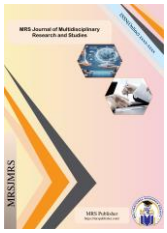
MRS Journal of Multidisciplinary Research and Studies
Abbreviate Title- MRS J Mul Res Stud
ISSN *(Online) 3049-1398*
Vol-1, Iss-1(December-2024)



Gender Perspectives in the Adoption of Carbon Farming Technologies: A Research Review

Sadiq, M.S[1*], Singh, I.P[2], Ahmad, M.M[3]

[*1]Department of Agricultural Economics and Agribusiness, FUD, Dutse, Nigeria

[2]Department of Agricultural Economics, SKRAU, Bikaner, India

[3]Department of Agricultural Economics and Extension, BUK, Kano, Nigeria

Corresponding Author Sadiq, M.S

Department of Agricultural Economics and Agribusiness, FUD, Dutse, Nigeria

Article History

Received: 27 / 11 / 2024

Accepted: 09 / 12 / 2024

Published: 13 / 12 / 2024

Abstract: *Carbon farming technologies (CFTs), which encompass practices aimed at increasing carbon sequestration in agricultural systems, have emerged as pivotal strategies for mitigating climate change. However, the adoption of these technologies is influenced by socio-cultural dynamics, including gender roles. This paper explores how gender perspectives shape the adoption of CFTs, considering differences in access to resources, decision-making authority, and the perception of benefits and risks. Drawing on interdisciplinary literature, the review highlights the theoretical and practical implications of integrating gender considerations into CFT promotion strategies. The findings underscore the need for inclusive policies that address structural inequities, enhance women's participation, and foster sustainable development.*

Keywords: *Carbon farming; Empowerment; Equity; Gender; Innovation; Sustainability.*

Introduction

Carbon farming, encompassing practices such as agroforestry, cover cropping, and reduced tillage, is a cornerstone of sustainable agricultural strategies aimed at mitigating climate change (Mao et al., 2023). By enhancing soil carbon sequestration and improving biomass storage, these practices contribute significantly to the reduction of greenhouse gas emissions, while simultaneously offering co-benefits such as enhanced soil fertility, biodiversity conservation, and improved water management (Lal, 2020; Huang et al., 2022). The significance of carbon farming is underscored in international climate agreements such as the Paris Accord, which emphasizes sustainable land management as a pathway to achieving carbon neutrality. However, the effectiveness and scalability of carbon farming technologies (CFTs) hinge on their adoption across diverse agricultural systems globally.

While carbon farming presents promising environmental and economic benefits (Yang & Zhou, 2022), its adoption is deeply influenced by a variety of socio-economic and cultural factors, including gender dynamics. Gender roles and relations, particularly in agrarian societies, shape access to and control over critical resources such as land, water, technology, and labor. In many contexts, women are key agricultural laborers, yet they often lack ownership of productive assets or decision-making authority within households and communities (FAO, 2011; Ogisi & Begho, 2023). These gender-based disparities are especially pronounced in the Global South, where structural inequities in education, financial systems, and extension services further marginalize women in agricultural innovation processes.

The barriers faced by women in adopting CFTs are multifaceted. For example, women typically experience limited access to agricultural training programs, which are often tailored to men or delivered in forums that are culturally inaccessible to women (Meinzen-Dick et al., 2011; Aryal et al., 2020). Additionally, social norms that prioritize men's control over land and financial resources exacerbate these challenges, as women may lack collateral to secure loans for technology adoption or investments in carbon farming practices. Such disparities undermine not only gender equity but also the overall efficacy of CFT programs, as women's roles in farming are crucial for household food security and the sustainability of agricultural practices.

Moreover, the interplay between gender and climate change exacerbates existing vulnerabilities. Women farmers are disproportionately affected by the adverse impacts of climate change, such as soil degradation, erratic rainfall, and reduced crop yields. This heightened vulnerability makes their participation in adaptive and mitigative strategies, like carbon farming, even more essential. Studies suggest that empowering women through equitable resource allocation, targeted training, and inclusive decision-making processes can significantly enhance the adoption of CFTs and magnify their benefits at both the household and community levels (Agarwal, 2018; Kanyenji et al., 2020).

