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Unsung stewards of sustainable agriculture: A review on the role of tribal women in Indian agriculture

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Abstract

Tribal women in India play a foundational role in sustaining traditional agricultural systems that are environmentally friendly, economically viable, and socially inclusive. As custodians of agro-biodiversity and practitioners of low-input farming, they have developed adaptive strategies that align closely with principles of sustainability and resilience. Their contribution spans seed conservation, ecological farming, integrated livelihood systems, and climate adaptation, yet their knowledge and labor often remain undervalued. This paper critically reviews the multifaceted roles tribal women play in sustainable agriculture, identifies barriers to their empowerment, and recommends policy frameworks to integrate their knowledge systems into mainstream sustainable development discourse.

Keywords: Tribal women, agriculture, biodiversity, sustainability, livelihood

1. Introduction

Tribal women play a pivotal role in Indian agriculture, serving as both custodians of traditional knowledge and active contributors to food production, biodiversity conservation, and sustainable land management. In India, the tribal population constituting approximately 8.6% of the total population and is primarily concentrated in ecologically rich and agriculturally significant regions such as the North-Eastern states, Central India (Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha), and parts of Western and Southern India (Census, 2011).

Agriculture among tribal communities is deeply interwoven with cultural traditions, local ecology, and community-based systems. Tribal women are integral to every stage of farming i.e. from seed selection, sowing, weeding, and harvesting to post-harvest processing and storage. They are also deeply engaged in collecting wild edibles, herbs, and medicinal plants from forests, contributing significantly to household food and nutritional security. Kalyani *et al.* (2011) ^[11] reported that the tribal women play an indispensable role in sustaining rural economies through the collection and marketing of minor forest produce such as amla, soapnuts, shikakai, adda leaves, hill brooms, firewood, bamboo, and gumkaraya (Kovela gum). These resources are sold in local markets or exchanged through traditional barter systems to fulfill household needs. Empirical evidence highlights that tribal women demonstrate a higher work participation rate

and more significant role performance in agriculture and allied activities compared to their male counterparts. Their contributions constitute a major share of household income, emphasizing their pivotal role in the socio-economic fabric of tribal communities.

Despite their immense contribution, tribal women often face challenges such as limited access to land ownership, agricultural extension services, credit, and market linkages. Yet, their indigenous technical knowledge (ITK), especially in sustainable practices like mixed cropping, shifting cultivation (e.g., jhum), and conservation of landraces, plays a critical role in agro-biodiversity and resilience against climate change.

2. Role of tribal women in agriculture

Understanding the role of tribal women in agriculture is crucial not only for promoting gender equity and rural development but also for strengthening traditional agro-ecological systems that support both environmental sustainability and food sovereignty.

2.1. Indigenous Knowledge and Agricultural Planning

Indigenous knowledge in agriculture refers to the traditional practices, skills, and understandings that have evolved over centuries through farmers' direct interaction with their local environment. This form of knowledge is decentralized, community-based and often transmitted orally from

generation to generation. Across India, it has shaped farming practices in ways that enhance sustainability, promote biodiversity and increase resilience to climatic stress. Studies conducted by the Indian Council of Agricultural Research (ICAR) and National Innovation Foundation (NIF) have documented numerous examples of such knowledge across different agro-ecological zones.

Traditional systems like the Zabo water harvesting system of Nagaland and the Apatani paddy–fish cultivation method in Arunachal Pradesh are recognized for their ecological efficiency and productivity. A 2021 report by the ICAR–Indian Institute of Water Management highlighted the effectiveness of indigenous water harvesting techniques in semi-arid regions like Bundelkhand, where farmers use small ponds, field bunds, and tankas to conserve and utilize rainwater. Similarly, a 2019 field study by the National Bureau of Plant Genetic Resources (NBPGR) reported over 4,000 varieties of rice conserved by tribal communities in Odisha and Chhattisgarh, demonstrating the role of local knowledge in maintaining genetic diversity.

