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Farm women perspective in technological adoption under watershed management programmes

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Abstract

Watershed management plays a pivotal role in promoting water conservation, natural resource sustainability, and livelihood security, particularly across India's diverse and fragile terrains. Integrating gender perspectives into watershed programs is essential for achieving inclusivity and long-term effectiveness. Women, who are central to household and agricultural water management, face disproportionate burdens due to terrain-specific challenges and limited participation in formal decision-making processes. This study taken up in AICRP centres of ICAR-CIWA, Bhubaneswar in collaboration with ICAR-Indian Institute of Soil and Water Conservation, Dehradun, examines the role of women in watershed management and its impact on their empowerment. Using an ex-post facto design, data were collected from 1,120 respondents across treated and control watersheds representing 12 agro-ecological regions. Results revealed significant economic and technological gains in watershed villages, with higher average family income (2.5 times) and irrigated area (2.3 ha) compared to controls (0.8 ha). Women in watershed areas also demonstrated greater technology adoption and active participation in certain agricultural decisions, particularly harvest and post-harvest activities, though male dominance persisted in areas such as fertilizer application and irrigation management. The findings further highlighted substantial reductions in women's drudgery; time spent on collecting water (88.6%), fuelwood (29.6%), and fodder (36.9%) following watershed interventions. The study underscores that empowering women through inclusive, terrain-sensitive watershed management not only enhances gender equity but also strengthens ecological sustainability and rural resilience.

Keywords: Agro-ecological regions, drudgery, perception, watershed, women

Introduction

Watershed management is a vital strategy to address challenges of water conservation, natural resource sustainability, and livelihood security in varied agro ecological regions of India. The watershed approach not only addresses environmental concerns but also contributes to the socio-economic upliftment of rural communities (Joshi *et al.*, 2006) [4]. Evaluations of watershed programs have consistently shown that community involvement and strong local institutions as key to their success. Projects emphasizing community participation were found to be significantly more effective than those relying primarily on technical solutions (Gray and Srinidhi, 2013; Palanisami *et al.*, 2009) [3, 8]. However, for these initiatives to be truly inclusive and effective, watershed programme must ensure gender integration into planning and execution. Gender equality forms the foundation of the Sustainable Development Goals (SDGs), and in India, women's relationship with water management is both deep-rooted and multifaceted. Across varied landscapes—from arid plains where women walk long distances to fetch water, to hilly terrains where carrying water uphill adds physical strain—women are central in managing household as well as agricultural water use. Their daily tasks of fetching water, irrigating fields, and conserving soil make them natural stakeholders in watershed development. However, changes in their natural habitat have also impacted the way they manage their household chores (Rawat *et al.*, 2019) [10].

Despite their critical role, women's participation in formal watershed governance remains limited, often constrained by institutional and cultural norms that prioritize men's decision-making. In difficult area, these exclusions are even more distinct, as women shoulder additional burdens of labour due to scarce resources with her limited accessibilities. Yet, evidence shows that empowering women through participatory watershed institutions, water user groups, *jal sahelis* or *pani panchayats* not only reduces their drudgery but also enhances sustainability of interventions. For example, construction of check dams has been shown to reduce women's time spent on fetching water by nearly one-third, while increased groundwater recharge in drought-prone regions lightens the effort of drawing water from wells and hand pumps (Srivastava, 2022) [14]. The studies further highlight that when women are actively involved in planning, implementing, and monitoring watershed projects, positive impacts extend beyond immediate water security.

Improved agricultural productivity, higher household incomes, better employment opportunities, and strengthened local infrastructure have all been associated with gender-inclusive watershed management. Gender equality means ensuring the rights, responsibilities, and opportunities of individuals do not depend on whether they are born male or female (Warth and Koparanova, 2012) [15]. For true participatory watershed management, the active involvement of women and resource-poor farmers across all phases—preparatory, work, and consolidation—is essential (Sreedevi *et al.*, 2007) [13]. Thus, empowering women within watershed development processes not only enhances their agency and livelihoods but also ensures that natural resource management is better adapted to the physical realities of diverse agro-ecological regions. Keeping these dimensions in view, a study was undertaken to assess the impact of watershed management programmes on farm women and the technology adoption by them across India's different agro-ecological regions of India.