This review seeks to provide a comprehensive exploration of the gendered dimensions of CFT adoption. By synthesizing existing literature, it aims to uncover the socio-economic and cultural factors that influence gender-specific adoption patterns, identify gaps in research and practice, and propose actionable recommendations for fostering equity and inclusivity in carbon farming initiatives. Understanding these dynamics is essential for designing policies and interventions that not only advance climate mitigation goals but also contribute to the broader objectives of gender equality and sustainable development.

Theoretical and Conceptual Frameworks

1. *Gendered Resource Access Framework*

The Gendered Resource Access Framework focuses on structural inequities that limit women's access to resources essential for agricultural innovation. In many regions, systemic barriers prevent women from owning or inheriting land due to customary laws or societal norms, leaving them reliant on male family members to access land for farming (FAO, 2011). This lack of ownership diminishes their ability to make independent decisions about long-term investments, including carbon farming technologies (CFTs), which often require sustained commitment to practices such as agroforestry or soil conservation. Moreover, women's access to financial services is frequently hindered by institutional biases that demand land as collateral for loans (World Bank, 2019).

Beyond physical resources, gender disparities in access to information and agricultural extension services further widen the adoption gap. Training programs and extension services often fail to account for women's time constraints, literacy levels, or mobility challenges, leaving them underinformed about CFT benefits and implementation methods (Meinzen-Dick et al., 2011). Addressing these disparities requires policy interventions that secure women's resource rights, promote gender-sensitive extension services, and create inclusive financial products tailored to women farmers.

2. *Agency and Empowerment Perspective*

The Agency and Empowerment Perspective emphasizes the transformative potential of empowering women to make strategic choices in agriculture. Empowerment is multidimensional, encompassing economic, social, and political dimensions. For example, access to education equips women with knowledge and skills necessary to adopt and adapt CFTs to their local contexts. In addition, women's participation in cooperatives or farmer organizations enhances their bargaining power and access to shared resources, such as community-based seed banks or water conservation infrastructure (Agarwal, 2018).

Leadership opportunities are particularly impactful. When women are represented in decision-making bodies, they can influence policies and practices that address their unique challenges and priorities. For instance, women leaders have been instrumental in implementing community-led agroforestry projects in Sub-Saharan Africa, demonstrating their ability to scale sustainable practices (Place et al., 2007). Empowering women also amplifies social capital, as women often act as conduits for knowledge dissemination within their communities, accelerating the spread of CFT innovations.

3. *Intersectionality Framework*

The Intersectionality Framework provides a nuanced understanding of how intersecting identities-such as gender, class, ethnicity, and geographic location-compound marginalization. Women from marginalized ethnic groups or economically disadvantaged households are often doubly burdened by systemic inequalities. For instance, in South Asia, Dalit women farmers face not only gender discrimination but also caste-based exclusion, limiting their participation in carbon farming initiatives (Kumar et al., 2017).

Intersectionality also reveals the heterogeneity within "women farmers" as a category, highlighting that one-size-fits-all approach to CFT promotion may fail to address the needs of the most vulnerable subgroups. Policies that consider these intersecting identities are more likely to achieve equitable outcomes. For example, participatory approaches that engage diverse community members-across gender, class, and ethnicity-have proven effective in creating inclusive programs tailored to local realities (Crenshaw, 1989).

4. *Technology Adoption Models*

Theories such as Rogers' Diffusion of Innovations (DOI) model provide valuable insights into the gendered dynamics of technology adoption. DOI identifies five key attributes-relative advantage, compatibility, complexity, trialability, and observability-that influence an individual's willingness to adopt a new technology (Rogers, 2003). Women farmers may perceive these attributes differently due to their unique socio-economic contexts.