A study by Kurmi *et al.*, (2020) ^[13] in the tribal-dominated district of Anuppur, Madhya Pradesh, offers valuable insights into the continued relevance and effectiveness of traditional knowledge-based agricultural practices. Through extensive field documentation, the study recorded over thirty indigenous methods employed by tribal farmers, many of which are deeply rooted in local ecological understanding. These practices—ranging from the use of organic inputs like cow dung, ash, and compost to the selection and preservation of native seed varieties, demonstrate low-cost, resource efficient strategies for pest control, soil fertility management, and crop resilience. With growing concerns over the environmental and economic costs of chemical-intensive agriculture, these traditional systems are witnessing a revival. The findings underscore the potential of tribal agro-practices to serve as models for sustainable, climate-adaptive farming, particularly in ecologically sensitive and resource-constrained regions.

The use of plant-based pest repellents such as neem leaves, cow dung ash, garlic-chilli paste, and lantana extract is widespread and continues to be an integral part of low-input farming systems. Research conducted by Tamil Nadu Agricultural University (TNAU) in 2020 found that these traditional pest control methods significantly reduced pest incidence in smallholder vegetable farms without harmful environmental effects. In Andhra Pradesh and Telangana, community seed banks managed by women's self-help groups have successfully revived traditional millets and pulses, supported by initiatives under the Government of India's Paramparagat Krishi Vikas Yojana (PKVY), which emphasizes organic and traditional farming systems.

Traditional weather prediction remains another important aspect of indigenous knowledge. Farmers in Karnataka and Maharashtra have long used the behaviour of birds, frogs, and certain tree species as indicators for the onset of monsoons or dry spells. A collaborative study by the University of Agricultural Sciences, Dharwad (2018) ^[35], documented over 75 such indicators used in rainfed farming areas, which were found to be consistent with long-term meteorological patterns in nearly 60% of the cases.

While indigenous knowledge systems offer numerous ecological and economic benefits, they are often undervalued

or overlooked in formal agricultural planning. There is an urgent need to document, validate, and integrate these practices into extension and research programs. The National Agricultural Innovation Project (NAIP) supported several farmer-led innovations that combined traditional and scientific approaches, leading to improved yields and incomes in tribal districts of Madhya Pradesh and Jharkhand. Such integrative models serve as blueprints for scaling sustainable farming across India.

Challenges such as loss of oral traditions, reduced interest among youth, lack of scientific validation, and absence of policy recognition continue to threaten the survival of this knowledge. However, research-backed interventions and institutional support, such as the efforts of ICAR, NIF, and NGOs like the Deccan Development Society, have shown that indigenous knowledge, when empowered and integrated with formal systems, can contribute significantly to climate-resilient, resource-efficient, and culturally rooted agricultural development in India. Revitalizing this knowledge base is crucial not just for conserving heritage, but for securing the future of Indian agriculture.

Natarajan and Santha Govind (2006) ^[14] explored the depth and relevance of indigenous agricultural practices among tribal women residing in the Kalrayan Hills of Tamil Nadu to document, evaluate, and analyze the adoption of indigenous practices in paddy and tapioca cultivation. The findings revealed a rich repository of traditional knowledge transmitted orally across generations, covering aspects such as seed selection, soil preparation, planting schedules, pest control, and post-harvest methods. Most of the practices were found to be ecologically sustainable, cost-effective, and well-suited to local agro-climatic conditions.

The ethnographic study made by Hari Charan Bahera (2021) delves into the traditional agricultural systems and Indigenous Knowledge (IK) of the Kondh tribe in Odisha's Kandhamal district. It emphasizes the cultural and ecological embeddedness of their agricultural practices, which include both *podu* (shifting) and settled farming systems. These methods are informed by centuries-old wisdom, spiritual beliefs, and intimate ecological knowledge of local soils, crops, and biodiversity. The Kondhs use a mixed cropping system in shifting cultivation, growing a diversity of millets, pulses, vegetables, and oilseeds, selected for resilience to local climatic conditions. Agricultural activities are closely tied to rituals, festivals, and community decision-making, often led by elderly members and local deities. Seasonal calendars, lunar cycles, and natural indicators like bird migration or insect behavior can guide planting and harvesting. Importantly, the study notes the rationality behind many traditional practices, often overlooked by modern science. For instance, their practices enhance soil fertility, conserve water, and minimize external inputs, showing a clear ecological logic. Women play a key role in seed selection, preservation, and cultivation decisions, reinforcing gendered aspects of IK transmission.

