2 (37%) of total geographical area, occupying mainly the states of Rajasthan, Punjab, Haryana, Uttar Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Karnataka andhra Pradesh and Tamil Nadu (Sathyakumar and Sivakumar, 2007). Semi-arid regions receive limited rainfall (150-500 mm), resulting in dry conditions for a significant portion of

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the year and the regions have been classified between desert and humid climate (Rajpoot *et al*., 2021; Verma *et al*., 2024). Watershed programmes in semi-arid zones are initiatives focussing on sustainable land and water management practices to improve soil health, increase water availability and enhance the overall resilience of the ecosystems (Omran *et al*., 2020). Conservation of natural resources results in long-run improvement of agricultural productivity, a key driver for poverty reduction (Heba *et al*., 2021). Implementing practices related to soil and water conservation technology within watersheds help to prevent soil erosion, maintain water quality and preserve the ecosystem health. Numerous studies to evaluate the influence of watershed programs in India, have documented significant lessons that have been learnt from these assessments (Wani *et al*., 2008).

Evaluation of watershed programs revealed the significance of people's involvement in the development process and the institutions in fostering enhanced community participation. The gender perspective in watershed development programs is of vital importance as gender equality is the focal issue in sustainable development goals set by United Nations. The watershed programs execution should be essentially based on women's needs and demands. Involving women in the identification of field problems, planning and at every step of execution, is the core of gender equality. As women are mainly involved in agricultural activities, they play a significant role in soil and water conservation technologies, both as beneficiaries and as active participants in adopting and implementing the techniques. In view of shrinking natural resources, women are more inclined towards conserving natural resources. Rawat *et al.* (2018) found out that farm women opted for afforestation and construction of *kachcha* pond to conserve water, as a consequence of drying of natural water bodies. The adoption of Soil and Water Conservation (SWC) technologies by women in different agro-ecological regions of India varies due to several factors, including cultural norms, economic conditions, education levels and resources availability. Keeping the above perspective in consideration, a study was undertaken to assess the level of adoption of SWC technologies by farm women, impact of various factors on the adoption of technologies and the correlation between selected factors and technology adoption.

MATERIALS AND METHODS

Description of the study areas

The present study was undertaken in three project watersheds of ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun. The watershed namely Kajiana (Latitude 30.46, Longitude 76.56) is located in Research Centre, Chandigarh (Punjab), Dhoti watershed (Lat. 24.55, Long. 76.31) in Research Centre, Kota (Rajasthan) and Vejalpura-Rampura watershed (Lat. 23.00, Long. 73.08) in Research Centre, Vasad (Gujarat) (Fig 1). The ICAR-IISWC implemented these watersheds under National Watershed Development Project for Rainfed Areas (NWDPRA) Scheme of Govt. of India during 2007-2012.

The Kajiana watershed with elevation of 334 m is in Shivalik hills having steep hills followed by eroded piedmont and fluvial valleys. The average rainfall is 1260 mm. The Dhoti Watershed is located in the Panchayat Samiti Atru of Baran district of Rajasthan. The elevation is 290 m. Climate of the region is dry sub-humid. Average annual rainfall in the watershed area is 874 mm and its distribution is highly erratic as more than 90% rainfall is received during July to September in the form of intense storms. Watershed is located in '*Pathar* and Bundelkhand Upland' sub-region of Central Highlands. Vejalpur-Rampura watershed (elevation 85 m) in Gujarat has average annual rainfall of 812 mm, most of which (about 94%) is received during the rainy season (June to September) accompanied with high intensity storms.

SWC technologies assessed in the study area

The major SWC technologies pertaining to semi-arid regions were mixed cropping, mulching, field bunds, in-situ measures, vegetative barriers, trenching and contour cultivation.

