Women, Household Resource Capabilities, and Food Security in Rural Communities: Empirical Evidence

Abstract

Given the critical nexus between gender and food security, a rich interdisciplinary literature has emerged at the intersection of development studies, agricultural economics, and gender studies. Development scholars have long emphasized that food security is a multidimensional concept, encompassing availability, access, utilization, and stability, and is deeply intertwined with social factors such as gender roles and intra-household power dynamics. Women have long been at the heart of Kenya's agricultural sector and thus central to household food security. Within this context of widespread food insecurity, gender disparities are increasingly recognized as a critical factor. To analyze the role of women in food security with multiple moderating influences, we adopt an integrated theoretical framework that incorporates gender and development (GAD) and empowerment theory, providing a foundation that focuses on the social construction of gender roles and power dynamics in development, complemented by the capability approach. We argue that the extent to which women-headed households shape food production depends on capability, empowerment, and institutional support. Using a sample of 89260 rural households in Kenya, we find that educated women and land ownership significantly amplify the women-food security nexus. Additionally, financial and mobile money literacy mediates the relationship between women-headed households and food security. The role of government support further attenuates the negative link between financial literacy, endemic zones, and food security. Our findings emphasize that addressing a complex issue like food security requires coordinated efforts across all levels — from family practices to institutional policies — and align with our approach of examining contextual factors ranging from household land ownership to government aid and regional conditions.

Keywords: *Women, agricultural land, food production, education, endemic zones, government support*
JEL Codes: *C12; I38; J16; N37; O13; Q12; Q15; Q18*

Introduction

Kenya continues to face formidable food security challenges, with recurrent droughts, high poverty rates, and rapid population growth straining the country's ability to feed its people (Oberlack et al., 2021; Rarieya & Fortun, 2010). Arid and semi-arid lands comprise about 80% of Kenya's territory, making agriculture, the primary source of livelihoods, perilously dependent on erratic rainfall (Mganga, 2023; Mganga et al., 2015). As a result, a significant share of the population lacks consistent access to sufficient food. Recent estimates as of 2024 indicate that over 13 million Kenyans lack adequate access to food, a crisis exacerbated by soaring prices and climate-related shocks (Ouko & Odiwuor, 2023). Malnutrition indicators remain troubling; for instance, nearly 29%

of children in rural areas are stunted from chronic undernourishment (Oliveira et al., 2025; Sibanda et al., 2023). Within this context of widespread food insecurity, gender disparities are increasingly recognized as a critical factor (Moon, 2024). Notably, households headed by women are statistically *more likely to be food insecure* than those headed by men (Akalu & Wang, 2023; Militao et al., 2024), reflecting more profound inequities in resource access and social vulnerability. These patterns underscore that any serious effort to improve food security in Kenya must address the gender dimensions of agriculture and household provisioning.

Women have long been at the heart of Kenya's agricultural sector and thus central to household food security. Kenyan women comprise roughly 60% of the agricultural workforce and are responsible for 70–80% of national food production, particularly in subsistence farming (Wakibi & Oleche, 2024). In rural communities, it is most often women who cultivate staple food crops, manage kitchen gardens, tend small livestock, and ensure that their families are fed. This outsized contribution has earned women the moniker of "the hidden backbone" of African agriculture in development discourse. Nevertheless, and paradoxically, women farmers in Kenya operate under severely constrained conditions. Women have significantly less access to critical productive resources, such as land, credit, extension services, and technology, compared to men (Adebayo & Worth, 2024; Antriyandarti et al., 2024; Elias et al., 2024). For example, despite their significant role in food production, women hold only about 1–2% of all land titles in Kenya, and even when jointly owned land is included, their share remains under 10% (Etale & Simatele, 2024). Recent national data from the 2022 Kenya Demographic and Health Survey (KDHS) starkly illustrates this gap: approximately 75% of Kenyan women report owning no agricultural land, a proportion that has increased from 61% in 2014. Such gender disparities in land ownership and control reflect enduring patriarchal norms and legal barriers that marginalize women (Etale & Simatele, 2024). Lacking secure land rights, women farmers often cannot make independent decisions on crop production or long-term investments in soil and water management (Njuki et al., 2022). This disconnect between women's labor contributions and their limited resource rights fundamentally undermines their productivity and, by extension, household food security (Etale & Simatele, 2024; Njuki et al., 2023). Indeed, it is estimated that if women farmers had equal access to land and inputs as men, farm yields could increase by 20–30% and hunger rates could drop significantly (Diiro et al., 2018). Addressing gender-based constraints in agriculture is therefore not just a matter of equity, but a practical strategy to boost food availability and resilience for millions.

