Enhancing Climate Resilience of Hill Farm Women through Soil and Water Conservation Practices

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ABSTRACT

Farm women in hills play a crucial role in sustaining agriculture and natural resource management in fragile hill ecosystems. However, challenges such as soil erosion, water scarcity, small landholdings, and climate variability severely affect their livelihoods. Integrating Soil and Water Conservation (SWC) practices such as contour bunding, mulching, agroforestry, and rainwater harvesting improves soil fertility, water availability, and resilience to climatic stress. Women's participation in watershed programs and self help groups strengthens adoption and maintenance of these practices. Empowering women through capacity building, access to finance, and inclusive institutional support promotes sustainable hill farming and enhances both ecological and social resilience.

INTRODUCTION

Hill farming system in India is characterized by diverse agro-ecological conditions, fragile environment, undulating topography, erratic rainfall and traditional practices that have evolved to sustain livelihoods under challenging terrains. About 70% of hills population is engaged in agriculture. Hills play a very important role in sustaining about 10% of the world population. In addition; only 13% area in hills is under agriculture. The land holding in hill region is less than 1 hectare and

that, too, is scattered in its distribution (Singh, 2015). These regions also face acute problems of soil erosion, declining soil fertility, and water scarcity. Irrigation facilities are poor and most of the agriculture land could be utilized under rainfed condition.

Soil and water resources play a pivotal role in maintaining the productivity and sustainability of hill agriculture, where fragile ecosystems are often prone to high intensity rainfall, landslides, erosion and degradation. Farm women play a pivotal role in sustaining agricultural production and natural resources. They are the backbone of hill agriculture—engaged in crop cultivation, livestock rearing, collection of fuel and fodder, and management of household water. However, their work is often constrained by drudgery, resource depletion, and the effects of climate variability. These constraints underline the importance of integrating soil and water conservation (SWC) technologies not only to enhance productivity but also to empower women and strengthen their livelihood security in hill regions.

CHALLENGES FACED BY HILL FARM WOMEN

Hills are vulnerable to disasters like cloud burst, extreme cold waves, and varied fluctuating rainfalls, rising temperature causing heat waves greatly harm the different agriculture activities. (Bhadwal *et al.,* 2019) Most of the agricultural activities are performed by women in different vulnerable climatic conditions manually or with traditional tools. All this leads to less production, drudgery, and leads to various health problems. Women farmers face great challenges such as limited access to new technology, limited resources like irrigation facilities, improved varieties, education and trainings. The major challenges faced by hill farm women are as follows:

1. **Soil erosion and land degradation:** The steep slopes and heavy monsoon rainfall accelerate soil erosion, leading to the loss of fertile topsoil and reduced productivity. Women, who depend heavily on subsistence farming, are directly affected by declining yields and increased workload for land maintenance.

2. **Water scarcity and drudgery:** Seasonal water shortages force women to walk long distances to fetch water for domestic and agricultural use. Inadequate irrigation infrastructure limits crop diversification and affects household nutrition.

3. **Limited access to technology and extension services:** Due to gender barriers, women have less access to agricultural training, technical knowledge, and decision-making spaces. Consequently, their participation in planning and adopting new technologies remains limited.

4. **Labour burden and energy demand:** Terraced cultivation and traditional tools demand heavy physical labour. The scarcity of fuelwood and fodder further increases women's workload.

5. **Climate vulnerability:** Unpredictable rainfall, landslides, and prolonged dry spells have intensified livelihood risks. Women's dependence on natural resources makes them particularly vulnerable to such climate-induced stresses.

6. **Small landholding:** One of the most critical constraints faced by hill farm

women is the fragmentation and small size of landholdings. Limited land area restricts crop diversification and reduces the scope for long-term conservation measures such as terracing, bunding, or agroforestry. Small landholdings also intensify labour demand, as each fragment requires separate attention for sowing, weeding, and irrigation. This adds to women's workload and reduces their time for income-generating or capacity-building activities.

7. **Lack of finance:** The lack of finance prevents women from adopting improved SWC technologies, purchasing farm inputs, or investing in small-scale irrigation systems. Moreover, absence of insurance or savings mechanisms makes them highly vulnerable to crop failures and climate shocks. Strengthening access to institutional credit, promoting women-friendly financing schemes, and linking Self-Help Groups (SHGs) with microfinance institutions can significantly enhance women's capacity to implement and sustain SWC measures on their farms.