Sampling technique

For assessing the influence of socio-economic characteristics of farm women in technology adoption, from each watershed a sample of 40 farm women was selected through purposive sampling and thus total of 120 farm women were chosen from different semi-arid regions. Quantitative as well as qualitative data was gathered from primary and secondary sources to fulfil the project objectives. The data were collected using various tools including Focus Group Discussions (FGD), gender analysis, key informant and individual household interviews using a structured interview schedule. Before conducting the survey, pre-testing of the questionnaire was carried out in the study area to ensure that all the important information is captured during the actual data collection.

Method of data analysis

The demographic characteristics were analyzed and explained using descriptive statistical analysis (Panse and Sukhatme, 1989). The selected dependent and independent variables were analyzed using a regression model in SAS program to estimate factors influencing the adoption of watershed management. Table 1 describes about the various variables used in the study.

RESULTS AND DISCUSSION

Extent of technology adoption

The adoption level of SWC technologies by farm women is elucidated in Table 2. It signifies that majority of women (55%) had a medium level of technology adoption followed by low adoption (34.17%). Whereas, very few respondents (10.83%) had high rate of adoption. These findings indicate

Table 1: Definition and statistical description of variables used in study.

Variables	Definition	Dimension	Question	Calculation of score
Age	Someone with older age may not take interest to adopt new technology (Morris and Venkatesh, 2000).	Continuous variable	Age of the respondent in years	Age categories: -20-30 yrs (1) -30-40 yrs (2) ->40 yrs (3)
Education	Higher a person is educated, more likely she will adopt a new technology because she is able to learn a new technology sooner (Kolodinsky *et al*., 2004)	Continuous variable	How many education years do you have?	Number of schooling years: - upto 5 yrs (1) - 5-10 yrs (2) >10 yrs (3)
Farming experience	It may influence the thinking to take decisions about adoption of new technology	Continuous variable	For how much time, you are doing farming?	Farming experience in years
Caste	Caste related restrictions play an important role in adoption of technology	Categorical variable	Which caste do you belong?	Categories: General (1), OBC (2), SC (3), ST (4)
Family size	No. of family members in a household	Continuous variable	How many members are there in the family?	-Members up to 4 (1) -Members 4-6 (2) -Members >6 (3)
Monthly household income (MHH)	Per household monthly income (Rs)	Continuous variable	-How much money do you earn from agriculture and other sources?	Income sources: -Agriculture (1) -Business (2) -Service (3) -Others (4)
Average land holding (ALH)	Size of land holding will determine the adoption of some NRM technologies like trenching, farm pond *etc*.	Continuous variable	How much operational land holding do you own?	-Marginal farmers (1) -Small farmers (2) -Medium farmers (3)
Risk bearing	New technology always bears some risk of failure. Depending upon the degree of risk, adoption chances will vary	Categorical variable	Adoption level of technologies by farm women	Per cent adoption of NRM interventions by farm women
Social participation	Women membership in farmer's organization like SHG/FPO/ cooperative society/ NGOs *etc*.	Categorical variable	Type of organization you are involved in:SHG, FPO *etc*	Extent of participation: -Always (2) -Sometimes (1) -Never (0)
Agro advisory	Prior information about agricultural inputs, crop insurance, weather forecast *etc* facilitates the farmers to take timely decisions	Categorical variable	How do you get agro advisory?	Frequency of getting advisory: -Always (2) -Sometimes (1) -Never (0)
Weather advisory	Prior information about weather forecast and related aspects *etc* facilitates the farmers for timely farming operations	Categorical variable	How do you get weather advisory?	Frequency of getting advisory: -Always (2) -Sometimes (1) -Never (0)
Market information	Prior information with regard to market rates of agricultural inputs *etc* to facilitate the farmers for efficient and profitable farming	Categorical variable	How do you get market information?	Frequency of getting advisory: -Always (2) -Sometimes (1) -Never (0)

Table 1: Continue...