An integrative theoretical context and research gap

Given the critical nexus between gender and food security, a rich interdisciplinary literature has emerged at the intersection of development studies, agricultural economics, and gender studies. Development scholars have long emphasized that food security is a multi-dimensional concept – encompassing availability, access, utilization, and stability, which is deeply intertwined with social factors like gender roles and intra-household power dynamics ((Chebuche & Wakhungu, 2021). It is widely recognized in development discourse that empowering women is key to achieving sustainable food and nutrition security. For instance, improvements in women's education and status often translate into better child nutrition and household health, amplifying food security outcomes at the family level. Gender studies perspectives further highlight how cultural norms assign women the responsibility for food provision while denying them a voice in decision-making. Feminist economists argue that increasing women's control over resources tends to improve household welfare, as women are more likely to allocate income toward food, healthcare, and children's needs. This claim is supported by cross-country evidence and has informed global policy agendas linking Sustainable Development ***Goal 2*** (zero hunger) with ***Goal 5*** (gender equality) (Abass, 2018).

Agricultural economics research adds quantitative evidence that reducing the gender gap in agriculture would significantly raise productivity and food output. A frequently cited Food and Agriculture Organization (FAO) analysis estimates that giving women farmers equal access to inputs could raise total agricultural output in developing countries by up to 4%, potentially reducing the number of undernourished people worldwide by 100–150 million (Abass, 2018). In East Africa specifically, studies have shown that women's access to credit, extension training, and cooperative membership can markedly improve farm yields and household food security (Ingutia & Sumelius, 2022b). For example, a recent empirical study in rural western Kenya found that women farmers who joined agricultural cooperatives achieved higher food security and dietary diversity outcomes than non-members, largely because cooperatives facilitated women's access to credit and irrigation technology (Ingutia & Sumelius, 2022a). This evidence aligns with broader findings that when women gain economic empowerment – whether through land rights, income-generating activities, or leadership roles – the benefits reverberate in better food availability and nutrition for their families (Kanyiva, 2025).

Despite consensus on the importance of women in food security (Andrew et al., 2022; Ferreira et al., 2022; Kotzé, 2003; Rehman et al., 2019), significant gaps remain in the literature. First, much of the existing research examines single dimensions of the issue in isolation. Development studies often discuss gender and food security in qualitative terms or at a conceptual level. In contrast, econometric analyses in agricultural economics may test the impact of a single factor, such as land ownership or microcredit, on household food outcomes. There is a paucity of integrated studies that bring together multiple determinants, such as education, land tenure, and institutional support, in a unified analytical framework. In the Kenyan context, prior studies have been region-specific or focused on particular sub-populations, leaving questions about generalizability. For instance, research in pastoralist communities in northern Kenya has examined women's empowerment in relation to nutrition outcomes (Lentz et al., 2025), and case studies in western Kenya have examined women's group initiatives (Ingutia & Sumelius, 2022b), but these do not capture the national picture. Crucially, no studies to date have leveraged the newly available 2022 KDHS data to quantitatively assess women's role in household food security. The KDHS 2022 is the most recent nationally representative survey and includes expanded modules on nutrition, food security, and women's ownership of assets (Abass, 2018). Earlier analyses (e.g., using KDHS 2014 or other datasets) could not examine some of the nuanced relationships that the 2022 data now enable, such as detailed measures of household food production and women's participation therein. Moreover, previous research has rarely probed the interactive or conditional effects, specifically how the influence of women's involvement in agriculture might depend on contextual moderating factors. This represents a critical knowledge gap. While we know women's farming contributions are vital, we know far less about *when, how, and under what conditions* those contributions translate into improved household food security.