- Relative Advantage: Women often prioritize technologies that provide immediate benefits, such as food security or reduced labor, over long-term environmental gains.
- Compatibility: Technologies must align with women's existing roles and responsibilities. For instance, reduced tillage practices may be more appealing if they decrease time spent on field preparation, aligning with women's dual responsibilities in agriculture and household management.
- Complexity: Women may find technologies with intricate implementation processes, such as precision agriculture, less accessible due to lower literacy levels or limited training opportunities.
- Trialability and Observability: Providing opportunities for women to observe successful examples of CFT adoption in similar socio-economic settings can build trust and confidence in these practices.

Furthermore, the DOI model highlights the importance of "change agents"-such as extension workers and community leaders-in facilitating technology diffusion. Ensuring these agents are gender-sensitive or that women themselves are trained as change agents can significantly enhance adoption rates among women farmers.

Step-by-Step Development of the Conceptual Framework for Gender Perspectives in Carbon Farming Technology Adoption

A conceptual framework visually organizes and explains the key elements, their relationships, and the processes influencing a

phenomenon-in this case, the gendered dynamics of carbon farming technology (CFT) adoption. Below is a step-by-step approach to building the framework:

Step 1: Define the Core Objective

The core objective is to understand how gender influences the adoption of carbon farming technologies (CFTs) and to identify mechanisms to foster equitable participation and benefits.

Step 2: Identify the Key Elements

The following are the critical components influencing gendered adoption of CFTs:

1. **Sociocultural Context**
   - Gender roles and norms
   - Intersectionality (class, ethnicity, location)
2. **Resources**
   - Access to land
   - Access to credit and financial services
   - Knowledge and training opportunities
3. **Agency and Decision-Making**
   - Women's empowerment (education, leadership)
   - Autonomy in agricultural decision-making
4. **Technology Characteristics**
   - Compatibility with existing practices
   - Perceived benefits (short-term vs. long-term)
   - Complexity and observability
5. **Institutional and Policy Environment**
   - Gender-sensitive extension services
   - Supportive policies and programs
   - Community organizations and cooperatives

Step 3: Establish Relationships Between Elements

Map out how the elements interact and influence one another:

1. **Sociocultural Context → Resources**
   - Social norms and gendered power structures often limit women's access to critical resources like land and finance.
2. **Resources → Agency and Decision-Making**
   - Limited access to resources diminishes women's ability to exercise agency, reducing their capacity to adopt CFTs.
3. **Agency and Decision-Making → Technology Adoption**
   - Empowered women with decision-making autonomy are more likely to adopt CFTs, especially when supported by targeted policies.
4. **Technology Characteristics → Adoption**
   - Technologies that align with women's roles and resource constraints are more likely to be adopted.
5. **Institutional Environment → All Elements**
   - Policies and programs mediate access to resources, empowerment opportunities, and technology dissemination.

Step 4: Visualize the Framework

The framework can be visualized as a flow diagram showing the relationships between the elements. Here's the structure in a text-based representation (can be visualized in a diagram software):

1. **Sociocultural Context (starting point):**
   - Influences access to resources and agency.
   - Moderates institutional interventions.
2. **Resources:**
   - Access to land, credit, and knowledge.
   - Directly affects the ability to adopt technologies.
3. **Agency and Decision-Making:**
   - Mediates adoption by empowering individuals to act.
4. **Technology Characteristics:**
   - Compatibility, complexity, and perceived benefits influence the likelihood of adoption.
5. **Institutional Environment (cross-cutting):**
   - Shapes access to resources, builds agency, and ensures technology dissemination is inclusive.

Step 5: Specify Feedback Loops

Include feedback loops to demonstrate iterative processes:

- Adoption of CFTs → Improved Resources: Successful adoption enhances access to resources (e.g., income, soil fertility).
- Empowered Women → Changing Sociocultural Norms: Women's participation in CFTs may challenge restrictive norms over time.