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Skill development training	Training of women in SWC certainly helps in changing their attitude and behaviour towards new interventions	Categorical variable	-Which type of training undergone? -For how much period training attended? -Training useful or not	Training attended: -Yes (1) -No (0)
Subsidy on adoption	Financial assistance provided by government to adopt any technology, to make technology more accessible and affordable	Categorical variable	-Are you aware of any subsidy on SWC technology? -Whether you will adopt technology if subsidy given?	Subsidy availability: -Yes (1) -No (0)
Ease of use	Easiness in construction of any technology like trenches, farmpond *etc* and ease in their usage	Categorical variable	-Are you comfortable with new technology?	Ease of use: -Yes (1) -No (0)
Cost effectiveness	The investment behind adoption of technology	Categorical variable	-Is the cost reasonable? -Is it beneficial to invest in a particular technology?	Cost effectiveness: -Yes (1) -No (0)

Table 2: Level of technology adoption by farm women.

Technology adoption	Frequency	Per cent	Mean	Std. Dev.
Low	41	34.17	4.208	1.784
Medium	66	55.00		
High	13	10.83		
Total	120	100.00		

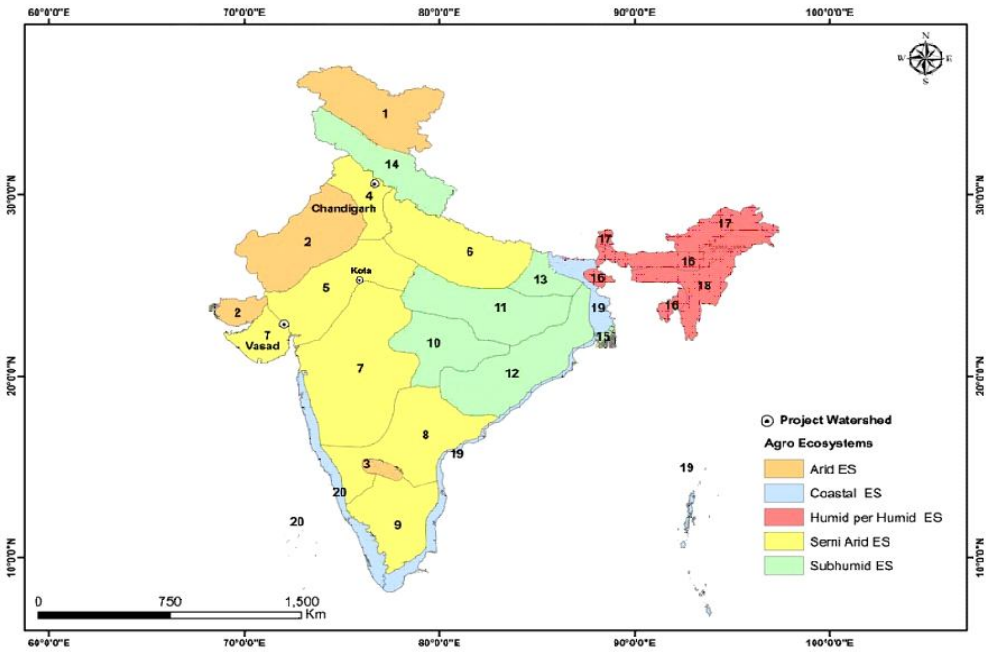

Fig 1: Studied watersheds in semi-arid regions of India.

that women farmers are reluctant in accepting a new technology. Supporting this view, a study in Burkina Faso revealed that women have less bargaining power than men which limits access and control over household resources by them which also influences the adoption of technology (Theriault *et al*., 2017). In some developing countries, access to credit is gender biased where female-headed households are discriminated by credit institutions and they are unable to invest in yield raising technologies, leading to low adoption rate (Mwangi and Kariuki, 2015).