Against this backdrop, this study is unique in several important ways. Firstly, we integrate theoretical perspectives across disciplines to build a comprehensive analytical framework. Drawing on gender theory, we center on women's agency in food production decisions and intersect this with agricultural economics models of household production and consumption. This integration allows us to consider both the *agency of women producers* (a focus of gender studies) and the *constraints/opportunities in the production environment* (a focus of development and agricultural economics). The study's conceptual model posits that a household's food security, represented by its level of food production, is directly influenced by the extent of women's involvement in agriculture as decision-makers and labor contributors. This choice of food security measures is

novel in itself. While many prior studies have focused on outcomes such as calorie intake, food expenditure, or dietary diversity, we use household food production as an indicator of the availability dimension of food security. This is particularly relevant in Kenya, where many households (especially in rural areas) rely on subsistence production for their staple foods. By examining food production, we capture a critical foundation of food security (having food on the table to begin with) and explicitly link it to women's roles in producing that food.

At the same time, we acknowledge that production alone does not ensure nutritional well-being. Therefore, our approach is situated within the broader food security discourse, which also values access and utilization (Lang & Barling, 2012; Voola et al., 2018). Theoretically, our study breaks new ground by exploring serial moderation effects in the relationship between women's involvement and food security. In plain terms, we investigate how multiple factors, when combined, condition the strength of this relationship. Specifically, we test a mediated-moderation model in which women's influence on food production may be strengthened or weakened by several sequentially acting contextual variables. For example, we hypothesize that an educated woman will be more effective at improving household food production (through better farming knowledge or bargaining power), especially if the household has land assets and receives external support (from the government), and further, that these effects might be most pronounced in certain high-risk geographic zones. This nuanced approach moves beyond simple two-way interactions, reflecting the complex real-world scenario in which education, resources, and the environment jointly shape outcomes. To our knowledge, no previous study has analyzed the intersection of mediated-moderating factors (women's education, financial literacy, land ownership, institutional support, and agro-ecological context) in the context of food security and gender.

Empirically, employing the 2022 KDHS data is a major innovation. The 2022 KDHS is the seventh and latest Demographic and Health Survey for Kenya, covering over 42,000 households nationwide. It is the first KDHS to include detailed questions on household food security and production. By utilizing this fresh data, our research captures post-2010 developments in Kenya's socio-economic landscape, including the effects of recent drought cycles, economic changes, and policy initiatives, providing an up-to-date evidence base. The large sample and rich variables allow us to generalize our findings across both rural and urban populations (with rural households comprising the majority of observations, reflecting Kenya's demographics). This contrasts with many earlier studies that were limited to single counties or specific community samples. The novelty of our study, therefore, lies in its theoretical breadth, its methodological rigor in examining

moderated relationships, and its empirical timeliness. We offer one of the first comprehensive analyses of women's roles in Kenyan household food security, accounting simultaneously for educational, economic, and institutional contexts at the national scale.

This study makes several contributions. From a theoretical standpoint, our integration of gender empowerment theory with food security and agricultural production models contributes to a more holistic understanding of development processes. We provide empirical evidence to support the proposition that women's agency in agriculture is not a siloed factor but is deeply contingent on intersecting conditions. This helps refine existing theories of women's empowerment and household welfare by highlighting conditional pathways, such as demonstrating that the benefits of women's agricultural involvement materialize most strongly when supportive factors (education, land rights, extension services) are in place. Such insights can inform scholarly debates on the relative importance of addressing "hard" constraints (such as land access) versus "soft" factors (such as information and social support) in empowering women to achieve food security. By uncovering interaction effects, our study also contributes to the methodological literature by showcasing the value of advanced moderation analysis in development research.