Step 6: Create the Diagram

Below is a textual representation of the conceptual framework:

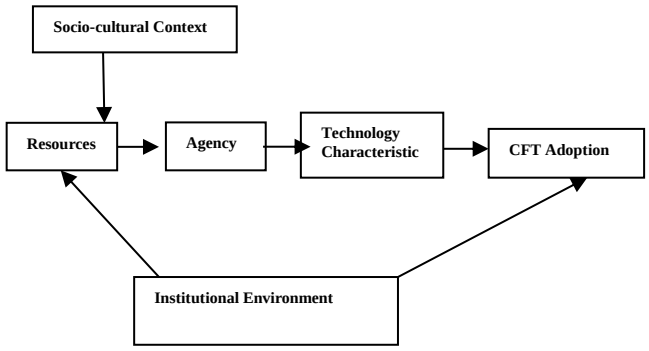


Figure 1: Conceptual framework

This structured and iterative conceptual framework explains how gender influences CFT adoption and highlights intervention points for achieving equity.

Research Methodology

The present study relied on secondary data sourced from journals, conference proceedings, articles, manuals, monographs, edited books, newspapers, internet to generate data. Furthermore, to have an insight into the research review, the collected data were systematically analyzed.

Results and Discussion

1. Gendered Constraints to CFT Adoption

Women face significant structural barriers that impede their adoption of carbon farming technologies (CFTs). These barriers are deeply entrenched in socio-economic systems and manifest in multiple ways:

- **Land Tenure Insecurity**:

  Women often lack secure land tenure due to discriminatory inheritance laws and customary practices. Studies indicate that in Sub-Saharan Africa and South Asia, only about 10–20% of women are landowners, and even fewer have formal titles (Agarwal, 2018). This insecurity discourages investments in CFTs like agroforestry or no-till farming, which require long-term commitment to land stewardship.

- **Financial Exclusion**:

  Women's access to financial institutions is limited by societal norms, legal barriers, and biases in credit systems. For example, many financial programs demand collateral, typically in the form of land, which women disproportionately lack. Additionally, women are often restricted to microfinance options, which may be insufficient for adopting cost-intensive technologies like biochar production or precision irrigation (World Bank, 2019).

- **Knowledge Gaps**:

  Gender biases in agricultural extension services perpetuate unequal access to knowledge about innovative farming practices. Extension programs are often male-centric, both in content and delivery, marginalizing women by assuming they are not the primary decision-makers in farming (Meinzen-Dick *et al*., 2011). Even when women are included, logistical barriers such as timing conflicts and mobility constraints further limit their participation.

2. Social Norms and Gender Roles

Cultural and societal norms play a significant role in limiting women's involvement in carbon farming initiatives. In many rural communities:

- Subsistence-Oriented Roles: Women are primarily engaged in subsistence farming and household activities, while men often control market-oriented agricultural ventures. This division of labor restricts women's exposure to and benefits from market-driven incentives like carbon credits (Pandey & Seto, 2015). For instance, agroforestry projects offering financial rewards through carbon markets often exclude women due to their limited market access.
- Unequal Workloads: Women's dual responsibilities in farming and domestic chores leave them with less time to explore, learn, and implement new technologies. This time poverty exacerbates their exclusion from training sessions and decision-making processes.
- Social Perceptions: In some regions, women's involvement in leadership roles or decision-making in agriculture is stigmatized, reducing their ability to influence or adopt CFTs effectively. Addressing these deeply rooted norms requires long-term cultural shifts and community sensitization programs.

3. Women as Change Agents

Despite facing systemic challenges, women have demonstrated remarkable potential as catalysts for sustainable agricultural practices, including CFTs. Examples from various regions highlight this potential:

- Community-Based Natural Resource Management: In Sub-Saharan Africa, women-led agroforestry initiatives have achieved notable success due to their emphasis on collective action. For instance, women in Kenya's Green Belt Movement have played a pivotal role in tree planting campaigns, significantly contributing to reforestation and carbon sequestration (Wangari Maathai, 2006).
- Knowledge Transfer: Women's roles as primary caregivers and educators in households make them effective channels for disseminating information about sustainable practices. Involving women in training programs often leads to broader adoption within communities.
- Innovative Leaders: Women entrepreneurs in agricultural technology are driving change by introducing locally adapted solutions for carbon farming. For example, women in India's Self Employed Women's Association (SEWA) have promoted organic composting techniques, aligning with carbon farming objectives while enhancing soil fertility.