Multiple regression analysis

To explore the nature of relationship on factors for adoption of soil water conservation measures, multiple regression analysis was done. The regression model was employed to establish relationship between dependent (adoption of SWC technologies) and independent variables (demographic and socio-economic factors) affecting women's participation in SWC (Table 3). For this purpose, 17 explanatory variables were selected to explain the dependent variable. However, only six variables namely age (X_1), education (X_2), farming experience (X_3), risk bearing (X_8), social participation (X_9) and cost-effectiveness (X_{16}) influenced the dependent variable.The detailed explanation of each variable is given below:

Age

The output of regression model demonstrated that age of farm women had a negative significant association with technology adoption (P<.01) with the value of -4.81. This implies that with increasing age, women have shown decreasing interest in trial and adoption of new technology. The young farmers as compared to older community largely adopt the technologies due to increased exposure and educational levels. Few findings also revealed a negative relationship between age and technology adoption (Berkowsky *et al*., 2018). However, some studies reported a positive relationship (Chuang *et al*., 2020), few concluded that age has a positive as well as a negative impact on technology adoption (Melesse, 2018). He also mentioned that older farmers have more experience compared to young farmers. Moreover, older farmers have more resources than young farmers that help in adoption of new technologies. On the contrary, the young farmers largely adopt the technologies due to their tech savvy behaviour (Belcher, 2022).

Education

Another important variable is the education of women in terms of number of schooling years, which has positive significant impact on the adoption of technology with t-value of 5.42. Education level of household heads and training participation significantly affected farmers' adoption decision (Dilebo, 2017; Kumari, 2023). Most studies found that better-educated farmers, regardless of gender, are more likely to adopt new technologies but women farmers with less education, less land access are less likely to adopt new technologies (Quisumbing, 1995). Furthermore, farmers who had higher education level were more interested in adoption of high yielding variety in Ethopia (Egge *et al*., 2012). It might be due to change in the knowledge, attitude and skills of farmers through higher level of education (Choudhary *et al*., 2013).

Farming experience

The farm experience is an important determinant in deciding the level of adoption of SWC technologies. The t-value for this variable was observed negative (-12.65) at 1% level of significance. Contrary to this, gender differences in cassava production technology adoption were examined and found that the adoption level was 26% higher among male adopters than their female counterparts (Obisesan, 2014). He concluded that adoption was significantly influenced by gender, participation in off-farm activities, distance to market, land area cultivated, years of farming experience, access to credit, cassava yield and level of education. Besides, greater experience of older farmers might have led to adoption of new technology (Silva and Broekel, 2017).

Risk bearing

The farm women who were already adopting improved agricultural practices, vermi-composting, organic farming, new variety *etc*., were able to bear risks of adoption of new technologies. Risk bearing of farm women had positive association with adoption (2.26). Risk-averse people are generally small farmers, who are resistant to adopt new technologies due to low income and less capital. They are relatively experienced in growing and are more satisfied

Table 3: Multiple regression analysis between technology adoption and selected independent variables. n=120

Variables	Reg. Coef. (b)	SE of b	t-value for b
Age	-0.020	0.00	-4.81**
Education (yrs)	0.107	0.02	5.42**
Farming Exp (yrs)	-0.141	0.01	-12.65**
Caste	-0.148	0.10	-1.52
Family size	0.022	0.03	0.84
MHH Income	0.000	0.00	1.50
ALH (acres)	-0.011	0.01	-0.77
Risk bearing	-0.090	0.04	2.26**
Social participation	0.291	0.11	2.60*
Agro advisory	0.019	0.06	0.33
Weather advisory	-0.025	0.09	-0.29
Market information	0.054	0.04	1.24
Skill development	0.047	0.08	0.58
Subsidy on adoption	-0.093	0.07	-1.33
Ease of use	0.064	0.08	0.84
Cost effectiveness	0.163	0.09	1.77*
Constant	10.18		
R-square value	0.97		
Multiple R-value	0.98		

** Significant at 1%, * at 5% respectively.

with the use of current technology and less receptive to new technology (Gwara *et al*., 2022).