Materials and Methods

Description of Study Area: For this study, a total of fourteen model watersheds developed by ICAR-Indian institute of Soil and Water conservation (previously CSWCR&TI) along with its regional centres and AICRP Centres of ICAR-CIWA, Bhubaneswar, located in 12 different agro-ecological regions characterised by arid, semi-arid, sub humid, humid per humid and coastal ecosystems covering diversified bio-physical and population features (Fig. 1 & 2) were taken up.

Sampling Design: An ex-post facto research design (before and after design) was adopted to assess the impact of watershed management programmes on farm women and the technology adoption by them across India's different AERs. From each treated watershed implemented by various Research Centers, total of 40 women representatives were selected through random sampling. To compare the variables and other parameters, the adjoining untreated watersheds were also identified and from these, 40 representative samples were selected. Therefore, from fourteen locations of different agro-ecological regions, 14 watersheds (treated) and 14 control watersheds (untreated) constituted a sample of 1120 respondents (1120= 14*(40+40). The common interview schedule was used to interview the respondents from watershed and control areas. The difference-in-difference technique was then applied to calculate the actual impact. Focused group discussions (FGDs) were also conducted. The survey tool was sent to experts for feedback and suggestions, and necessary modifications were made. It was translated into the local language, and a pilot survey was conducted for further refinement.

Data Analysis: Descriptive statistical analysis was used to analyze and explain demographic characteristics. Comparison of socio-economic characteristics of members of watershed in the study area was done through non-parametric tests, *viz*. (Mann-Whitney). For the statistical analysis, the data were analysed using MS excel and SAS software. Adoption index refers to degree of adoption of 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, 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 farmwomen. 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%).

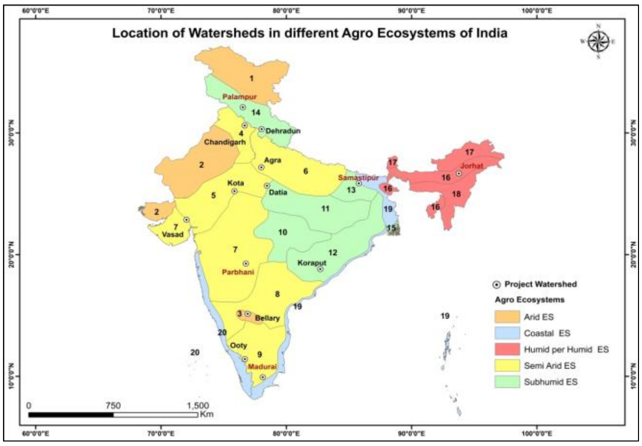

Fig 1: Selection of watersheds in different AERs

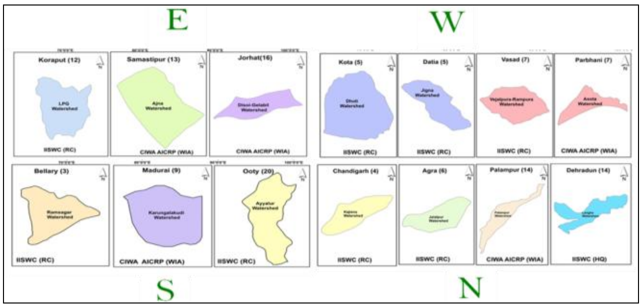

Fig 2: The watersheds selected for the study

Results and Discussion

Socio-economic Assessment

The socio-economic features of the watershed and control villages are presented in Table 1. No significant differences were observed between the two groups of farm women in terms of age, education, farming experience, and family size. However, notable differences emerged in economic and technological aspects. The average annual family income in watershed villages was 2.5 times higher than that of the control villages. Similarly, the average irrigated area was greater in watershed villages (2.3 ha) compared to control villages (0.8 ha), owing to the interventions implemented under the watershed program. Farm women in watershed villages also exhibited a higher level of technology adoption (Mean 9.5) aimed at enhancing productivity and conserving natural resources, whereas the mean score in control villages was 6.7. Furthermore, skill development parameters were comparatively higher in watershed villages (1.6) than in control villages (0.9).