The consequences of climate change like water scarcity, escalating temperatures, shifting weather patterns has an adverse effect on agriculture sector which in turns has a great impact on the hill farm women as she bears the responsibility of household, farm and allied activities. The farm women engaged in farming operations for long hours in extreme weather conditions, results in heat stress or other weather-related health issues.

On the other hand, variable rainfall and prolonged droughts lead to reduced crop yields. Women engaged in hill farming encounter numerous constraints arising from the difficult terrain and fragile environment. The steep slopes and undulating land lead to soil erosion and restrict cultivable areas, while erratic rainfall patterns and poor water retention capacity result in severe water scarcity (Rao *et. al.*, 2025). Most farming operations are manual, adding to the physical drudgery of women who also bear the burden of collecting fuelwood and fodder from distant locations. Socio-economic barriers further exacerbate their vulnerability, as women often lack access to improved technologies, credit facilities, agricultural extension services, and market opportunities. The effects of climate change — including unpredictable rainfall, frequent landslides, and recurrent crop failures — further threaten their livelihoods and food security.

SOIL AND WATER CONSERVATION TECHNOLOGIES

Soil and Water Conservation (SWC) technologies are instrumental in enhancing land productivity, water availability, and climate resilience in hill regions. To address the unique challenges of hill agriculture, several soil and water conservation technologies have been developed and adapted to local conditions (Bhutte *et al.,* 2024). Some of the technologies used for soil and water conservation in hilly areas are detailed below:

1. **Mulching and cover cropping:** Mulching with crop residues or grasses minimizes evaporation and suppresses weeds. For women farmers, it helps save time and effort in weeding, conserves moisture during dry spells, and promotes soil health.

2. **Agroforestry systems:** Integrating trees with crops and livestock ensures year-round availability of fodder and fuelwood while improving soil fertility through organic matter addition. Women benefit directly from reduced energy burden and diversified income sources.

3. **Rainwater harvesting structures:** Small ponds, percolation pits, and rooftop rainwater harvesting systems provide a reliable water source for irrigation and domestic use. These interventions

substantially reduce the drudgery of water collection.

4. **Vegetative barriers and grassed waterways:** Planting grasses like Vetiver or Napier on contour lines stabilizes soil and reduces runoff. Such measures can be easily managed by farm women), encouraging collective participation in watershed management.

5. **Contour bunding:** Contour bunding is a soil and water conservation technique that involves constructing embankments or bunds along the contours of sloped fields. This method is particularly effective in hilly and mountainous regions where water flow is rapid and soil erosion is a significant concern. By creating these bunds, the flow of water is slowed down, allowing it to spread evenly across the field and seep gradually into the soil. This retained soil remains fertile and supports better crop growth. Additionally, the moisture retained in the soil due to slowed water flow ensures that plants receive adequate water over a longer period, even after the rains have stopped. This consistent moisture availability is crucial for maintaining agricultural productivity, especially in regions that experience irregular rainfall patterns.

6. **Check dams:** Check dams are small but significant water structures designed to slow down the flow of rivers or streams, thereby facilitating groundwater recharge. These dams, often constructed using locally available materials like stones, concrete, or soil, play a crucial role in water management, particularly in areas prone to water scarcity. By controlling and slowing the water flow, check dams create small reservoirs that allow water to seep gradually into the ground, thereby replenishing the aquifers. This process is vital for increasing groundwater levels, which in turn enhances the overall availability of water resources in the region.

(Check Dams)

7. **Gabion structures:** Gabion structures are a sustainable and effective solution utilized along riverbanks and streams to address various environmental challenges. These structures consist of wire mesh cages filled with stones or other locally available materials, strategically placed to combat soil erosion, enhance water retention, and manage water flow dynamics. One of the primary uses of gabion structures is in preventing soil erosion along water bodies. By lining riverbanks and streams with these cages filled with stones, gabions create a barrier that absorbs the impact of water flow, reducing the erosive forces that can degrade soil and undermine stability. This erosion control function helps to maintain the integrity of riverbanks, protect adjacent land from degradation, and preserve valuable agricultural or residential areas from water-induced damage.