Social participation

Participation in social institutes like SHG, FPO make women exposed to new avenues with more confidence (Choudhary *et al*., 2013). While discussing, the problems related to soil erosion, water scarcity, *etc*., women with no participation in social organization or local institutions showed less probability of adopting SWC measures than those women involved in discussions. Social participation in institutions has positive association with the adoption of technology with value of 2.60 at 5% level of significance. This suggests that women who take an active role in discussions, meetings and various community dialogues, have 14.2% higher likelihood of participation in SWC compared to those who are not engaged in any discussion. Traditional management practices and discussions within social institutions play a crucial role in fostering robust and cooperative social network within SWC practices (Bekele and Drake, 2002). A study on similar lines revealed the connection of social network relations formed by cotton farmers based on geography and association makes information transfer, collective communication and decision-making as the main way of technology diffusion (Ren *et al*., 2022).

Cost-effectiveness

The impact of cost-effectiveness on technology adoption is multifaceted and can be analysed from several perspectives, *i.e*. initial investment, scope for scalability, operational efficiency, *etc*. The cost-effectiveness of SWC technology had a significant positive (1.77) association with its adoption at 5% level of probability. The two main factors that affect the adoption process are the availability and affordability of new agricultural technologies and farmers' expectations of long-term profitability (Silva and Broekel, 2017). Furthermore, some workers have described that the "relative advantage, compatibility, complexity, trialability and observability" of the innovation are key pillars in the adoption process (Warner *et al*., 2019). The R^2 value (0.97) in Table 3, expressed the idea that six variables jointly contributed toward 97% of the variation in the level of adoption.

Correlation analysis

Unlike, the regression analysis, correlation depicted that out of sixteen variables, eleven variables significantly affected the adoption of SWC technologies (Table 4). Age was found as negatively correlated (0.857) with adoption at 1% level of significance. The impact of age on the adoption of technology has contested explanations. Some findings revealed a negative relationship between age and technology adoption (Berkowsky *et al*., 2018), while other researchers revealed a positive relationship (Chuang *et al*., 2020). Education of farm women has a positive correlation with their adoption (p<.01) with the value of 0.926. This relationship was revealed in other studies too (Ha and Park, 2020). The main reason for this positive relationship

Table 4: Correlation analysis of variables for technology adoption in semi-arid regions of India*.

	Variables	Age	Edu (yrs)	Farm exp (yrs)	Caste	Family size	MHH income	ALH (Acres)	Risk bearing	Social parti.	Agro advisory	Weather advisory	Market information	Skill develop	Subsidy on adoption	Ease of use	Cost effective-ness
1	Age	-0.857**															
2	Edu (yrs)	0.926**	-0.787**														
3	Farming exp. (yrs)	-0.961**	0.801**	-0.875**													
4	Caste	-0.176^{NS}	0.093^{NS}	-0.175^{NS}	0.155^{NS}												
5	Family size	-0.043^{NS}	0.058^{NS}	-0.066^{NS}	0.029^{NS}	0.091^{NS}											
6	MHH income	-0.109^{NS}	0.019^{NS}	-0.137^{NS}	0.116^{NS}	0.613**	0.082^{NS}										
7	ALH (Acres)	0.216*	-0.162^{NS}	0.203*	-0.216*	0.165^{NS}	0.094^{NS}	0.580**									
8	Risk bearing	0.895**	-0.812**	0.896**	-0.862**	-0.171^{NS}	-0.083^{NS}	-0.121^{NS}	0.271**								
9	Social participation	0.901**	-0.792**	0.897**	-0.859**	-0.142^{NS}	-0.115^{NS}	-0.115^{NS}	0.234*	0.955**							
10	Agro advisory	0.185*	-0.147^{NS}	0.242**	-0.153^{NS}	-0.032^{NS}	-0.126^{NS}	-0.104^{NS}	0.065^{NS}	0.273**	0.284**						
11	Weather advisory	0.806**	-0.696**	0.790**	-0.785**	-0.161^{NS}	0.051^{NS}	-0.099^{NS}	0.229*	0.833**	0.808**	0.222*					
12	Market information	0.025^{NS}	-0.027^{NS}	0.009^{NS}	0.000^{NS}	0.048^{NS}	-0.023^{NS}	-0.022^{NS}	-0.064^{NS}	0.015^{NS}	0.010^{NS}	-0.159^{NS}	0.064^{NS}				
13	Skill development	0.601**	-0.514**	0.571**	-0.589**	-0.057^{NS}	-0.017^{NS}	-0.139^{NS}	0.084^{NS}	0.551**	0.565**	0.207*	0.547**	0.038^{NS}			
14	Subsidy on adoption	0.118^{NS}	-0.190*	0.142^{NS}	-0.102^{NS}	-0.160^{NS}	0.014^{NS}	0.038^{NS}	0.012^{NS}	0.109^{NS}	0.105^{NS}	-0.020^{NS}	0.069^{NS}	-0.020^{NS}	0.033^{NS}		
15	Ease of use	0.200*	-0.135^{NS}	0.143^{NS}	-0.180*	-0.093^{NS}	-0.018^{NS}	-0.028^{NS}	0.165^{NS}	0.197*	0.197*	0.046^{NS}	0.174^{NS}	0.077^{NS}	0.094^{NS}	0.011^{NS}	
16	Cost effectiveness	0.622**	-0.545**	0.593**	-0.575**	-0.121^{NS}	-0.018^{NS}	-0.063^{NS}	0.301**	0.578**	0.571**	0.054^{NS}	0.612**	-0.043^{NS}	0.407**	0.127^{NS}	0.370**