Table 1: Socio-economic characteristics of households of farm women (N=1120)

S. No.	Particulars	Mean		Std. Error		Std. Deviation	
		Watershed	Control	Watershed	Control	Watershed	Control
1.	Age (years)	45.00	43.00	0.80	0.70	13.00	11.20
2.	Education (Years)	5.00	5.00	0.30	0.30	4.30	4.50
3.	Farming exp. (Years)	21.00	20.00	0.80	0.70	13.00	11.20
4.	Family members (Nos.)	5.00	4.00	0.10	0.20	1.70	3.30
5.	Annual Income (lakhs/ha)	1.34	2.50	0.10	0.10	0.90	1.50
6.	Land holding Rainfed (ha.)	4.20	1.60	0.10	0.10	1.40	2.30
7.	Land holding irrigated (ha.)	0.80	2.30	0.10	0.30	1.70	5.60
8.	Total land holdings (Acres)	5.00	3.90	0.10	0.40	2.30	6.70
9.	Technology Adoption (No.)	6.70	9.50	0.20	0.10	3.40	1.70
10.	Skill training (No.)	0.90	1.60	0.10	0.01	0.90	0.50

Perception analysis

The Fig. 3 sheds light on the perceptions of rural women regarding soil and water conservation technologies, reflecting the barriers, challenges, and opportunities in technology adoption. The data is presented in three response categories for each variable. This analysis delves deeply into each aspect, illustrating both quantitative trends and their qualitative implications. The data highlights that, a majority of respondents (84.6%) recognize the necessity of soil and water conservation for the sustainability of the village ecosystem, indicating a strong awareness of its ecological importance. However, several barriers to adoption are evident. Key challenges include lack of technical know-how (66.3%), the skilled nature of such technologies (58.8%) and limited knowledge (56.7%), reflecting a need for capacity-building initiatives and their up gradation to skill development. Financial constraints also emerge as a significant hindrance, with 75.8% agreeing that lack of finance limits adoption. Furthermore, poor participation (66.3%) and small landholdings (65.4%) are notable structural barriers. Social and institutional factors also play a key role in the limited uptake of these technologies. The group-based nature of these initiatives is widely recognized (80.4%), yet lack of consensus (77.1%) and poor extension services (64.6%) hinder collective efforts. This indicates a gap in support systems and collaboration among stakeholders. Overall, the data suggests that addressing knowledge gaps, improving access to technical support, strengthening financial mechanisms, and fostering group consensus are critical to enhance women's adoption of soil and water conservation technologies.