4. Policy and Institutional Gaps

Policies promoting CFTs often fail to account for gender-specific barriers, resulting in inequitable access and outcomes. Key gaps include:

- Gender-Blind Policies: Policies that treat farming communities as homogenous entities overlook the diverse needs and constraints faced by women. This one-size-fits-all approach perpetuates inequalities (Tavenner et al., 2020).
- Lack of Representation: Women are underrepresented in policymaking and agricultural governance structures, leading to decisions that do not reflect their priorities or challenges. For example, land redistribution programs rarely prioritize women, even in contexts where they are the primary agricultural laborers.
- Inadequate Data: Gender-disaggregated data on CFT adoption is sparse, making it difficult to design and monitor targeted interventions effectively.

Successful Interventions

Several initiatives have successfully integrated gender considerations into carbon farming programs, offering valuable lessons for scaling inclusive practices:

- **Participatory Approaches:**

Involving women in the co-design of carbon farming projects ensures that interventions address their unique needs. For example, participatory action research in Nepal has demonstrated that when women are actively engaged in planning agroforestry projects,

adoption rates increase significantly due to higher perceived relevance and ownership (Maharjan et al., 2018).

- **Targeted Credit Schemes:**

Group lending models, such as those implemented by Grameen Bank, have enabled women to access financial resources without requiring traditional collateral. These schemes have been instrumental in supporting women's investments in sustainable farming technologies like biochar and organic fertilizers (Johnson et al., 2019).

- **Gender-Responsive Extension Services:**

Tailored training programs have been critical in addressing knowledge gaps. For instance, in India, gender-sensitive agricultural extension services have increased women's adoption of soil conservation practices and improved yields (Swaminathan et al., 2020). These programs often use women trainers, flexible schedules, and localized delivery methods to overcome cultural and logistical barriers.

Technology Customization:

Technologies designed with women's needs in mind have higher adoption rates. For example, labor-saving tools for cover cropping or low-cost biochar kilns have proven particularly effective in increasing women's participation in carbon farming initiatives.

Conclusion

The adoption of carbon farming technologies is deeply influenced by gendered socio-economic structures. Women's limited access to resources, combined with cultural and institutional constraints, reduces their participation in CFT initiatives. Addressing these disparities requires gender-responsive policies, inclusive extension services, and financial mechanisms that empower women. By integrating gender considerations into CFT strategies, policymakers and practitioners can enhance adoption rates, ensure equity, and contribute to broader climate goals. Future research should focus on longitudinal studies that track the gendered impacts of CFTs and explore intersectional approaches to innovation dissemination.

Recommendation

1. Strengthen Land and Resource Rights for Women
- Enforce policies guaranteeing women's land ownership and access.
- Promote community awareness to challenge cultural norms restricting women's land rights.

2. **Enhance Access to Financial Services**
- Develop gender-sensitive financial products such as microfinance and group lending.
- Provide subsidies or grants to enable women to adopt carbon farming technologies (CFTs).

3. **Improve Access to Knowledge and Training**
- Introduce gender-responsive extension services, including female extension workers.
- Utilize mobile and digital platforms for knowledge dissemination.

4. **Promote Women's Leadership and Decision-Making**
- Empower women through leadership training and cooperative membership.
- Incentivize women-led projects in agroforestry and soil management.

5. **Foster Participatory and Inclusive Program Design**
- Engage women in co-designing carbon farming programs.
- Address intersectional challenges faced by marginalized women.

6. **Leverage Technology to Bridge Gaps**
- Develop digital tools tailored for women farmers, offering real-time agricultural insights.
- Implement systems to monitor gender-disaggregated adoption data.

7. **Align Policies with Broader Climate Goals**
- Embed gender equity into national and international climate strategies.
- Simplify carbon credit market access for women farmers.

8. **Promote Cultural Shifts**
- Conduct community dialogues to challenge restrictive gender norms.
- Highlight success stories of women in carbon farming to inspire others.