The depth and diversity of medicinal plant knowledge possessed by tribal women in selected regions, focusing on their ethnobotanical practices, transmission methods, and role in primary healthcare has been studied by (Holmukhe and Antwal, 2010) ^[9]. Through qualitative methods including interviews, participatory rural appraisals, and field observations, the research documents numerous plant species

used for treating ailments ranging from common colds to more complex gynecological and gastrointestinal disorders. The findings reveal that tribal women, often the primary caregivers, have inherited and safeguarded plant-based healing traditions over generations, ensuring the survival of local pharmacopoeias despite socio-economic changes. However, the erosion of traditional lifestyles and lack of formal recognition threatens this cultural heritage. The study underscores the need to integrate indigenous medicinal knowledge into formal healthcare systems and policy frameworks, ensuring its preservation, validation, and ethical utilization.

2.2. Seed Selection and Agro-Biodiversity Conservation

Tribal women have long served as custodians of traditional agricultural knowledge, particularly in the domains of seed selection and agro-biodiversity conservation. Rooted in generations of experiential learning and cultural wisdom, their role is fundamental to sustaining diverse and resilient farming systems in India's tribal regions.

These women possess a nuanced understanding of seed traits such as yield potential, drought tolerance, pest resistance, and taste preferences. Through careful observation and selection, they maintain and propagate indigenous crop varieties adapted to specific agro-ecological conditions. Their practices encompass both in situ conservation (on-farm seed preservation) and ex-situ methods (community-managed seed banks), thus safeguarding genetic diversity and enhancing food and nutritional security.

In states like Odisha, Chhattisgarh, and those in the North-Eastern region, tribal women actively engage in seed exchange networks, biodiversity fairs, and community seed-saving initiatives. Their involvement ensures the continuity of landraces and underutilized crops that are often more resilient to climate variability and ecological stress.

Recognizing and strengthening the role of tribal women in agro-biodiversity conservation is essential not only for sustainable agriculture but also for preserving cultural heritage and ensuring ecological balance in tribal landscapes. Nara (2016) ^[19] conducted a study highlighting the indigenous knowledge possessed by women regarding the use of various wild plant species for food security. He recorded that tribal women collect and utilize a diverse range of leafy greens such as *Gandhari*, *Muchari*, *Khapra Chakor*, *Siliyari*, *Pechaki*, *Sarsa*, *Chimti*, *Matha*, *Sunsuni*, *Karmi*, and *Sarla sag*, which serve as important seasonal vegetables. These plants are not only nutritional but also possess medicinal properties. For example, *Castella asiatica* (locally known as Bengsag) was widely recognized for its efficacy in treating jaundice. *Lymnophylla conferta* (Muchari sag) was used during fevers to cleanse the mouth and enhance appetite. Other plants such as *Ficus inpectoria*, *Hibiscus sabdariffa* (Red Kudrum), *Crotalaria juncea* (Sanai), and *Bambusa arundinacea* (Bamboo) were noted for their application in treating liver-related disorders. The fruits of Ber (*Zizyphus mauritiana*) were dried and used as vegetables, and the tree also holds economic value due to its importance in lac cultivation.

Biba Jasmine *et al.* (2016) ^[2] emphasized the extensive repository of traditional knowledge in India, particularly related to agriculture and medicine. Their work advocates for the urgent need to safeguard and promote traditional

knowledge systems to benefit the indigenous communities that have nurtured and preserved them over generations. The authors stress the risk of this knowledge being lost due to modernization, and highlight the importance of documenting and integrating it into national knowledge systems.

Tanusree (2017) explored the indigenous food practices of women in Northeast India, a region recognized for its ecological and cultural diversity. Her research shows that tribal women prepare a wide range of ethnic foods using locally available plant species such as soybean, bamboo shoots, and *Lai patta*. These foods are rich in nutrients and reflect a deep understanding of ecological balance. In Mizoram, Mizo women prepare and market a fermented soybean-based food known as *Bekang*, representing indigenous entrepreneurship and food preservation techniques. Similarly, in Assam, tribal women from communities such as Bodo, Rabha, Karbi, and Dimas demonstrate detailed ecological knowledge and strong cultural practices centered on biodiversity conservation. These women play a pivotal role not only in domestic food systems but also in the maintenance of traditional agroecological landscapes.