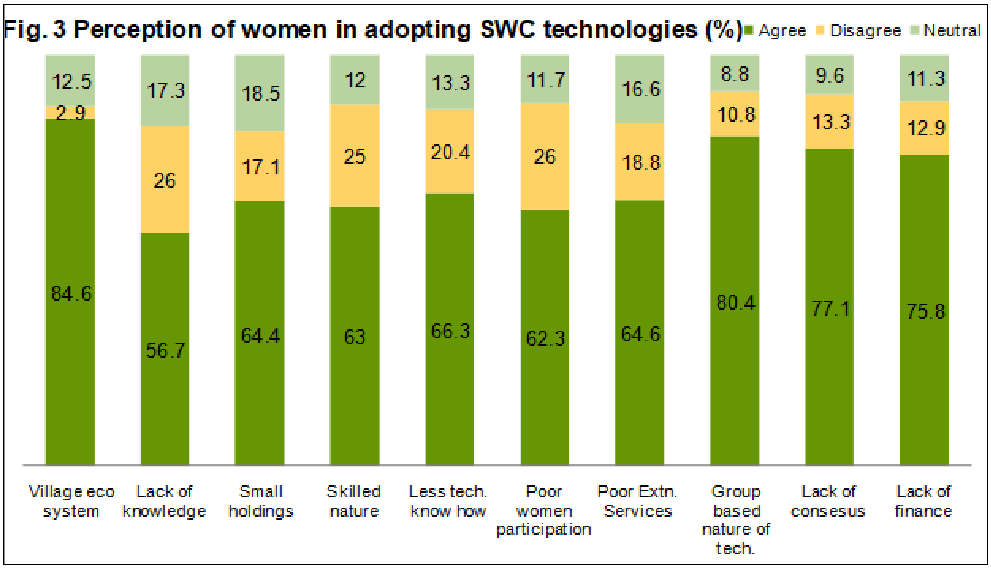

Fig 3: Perception of women in adopting SWC technologies (%)

Level of SWC technology adoption among farm women

The extent of SWC (Soil and Water Conservation) technology adoption among farm women (Table 2) reveal that the majority (55%) of women exhibited a medium level of technology adoption, followed by 34.17% with a low level of adoption. Only a small proportion (10.83%) demonstrated a high rate of adoption. These results suggest that farmers in general and women in particular tend to be cautious in adopting new technologies, a trend especially evident in rural India. In several developing countries, access to credit remains gender-biased, with female-headed households often facing discrimination from credit institutions. As a result, they are unable to invest in productivity-enhancing technologies, leading to lower adoption rates (Muzari *et al.*, 2012; Mwangi and Kariuki, 2015) [6, 7]. The data reveal that among the ten technologies studied, mulching recorded the highest adoption index (87.9) and ranked first, indicating its wide acceptance and perceived effectiveness. It was followed by intercropping (83.7) and contour farming (83.5), which occupied the second and third ranks, respectively. Technologies such as ridge and furrow (80.9) and field bunding (78.2) also showed a relatively high level of adoption, signifying moderate awareness and feasibility among women farmers. In contrast, practices like green manuring (72.1), vegetative barriers (70.8), and rainwater harvesting/farm ponds (70.5) exhibited moderate adoption levels, due to either limited resources or technical constraints. Stone bunding (54.0) and trenching (48.3) recorded the lowest adoption indices. This indicates that these practices are less preferred at individual adoption levels possibly due to their labour-intensive nature or higher initial investment requirements. However in group their adoption is high as reported by (Rawat *et al.*, 2024) [12] that Farmers organized at community level (56%) have been maintaining their large water bodies regularly on their own. Overall, the table indicates a gradual decline in adoption from relatively simple and low-cost measures like mulching to more capital- and labour-intensive technologies such as stone bunding and trenching.

Table 2: Adoption level of SWC technologies by farm women (N=1120)

S. No.	SWC technologies	High	Medium	Low	Adoption index	Adoption rank
1.	Mulching	1143	310	24	87.9	1
2.	Inter cropping	1029	320	57	83.7	2
3.	Contour farming plantation	1068	260	74	83.5	3
4.	Ridge Furrow (in-situ measures)	960	318	81	80.9	4
5.	Field bunding	726	538	49	78.2	5
6.	Green Manuring	393	778	40	72.1	6
7.	Veg. barriers	810	180	200	70.8	7
8.	Rain water harvesting/ farm pond	357	774	54	70.5	8
9.	Stone bund	189	442	276	54.0	9
10.	Trenching	210	222	379	48.3	10

Impact Assessment

The impact of watershed programs on various women-related activities by comparing control and watershed data values is elucidated in table 3. Each variable demonstrates distinct effects. A remarkable reduction (88.6%) in daily water collection time signifies a major benefit of the watershed program. This improvement, supported by a highly significant t-value (15.9), suggests better water availability closer to households, reducing the physical and temporal burden on women. The mean difference of 42.9 minutes per day equates to substantial time savings, which could be redirected to other productive activities or rest. The decrease in fuel wood collection time (29.6%) reflects better access to firewood resources or alternative energy solutions post-program. The t-value of 5.2 confirms the significance of this improvement. This change likely reduces energy spent on tedious tasks and may indirectly benefit women's health by alleviating physical strain. The 36.9% reduction in fodder collection time is another significant improvement, with a t-value of 4.9. The mean difference of 63.5 minutes/day indicates that women saved considerable time in gathering fodder, potentially due to enhanced vegetation or sustainable livestock management introduced by the watershed program. Similarly, Argaw *et al.* (2023) [1] and Jakhar *et. al.* (2024) [16] also concluded from their studies that watershed farm women registered higher levels (53%) of empowerment across dimensions compared to control.