Policy-wise, the study offers timely evidence for both Kenyan policymakers and international development agencies, focusing on food security and gender equality. The clear implication is that bolstering food security in Kenya requires multi-faceted interventions. Simply put, supporting women farmers is a highly leverageable strategy to combat hunger, but it must be done comprehensively. For national policy, our results underscore the importance of initiatives such as expanding women's access to land ownership (through legal reforms and enforcement of rights) (Ingutia & Sumelius, 2022a); investing in female education and literacy, especially in rural areas, to equip women with knowledge and confidence to adopt improved agricultural practices; and strengthening agricultural extension and credit programs with a gender lens (for example, deploying more female extension officers and tailoring services to women's needs, as suggested by prior studies (Ingutia & Sumelius, 2022b, 2022a). The finding that external support from governments or NGOs positively moderates outcomes would encourage scaling up targeted programs — e.g., subsidies, microfinance, and farmer field schools — that specifically involve women. It also speaks to climate resilience policies, given that women are frontline managers of food in drought-prone communities. Improving women's access to resources and skills can enhance household adaptability to climate shocks, thereby contributing to long-term food security in the context of Kenya's development plans and the Sustainable Development Goals. Our evidence

advocates for greater gender mainstreaming in food security and agricultural policies – not as abstract rhetoric, but through concrete measures that empower women as producers and decision-makers.

Finally, the study carries valuable lessons for development practice on the ground. For practitioners (NGOs, community organizations, and donors), the results emphasize the need for integrated programming. Projects that aim to improve household food security should simultaneously consider gender dynamics—for example, combining agricultural support (such as seeds, tools, and irrigation) with components that enhance women's decision-making power and knowledge. Our findings on serial moderation suggest that piecemeal approaches may have limited impact: providing a woman farmer with land without training, or training without access to land, might not yield the desired food security gains. However, when interventions are bundled — such as land titling, agricultural training, and input support — the synergistic effects can be dramatic. Additionally, given the dual rural-urban sample in our study, practitioners should note that while rural women are the primary food producers, urban poor women also contribute to food security (often through kitchen gardening, food marketing, or remittances). Tailored strategies for women in informal urban settlements (such as supporting rooftop gardening or women's food cooperatives) can also emerge from this research. In summary, the study presents an empirically grounded case for the proposition that empowering women in agriculture is not only a matter of justice but also a smart investment in food security and community well-being. By clearly identifying when and how women's involvement makes the greatest difference, this research offers guidance to amplify those impacts. We contribute by closing a crucial research gap and, in doing so, inform both scholarly debate and the practical pursuit of a food-secure, gender-equitable future for Kenya.

Theoretical framework and hypothesis development

Integrated theoretical perspective

To analyze the role of women in food security with multiple moderating influences, we adopt an integrated theoretical framework. Gender and Development (GAD) theory provides a foundation by focusing on the social construction of gender roles and power dynamics in development (Chebet, 2023). GAD theory, originating from feminist scholarship such as Molyneux (1985), argues that development outcomes, including food security, cannot be understood without examining gender-based inequalities in access to resources, division of labor, and decision-making power (Chebet, 2023). In many societies, women are the primary managers of household food and

nutrition, yet they face structural barriers–for example, discriminatory land rights, limited access to credit or extension services, and heavy unpaid care burdens – that impede their productivity and influence in agriculture (Gladwin et al., 2001; Karaya et al., 2013). GAD theory thus highlights the need to address these inequalities to harness women's full potential for improving household food security (Chebet, 2023).

Complementing this, Amartya Sen's Capability Approach (Sen, 2014; Sen, 1999) shifts the focus to individuals' freedom and abilities to achieve desired outcomes. Rather than focusing solely on resources or income, the Capability Approach emphasizes what people can do with them. In the context of food security, this means examining whether women have the capability (education, health, agency) to secure food for their families (Burchi & De Muro, 2012). Sen describes "agency" as the ability of people to help themselves and influence their world, a crucial element in achieving food security (Burchi & De Muro, 2012). If a woman is educated and empowered, she can better utilize assets such as land or farming inputs to produce food and make informed choices to improve nutrition. However, as Sen notes, individual agency is *constrained by institutional and environmental factors* beyond one's control (Saito, 2003; Sen, 2004; Walker, 2005). This insight underscores why we must consider higher-level moderators (such as government support) alongside individual-level factors. Indeed, basic education for women has been shown to enhance food security by improving their "functioning"—for instance, literate women can adopt improved agricultural practices and nutritional knowledge more effectively (Burchi & De Muro, 2012).