Kiran *et al.* (2020) explored the extent of tribal women's participation in agriculture and highlights their indispensable role in ensuring household food security and sustaining rural livelihoods in Chhotaudepur district of Gujarat state. Findings reveal that tribal women are actively involved in crop selection, sowing, weeding, harvesting, and storage processes, often working alongside or independently of male counterparts.

Collectively, several studies underline the indispensable role of tribal women play in maintaining food sovereignty, traditional healthcare, and sustainable resource management. Their indigenous knowledge systems serve as living libraries, guiding community practices in nutrition, medicine, and conservation. There is a growing recognition that such knowledge should not only be preserved but also integrated into formal development frameworks to enhance food security, health outcomes, and biodiversity conservation at local and national levels.

2.3. Crop Protection

Tribal communities follow time-tested, indigenous methods of pest management that are rooted in ecological wisdom and traditional knowledge. These practices ensure the cultivation of pest-resistant crops without relying on synthetic chemicals. A diverse range of pesticidal plant species is employed in these methods, including *Azadirachta indica* (Neem), *Vitex negundo* Linn., *Adhatoda vasica* Nees., and *Calotropis gigantea* R.Br. (Narayanasamy, 2006) ^[20]. In addition to botanical solutions, tribals also utilize locally available materials such as crop residues (ash, husk) and animal-derived substances (cow dung, red earth) to safeguard crops in the field and to preserve food grains during storage. These eco-friendly pest control measures reflect the sustainable ethos embedded in tribal agricultural systems.

Patidar *et al.* (2018) ^[26], in a study found that tribal communities in India continue to rely extensively on sustainable agricultural practices rooted in indigenous knowledge. A significant proportion of farmers used traditional pest control methods involving plant species like *Neem*, *Vitex negundo*, *Adhatoda vasica*, and *Calotropis*

gigantea. Organic inputs such as cow dung, ash, husk, and red earth were widely used for both field application and storage pest management. These practices contributed to maintaining agro-biodiversity through mixed cropping, seed saving, and crop rotation. The approach proved economically viable, reducing reliance on costly external inputs and enhancing farm profitability, especially in rain-fed areas. Furthermore, it supported environmental sustainability by preserving soil health, conserving water, and reducing chemical contamination, thereby enhancing the resilience of tribal farming systems to climatic changes.

2.4. Sustainable Farm and Livelihood Practices

Tribal farming systems are inherently integrated and multifunctional, blending crop cultivation, animal husbandry, forestry, and collection of non-timber forest products (NTFPs). These systems are shaped by centuries of indigenous knowledge, adapted to local agro-climatic conditions, and are inherently sustainable and resilient.

In animal husbandry, tribal women are responsible for the rearing of indigenous livestock breeds, which provide manure, milk, and meat, and serve as financial assets during distress. Their involvement ensures integration of crop-livestock systems that enhance nutrient cycling. A study by the Indian Council of Agricultural Research (ICAR) (2020) [6] in Odisha noted that women played a significant role in managing backyard poultry and small ruminants, improving household income and food diversity.

Forests play a complementary role in tribal livelihoods. Tribal women harvest NTFPs such as Mahua flowers, tamarind, bamboo, and wild fruits, which supplement nutrition and income. According to the Tribal Cooperative Marketing Development Federation (TRIFED), nearly 70% of NTFP gatherers in India are women. Their knowledge of forest ecology supports sustainable harvesting and regeneration practices.

In areas like the North-Eastern states and Odisha, traditional systems such as *jhum* (shifting cultivation) are practiced with ecological sensitivity. Hari Charan Bahera (2017) documents that tribal women among the Kondh community play a vital role in managing fallow cycles, conserving sacred groves, and ensuring the regeneration of biodiversity.

Water conservation practices are also shaped by women's participation. They maintain traditional water harvesting systems like *johads*, *nadis*, and *chulukya* tanks, ensuring the sustainability of farming in rain-fed regions. Their role in homestead farming and kitchen gardens enhances year-round food availability and household nutrition.