Changes in livestock numbers (11.5% reduction) and milk yield (2.9% reduction) were statistically insignificant, as indicated by t-values of 0.6 and 0.2, respectively. These findings suggest the watershed program did not directly influence these areas, possibly because interventions focused more on water resources and vegetation than on livestock-specific improvements. Significant reductions in rice (39.2%), wheat (50.9%), pulses (36.3%), and oil (45.4%) purchases reveal enhanced household self-sufficiency. These changes may reflect increased agricultural productivity or diversified income sources, reducing dependency on market purchases. Lower expenditure on staples likely improved household economic stability. It has been reported that implemented watershed development and management practices lead to increased income, employment opportunities and improved social services and infrastructure (Kumar *et al*. 2021; Bihari *et al.* 2022) [5, 2].

Table 3: Impact assessment of watershed interventions on women related activities

S. No.	Variables	Unit	Pre-watershed	Post-Watershed	Change (%)	Mean	SE (M)	t-value
1.	Water collection time	Min./ day	48.40	5.50	88.60	42.90	2.60	15.90**
2.	Fuelwood collection time	Min./day	159.00	112.00	29.60	47.00	8.90	5.20**
3.	Fodder collection time	Min./ day	171.80	108.30	36.90	63.50	12.70	4.90**
4.	Livestock	No. per HH	6.10	5.40	11.50	0.70	1.20	0.60
5.	Milk yield per day	Lit./animal	3.90	3.80	2.90	0.11	0.60	0.20
6.	Reduced procurement (Rice)	Kg per year	381.30	232.00	39.20	149.30	25.90	5.80*
7.	Reduced procurement (Wheat)	Kg per year	400.00	196.30	50.90	203.80	30.50	6.70**
8.	Reduced procurement (Pulses)	Kg per year	52.70	33.60	36.30	19.10	2.20	8.80
9.	Reduced procurement (Oil)	Lit. per year	303.40	165.60	45.40	137.80	13.60	10.10

The pre-program/control values reflect the challenges faced by women, such as excessive time spent on water (48.4 minutes/day), firewood (159 minutes/day), and fodder (171.8 minutes/day) collection. These tasks occupied significant portions of their daily lives, leaving little time for other activities. Post-program reductions, particularly in water collection (5.5 minutes/day), highlight the effectiveness of interventions like improved water accessibility. In a similar study Rawat *et al*. (2018) [9] reported greater women participation in watershed interventions and revival of natural water bodies. found out that, in absence of watershed projects. These changes indicate that watershed programs not only alleviate the physical burden on women but also support household economic sustainability through reduced market dependency. The watershed program's success lies in its ability to address time-intensive activities and resource management.

Conclusion

The study underscores that integrating women involvement into watershed management significantly enhances both social equity and environmental sustainability. Women's active participation in watershed programs not only improves water availability and reduces their drudgery but also strengthens household income, agricultural productivity, and community resilience. The findings from diverse agro-ecological regions reveal that watershed interventions have led to higher family incomes, increased irrigated areas, and greater adoption of conservation technologies among farm women. However, persistent gender disparities in decision-making and barriers such as limited technical knowledge, financial constraints, and weak institutional support highlight the need for more inclusive and capacity-building measures. Substantial reductions in water, firewood, and fodder collection times reflect improved natural resource accessibility. Time saved from these activities can empower women to engage in other productive or educational endeavours, enhancing their quality of life. Similarly, decreased dependence on external food purchases points to improved agricultural productivity and better resource management. Empowering women as equal partners in planning, implementation, and governance of watershed initiatives ensures that resource management is not only efficient but also equitable, sustainable, and better aligned with India's development goals.

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