*Significiant at 5%, ** at 1% respectively and NS = Non-Significiant

might be the ability of education to change the knowledge, attitude and skills of a farmer.

Farming experience is negatively correlated with adoption (0.961 at $p<.01$) indicating that women having rich experience in farming are less inclined towards the technology adoption. Farmers are adjusted to the old technologies and find hard to discontinue them. The long-term experience would facilitate the farmers in making the best option (Senanayake and Rathnayaka, 2015). However, negative experiences with similar technologies will affect the adoption negatively. Thus, proper awareness about the technology introduced is a prominent issue in influencing its adoption.

The land holding significantly affected adoption (0.216 at 5% level), which means as the land holding increases, there are chances to experiment with new technology. There is a positive relationship between the size of farm and the adoption of joint cultivation of inorganic and improved maize varieties (Ogada *et al*., 2014).

Risk bearing had a positive impact (0.895) on adoption at $p<.01$ which proves that risk-taking attitude and behaviour of farm women prepare them to adopt the technology. Social participation and adoption are positively correlated at 1% level of significance with a value of 0.901 which interprets that women who are more involved in social gatherings are more adaptable to the new technology. Farm women who are part of farmer organizations mostly had access to new information, also promoted technology adoption as well (Katungi and Kankwasa, 2010). Agro-advisory and weather advisory are positively correlated with adoption at 5% and 1% level of significance, as both extension advisories connects farm women with updates in agriculture and weather. In similar trend, it was also identified that availability and access to extension services are key aspects of technology adoption (Mwangi and Kariuki, 2015). Skill development was correlated with adoption at 1% level of significance with the value of 0.601. It indicated that skill development training positively affects the adoption process (Tayade and Chinchmalatpure, 2022). The ease of using new technology (0.200) and cost-effectiveness (0.622) positively influenced adoption at 5% and 1% level of significance respectively.

CONCLUSION

The study analysed the impact of several independent variables on the adoption of SWC technologies by farm women. Majority of the farm women were under medium category of adopters owing to multiple factors like cultural norms, economic circumstances, educational status and resource accessibility. The determining factors like age, education, farming experience, risk bearing capability, participation in social organizations and cost-effectiveness affected the process of adoption of SWC technologies. Other influencing factors which facilitated the adoption of technology were found as land holding, agro and weather advisory, skill development and ease of use. For sustainable adoption of SWC technologies among farm women, these factors can be taken into consideration.

Scope of the study

The study output will be useful as technical reference and an insight for farm women participation and adoption of soil and water conservation under natural resource management.

Conflict of Interest

We, the authors, hereby declare that we have no conflict of interest of any form pertaining to the publication of proposed manuscript.

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