In summary, tribal farming systems reflect a complex, interconnected structure where women are central to ecological stewardship, household food security, and cultural continuity. Studies across India highlight that any approach to improve tribal livelihoods and conserve agro-biodiversity must place tribal women's knowledge and agency at the core.

2.5. Food Security and Nutrition Management

Tribal women are central to the nutritional security of their families through their deep involvement in household food planning. Their decisions on crop selection, land use, and seasonal sowing are shaped not merely by economic returns but by a holistic understanding of nutrition, local ecology, and food diversity. These women follow traditional cropping

patterns that are inherently nutrition-oriented, aiming to meet the dietary needs of their households across seasons. The cropping systems adopted by tribal communities are often diversified, integrating cereals, pulses, oilseeds, tubers, vegetables, and fruits. Tribal women play a critical role in maintaining this diversity by preserving and selecting seeds of nutrient-rich varieties through generations. Crops such as millets like finger millet, little millet, and kodo millet, legumes such as pigeon pea and black gram, leafy greens, and tuber crops like yam and taro are prioritized in their farming practices for their high nutritional value and adaptability to local agro-climatic conditions.

A study by Rao *et al.* (2018) [27] in tribal regions of Odisha and Chhattisgarh reported that over 70% of household-level food crops were selected by women based on their nutritional contribution, particularly during lean seasons. Similarly, a participatory research study conducted by the MS Swaminathan Research Foundation (MSSRF) in the Koraput district of Odisha highlighted that tribal women's cropping choices ensured higher dietary diversity scores compared to neighbouring non-tribal communities. The study noted that households with female-led food planning had significantly better consumption of iron- and calcium-rich foods, especially minor millets and leafy vegetables.

Women also possess indigenous knowledge about mixed and intercropping systems that naturally replenish soil fertility and reduce pest outbreaks, leading to more sustainable and resilient food production. Their careful planning ensures year-round availability of food, balancing energy-rich staples with sources of proteins, vitamins, and minerals. Thus, tribal women are not just cultivators but also custodians of agro-biodiversity and traditional knowledge. Their nutrition-sensitive cropping choices contribute significantly to combating hidden hunger and ensuring food sovereignty in tribal regions.

2.6. Climate Change Adaptation

Climate change poses unprecedented threats to the ecosystems inhabited by tribal communities, disrupting traditional livelihood systems and undermining ecological stability. Tribal women, as custodians of indigenous knowledge, have historically played a crucial role in managing natural resources, conserving agro-biodiversity, and implementing sustainable farming and forest practices. This article explores the intersection of climate change, tribal ecosystems, and women's ecological knowledge, drawing upon multiple field studies and research reports from across India. It argues for the recognition and integration of tribal women's knowledge into mainstream climate adaptation and sustainability strategies.

India's tribal communities, comprising over 8.6% of the population (Census 2011), are predominantly located in ecologically sensitive areas such as forests, hills, and drylands. These communities are heavily dependent on natural resources for their sustenance. However, climate change has increasingly disrupted rainfall patterns, degraded soil quality, and reduced the availability of forest produce, threatening the fragile ecosystems these communities inhabit. Within this context, tribal women are emerging as key actors in resilience-building through their deep-rooted ecological knowledge and sustainable practices.

Tribal regions are among the most ecologically fragile and

vulnerable to climate-induced changes. Erratic rainfall, prolonged droughts, loss of vegetation, and shifting weather patterns are common challenges. These changes directly affect agriculture, water availability, forest regeneration, and food security. As primary gatherers, cultivators, and seed keepers, tribal women experience and respond to these changes more acutely.

Tribal women's knowledge is often holistic, encompassing understanding of seasons, soil types, plant behavior, and biodiversity. Practices such as seed saving and agro-biodiversity management, mixed cropping and intercropping, use of organic manure and natural pest control, and sustainable forest harvesting and conservation of sacred groves have contributed to maintaining environmental balance and agricultural resilience.