References

1. Agarwal, B. (2018). Gender and land rights revisited: exploring new prospects via the state, family, and market. World Development, 93, 400–412.
2. Aryal, J. P., Khurana, R., & Farnworth, C. R. (2020). Does women's participation in agricultural technology adoption decisions affect the adoption of climate-smart agriculture? Insights from Indo-Gangetic Plains of India. Review of Development Economics.
3. Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: a black feminist critique of antidiscrimination doctrine, feminist theory, and antiracist politics. University of Chicago Legal Forum, 1989(1), 139–167.
4. FAO. (2011). The State of Food and Agriculture: Women in Agriculture-Closing the Gender Gap for Development. Rome: Food and Agriculture Organization of the United Nations. https://www.fao.org/3/i2050e/i2050e.pdf
5. Huang, X., Yang, F., & Fahad, S. (2022). The impact of digital technology use on farmers' low-carbon production behavior under the background of carbon emission peak and carbon neutrality goals. Frontiers in Environmental Science.
6. Johnson, N., Kovarik, C., Meinzen-Dick, R., Njuki, J., & Quisumbing, A. (2019). Gender, assets, and agricultural development: lessons from eight projects. World Development, 83, 295–311. https://doi.org/10.1016/j.worlddev.2016.01.009
7. Kabeer, N. (1999). Resources, agency, achievements: reflections on the measurement of women's empowerment. Development and Change, 30(3), 435–464.
8. Kanyenji, G. M., Onyango, C. M., & Oluoch-Kosura, W. (2020). Prospects and constraints in smallholder farmers' adoption of multiple soil carbon enhancing practices in Western Kenya. Heliyon.
9. Lal, R. (2020). Managing agricultural soils for carbon sequestration and ecosystem services. Soil Science Society of America Journal, 84(6), 1775–1786. https://doi.org/10.1002/saj2.20087
10. Maharjan, K. L., et al. (2018). Participatory agroforestry and community development in nepal: success stories and lessons learned. International Journal of Sustainable Development & World Ecology, 25(2), 112–123. https://doi.org/10.1080/13504509.2018.1442359

11. Mao, H., Quan, Y., & Fu, Y. (2023). Risk preferences and the low-carbon agricultural technology adoption: Evidence from rice production in China. Journal of Integrative Agriculture.
12. Meinzen-Dick, R., et al. (2011). Engendering agricultural research. Journal of Gender, Agriculture and Food Security, 16(1), 24–39. https://doi.org/10.1016/j.worlddev.2016.02.012
13. Ogisi, O. D., & Begho, T. (2023). Adoption of climate-smart agricultural practices in sub-Saharan Africa: A review of the progress, barriers, gender differences, and recommendations. Farming System.
14. Pandey, B., & Seto, K. C. (2015). Urbanization and agricultural land loss in India: comparing satellite estimates with census data. Journal of Environmental Management, 148, 53-66. https://doi.org/10.1016/j.jenvman.2014.01.020
15. Place, F., Adato, M., Hebinck, P., & Omosa, M. (2007). Farmer organizations for market access: learning from experiences in sub-Saharan Africa. World Development, 35(4), 689-708. https://doi.org/10.1016/j.worlddev.2006.05.006
16. Quisumbing, A. R., et al. (2014). Closing the gender asset gap: learning from value chain development in Africa and Asia. World Development, 64, 290–303.
17. Rogers, E. M. (2003). Diffusion of Innovations (5th ed.). New York: Free Press.
18. Swaminathan, M. S., et al. (2020). Women in agriculture: issues and challenges. Agriculture and Human Values, 37, 383–395. https://doi.org/10.1007/s10460-020-10061-6
19. Tavenner, K., et al. (2020). Beyond ownership: managing assets and investments in smallholder farming systems. World Development, 128, 104857.
20. Wangari Maathai. (2006). The green belt movement: sharing the approach and the experience. Lantern Books.
21. World Bank. (2019). Women and Agriculture: Closing the Gender Gap. Washington, DC: World Bank Group. https://openknowledge.worldbank.org/handle/10986/29492
22. Yang, X., & Zhou, X. (2022). Modeling farmers' adoption of low-carbon agricultural technology in Jianghan Plain, China: An examination of the theory of planned behavior. Technological Forecasting and Social Change.