8. **Bioengineering measures:** Bioengineering techniques harness the power of living plants and organic materials to bolster the stability of watershed areas, effectively combating soil erosion and enhancing water quality. One of the fundamental approaches in bioengineering measures involves planting a variety of grasses, shrubs, and trees strategically in vulnerable areas. These plants play crucial roles: their root systems bind soil particles together,

creating a stable matrix that prevents erosion caused by rainfall and runoff. Grasses are particularly effective for their fibrous root systems, which form dense networks that hold soil in place and reduce surface runoff velocities. Vegetation intercepts sediment and pollutants carried by surface runoff, trapping them within plant structures and root systems. This filtration process helps to reduce sedimentation in water bodies and improves overall water clarity. Moreover, plants contribute organic matter to the soil as they grow and decompose, enhancing soil fertility and nutrient availability.

9. **Rainwater harvesting:** Rainwater harvesting is a crucial measure for water management that involves the collection and utilization of rainwater to replenish water resources. The primary goal of this practice is to prevent rainwater from being wasted by allowing it to run off and instead store it for various uses. One common method involves collecting rainwater from rooftops. This rainwater is directed through pipelines into storage tanks, making it readily available for later use. This technique is effective and widely implemented in both rural and urban areas, providing an alternative water source during dry periods.

(Silt Traps)

EMPOWERING WOMEN THROUGH WATERSHED AND SWC PROGRAMS

Several watershed development programs in India—such as the Integrated Watershed Management Programme (IWMP) and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)—have demonstrated how women's participation can transform resource conservation initiatives into engines of empowerment.

- Empowering women through participatory and gender-sensitive approaches is crucial for the successful implementation of SWC technologies. Women-led watershed management initiatives and self-help groups (SHGs) have emerged as effective models for collective action and sustainable resource management (Behl *et al.,* 2024). Capacity-building programs and hands-on training equip women with technical skills to adopt and maintain SWC practices efficiently.

- The promotion of labour-saving tools and ergonomically designed equipment tailored to women's needs helps in reducing workload and enhancing productivity. Strengthening women's involvement in decision-making processes and resource management institutions ensures that their perspectives and priorities are reflected in planning and execution, thereby fostering inclusive development.

- Across various hill regions such as Uttarakhand, Himachal Pradesh, the North-Eastern Hills, and Odisha's hilly tracts, there are numerous examples where women have successfully adopted soil and water conservation technologies. These initiatives have resulted in tangible improvements in crop productivity, soil health, and water availability, while simultaneously enhancing women's income and confidence.

In several cases, women's collectives supported by NGOs, ICAR institutes, Krishi Vigyan Kendras (KVKs), and government programs have played a pivotal role in scaling

up these practices. The outcomes demonstrate not only environmental benefits but also social empowerment, as women have transitioned from being labourers to decision-makers in farm and resource management.

Institutional support: Government schemes such as watershed development programs, MGNREGA, NRLM, and various ICAR initiatives have been instrumental in promoting soil and water conservation along with women's empowerment. However, there remains a pressing need to make these programs more gender-inclusive by integrating women's participation into every stage — from planning to monitoring. Strengthening linkages between research institutions, NGOs, and local governance bodies such as Panchayati Raj Institutions and SHGs can help in developing effective models of technology dissemination (Ansari *et al.,* 2025). Furthermore, combining the indigenous ecological knowledge of hill women with modern scientific SWC techniques can create context-specific, sustainable solutions that respect traditional wisdom while embracing innovation.

CONCLUSION

Soil and water conservation form the foundation of sustainable hill agriculture, particularly when viewed through a gender-responsive lens. The integration of SWC technologies not only mitigates environmental degradation but also enhances resilience, productivity, and women's empowerment. Hill farm women, when equipped with appropriate tools, training, and institutional support, can become catalysts of sustainable change. Expanded access to agro-advisory services, weather information, and skill development programs to bridge the gap in technical knowledge and resource accessibility. Promote cost-effective SWC technologies and practices through demonstrations and subsidies to encourage wider adoption. Therefore, it is essential to promote inclusive, participatory, and gender-sensitive strategies that ensure both ecological sustainability and socio-economic empowerment in hill farming systems.

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