Multiple studies highlight the critical role of tribal women in climate resilience. Srinivasa Buddi (2021) documented the indigenous conservation practices in tribal villages of Andhra Pradesh, noting the role of women in maintaining traditional seed banks that preserve climate-resilient varieties. Bahera (2019) observed that among the Kondhs of Odisha, tribal women's millet-based mixed farming systems contribute to food and ecological security. Rao *et al.* (2018) ^[27] reported from tribal areas of Odisha and Chhattisgarh that women engage in rotational forest use, enabling natural regeneration and biodiversity conservation. Nara (2016) ^[19] highlighted the traditional use of wild leafy vegetables and herbs among tribal women for both food and medicinal purposes, which serve as coping strategies during food scarcity. NBA (2017) ^[22] showed how tribal women's contributions to People's Biodiversity Registers (PBRs) have enriched local ecological knowledge databases and promoted community-led conservation.

Tribal women cultivate and collect diverse crops and forest produce that are nutrient-rich and climate-resilient. Their role in promoting underutilized crops such as millets, pulses, wild fruits, and leafy greens is crucial in combating malnutrition and ensuring food sovereignty under climate stress.

Despite their contributions, tribal women's voices are often marginalized in environmental governance and policy-making. Climate action plans rarely acknowledge their roles or include them in consultative processes. There is an urgent need for gender-sensitive, community-based adaptation models that build on local knowledge systems.

There is a need to recognize and document tribal women's ecological knowledge in national biodiversity and climate records. Gender-inclusive participation in local forest and climate governance bodies must be promoted. Community seed banks and indigenous food systems should be supported through public policy. Collaboration between scientific and indigenous knowledge systems must be encouraged through participatory research.

Tribal women are not merely victims of climate change but are proactive agents of resilience and sustainability. Their knowledge, rooted in centuries of ecological coexistence, offers valuable insights for building adaptive capacities in fragile ecosystems. Harnessing and institutionalizing this knowledge is critical for inclusive and sustainable climate action in India.

3. Socio-Economic Constraints and Gender Gaps

Tribal women in India, comprising a significant portion of the

indigenous population, are central to the sustainability of tribal economies, especially in agriculture, forest-based livelihoods, and household nutrition. However, they continue to face pronounced socio-economic constraints and gender-based disparities that hinder their well-being and development. Their lived experiences are shaped by marginalization not only due to ethnicity but also due to gender within patriarchal tribal frameworks.

3.1. Land and Resource Ownership Gaps

Land is central to economic security in tribal communities, yet tribal women are rarely recognized as legal landowners. The study by Agarwal (2003) ^[1] on property rights highlights that even in matrilineal tribes, decision-making over land use is predominantly male-dominated. Lack of legal ownership restricts women's access to institutional credit, subsidies, and agricultural inputs, rendering them dependent on male relatives.

3.2. Education and Literacy Barriers

Census 2011 data shows that the literacy rate among Scheduled Tribe (ST) women is 49.4%, compared to 64% for ST men. Maharatna (2005) ^[15] observes that tribal girls face layered disadvantages like early marriage, domestic workloads, distance to schools, and absence of tribal language instruction, which leads to high dropout rates. These educational constraints restrict their mobility, awareness of rights, and employment opportunities beyond traditional labour.

3.3. Employment and Income Inequality

Tribal women are largely engaged in low-paid, informal, and subsistence-level occupations. In their study in Odisha and Jharkhand, Rao *et al.* (2018) ^[29] found that although tribal women actively contribute to agricultural production, they are excluded from decision-making on crop choice and income use. Das and Mishra (2014) ^[3], in their study of tribal women's participation in MGNREGS, revealed that wage discrimination and lack of childcare facilities limit their engagement.

3.4. Health and Nutrition Deficits

Poor access to healthcare infrastructure in tribal belts results in high maternal and infant mortality rates. Sethi and Dash (2015) ^[32], studying the Kondh tribe in Odisha, reported severe anemia, undernutrition, and lack of reproductive health awareness among women. The absence of female health workers in remote areas limits the outreach of maternal health programs.

3.5. Gender-Based Violence and Cultural Constraints

Though tribal societies are often considered more egalitarian, gender-based violence persists. Nayak and Raghavendra (2012) ^[23], in their study across Chhattisgarh and Andhra Pradesh, found that domestic violence, early marriage, and trafficking were underreported due to cultural taboos and lack of legal literacy. Patriarchal customs in some tribes restrict women's mobility and economic autonomy.

3.6. Political Marginalization and Voice

The 73rd Amendment has reserved seats for women in Panchayats, leading to increased presence in local

governance. However, Ghosh (2014) ^[7] found that tribal women representatives in Jharkhand and Madhya Pradesh often lacked functional autonomy and were proxies for male relatives. Training and leadership capacity-building are lacking, limiting effective participation.

3.7. Lack of Gender Focus in Tribal Development Programs

Many tribal development programs operate on the assumption of household-level benefit, overlooking intra-household gender disparities. Rao and Raju (2019) ^[28] emphasized the need to design interventions that empower tribal women specifically through land titling, access to forest rights, value addition to NTFPs, and market linkages.

Addressing the socio-economic constraints and gender gaps faced by tribal women requires intersectional and context-specific interventions. These include securing land and forest rights, improving access to education and healthcare, recognizing unpaid work, enhancing political agency, and integrating their traditional ecological knowledge into formal systems. Bridging these gaps will not only empower tribal women but also strengthen tribal resilience and sustainability.

4. Empowering Tribal Women for Sustainable Agriculture

Tribal women play a crucial role in the continuation and preservation of sustainable agricultural systems in India's diverse agro-ecological zones. Their involvement in farming is not limited to manual labour; rather, they are knowledge holders of traditional farming practices, custodians of indigenous seed varieties, and key decision-makers in crop planning and food security strategies at the household level. Their close relationship with nature and understanding of local biodiversity allow them to practice agriculture in harmony with the environment, often without reliance on chemical inputs. These women engage in diverse tasks including sowing, transplanting, weeding, harvesting, and post-harvest management, and are deeply involved in the selection, conservation, and exchange of traditional seed varieties suited to local conditions. Despite this centrality, they often remain invisible in formal agricultural policy and programming.

Research from tribal-dominated areas such as Odisha and Chhattisgarh (Rao *et al.*, 2018) ^[29] demonstrates that women have preserved a wide range of traditional knowledge related to crop cycles, wild edibles, pest control, and soil fertility management. This indigenous technical knowledge (ITK) is critical for food and nutritional security, especially under changing climatic conditions. Yet, structural challenges such as lack of land ownership, limited access to extension services, and minimal control over income constrain their full participation and recognition as farmers. The absence of tailored capacity-building initiatives and the undervaluation of their traditional wisdom in formal agricultural research further exacerbate their marginalization.

Empowerment of tribal women in sustainable agriculture requires a multidimensional approach. It includes ensuring access to productive resources like land, credit, and water, as well as building their capacities in agroecology, climate-smart practices, and value addition. Recognition and incorporation of their indigenous knowledge into mainstream agricultural extension can validate their contributions and

promote inclusive innovation. Increasing their participation in community level institutions, self-help groups, and farmer producer organizations can enhance their bargaining power and agency. Gender-sensitive agricultural policies that prioritize women's roles in ecological farming and ensure equitable benefit-sharing mechanisms are essential for building resilient food systems.

Kiran *et al.* (2020) in study on role of tribal women in agriculture reported that, despite their substantial contributions, their role often remains underrecognized and undervalued in agricultural policies and programs. The study underscores the need for gender-sensitive interventions, skill enhancement, and institutional support to empower tribal women and enhance their productivity and decision-making in the agricultural sector.

Tribal women's empowerment in agriculture is not just about economic upliftment but also about sustaining biodiversity, promoting environmental stewardship, and achieving long-term food security. Their active inclusion in sustainable agricultural development is vital for achieving national goals related to rural development, climate resilience, and gender equity. Empowering these women ultimately strengthens the socio-ecological foundations of India's tribal communities and contributes meaningfully to the realization of sustainable development goals.

5. Conclusion

Tribal women's agricultural practices profoundly embody the foundational principles of sustainability which includes diversity, resilience and community welfare. Rooted in traditional knowledge systems and intergenerational wisdom, their farming methods prioritize biodiversity through mixed cropping, promote ecological balance and ensure food and nutritional security for their communities. Their role extends beyond cultivation to seed preservation, soil conservation, and the nurturing of ecosystems, reflecting a holistic and sustainable approach to agriculture. By valuing and supporting these indigenous practices, we not only empower tribal women but also pave the way for more inclusive, adaptive and sustainable agricultural development.

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