Furthermore, Ecological Systems Theory (Bronfenbrenner, 1979) provides a holistic lens to organize these multilevel influences. This theory posits that outcomes are shaped by interactions across nested systems: the microsystem (family, household), mesosystem (community networks, local organizations), exosystem (institutional structures like government programs), macrosystem (broader cultural and policy environment), and chronosystem (time, historical or environmental changes) (David, 2024). Applying this to our study, a woman's involvement in food production (microsystem) is embedded in her household's assets, such as land (also a microsystem), is affected by government policies or services (exosystem), and takes place within an environmental context that could include endemic drought or conflict (macrosystem). The ecological perspective encourages us to view women's contributions to food security as part of a dynamic system, in which support or stress at different levels can moderate outcomes. For example, a recent analysis of food insecurity in South Africa used Bronfenbrenner's framework. It showed that addressing a multidimensional challenge like food security requires coordinated responses at all levels, from

family practices to institutional interventions (David, 2024). This validates our approach of examining moderators ranging from household land ownership to governmental support to regional endemic conditions.

Ultimately, *Empowerment Theory* (Wilkinson, 1998) underpins the link between women's status and food security (Clement et al., 2019). Kabeer's framework of empowerment as "resources, agency, and achievements" (1999) suggests that when women gain access to resources (e.g., land, credit, education) and agency (the ability to make decisions and take strategic actions), the achievements (outcomes like improved food production and family nutrition) will follow. Empowerment in agriculture has been associated with better household food and nutrition outcomes in many studies (Njuki et al., 2023). For instance, notable studies observe that *many pillars of improved food security are embedded in women's empowerment*, with education identified as a central pillar (Asare-Nuamah et al., 2024; Kumari & Ferdous, 2019; Njuki et al., 2023; Onyeaka et al., 2024; Umar et al., 2020). When women are empowered to make farming decisions, control income, or access agricultural inputs, they tend to allocate more resources to family well-being – increasing food availability and dietary quality (Saka, 2024). Conversely, disempowerment – as seen when women lack land rights or voice–can trap households in food insecurity despite women's best efforts (Gladwin et al., 2001; Ingutia & Sumelius, 2022a; Visser & Wangu, 2021). Empowerment theory, therefore, reinforces insights from GAD (addressing power imbalances) and the Capability Approach (building capacities), while fitting naturally within the multi-level ecological view (since empowerment can be supported or hindered by factors at various levels).

Our integrated framework expects that women's active involvement in household food production will significantly improve food security, but the magnitude of this effect will depend on: women's capabilities, such as education; the household's access to critical resources like land; supportive institutional inputs from government; supportive social networks; and the broader environmental context. Hence, we develop each hypothesis in detail below, drawing on relevant theory and empirical evidence.

Hypothesis development

Women's involvement in food production and household food security

Women are often described as the *linchpins* of household food security in developing countries (Doss, 2014; Doss & Morris, 2000; Lentz et al., 2025). In rural Kenya, as in much of sub-Saharan

Africa, women shoulder primary responsibility for subsistence farming, food preparation, and family nutrition. They produce and provide food for the family, manage household resources, and care for children–roles that directly influence whether a household eats regularly and nutritiously (Kennedy & Peters, 1992; Onyeaka et al., 2024). However, these contributions were historically undervalued in development policy, leading to gender biases in resource allocation. Gender and Development theory reminds us that this oversight is perilous: ignoring women's role means ignoring the "backbone" of food production and family well-being (Karaya et al., 2013). Empirical evidence strongly supports the argument that women's involvement in agriculture and food-related decisions boosts household food security (Andrew et al., 2022; Clement et al., 2019; Kotzé, 2003; Rehman et al., 2019). For example, a recent study found that households with at least one working woman tend to have significantly better food security outcomes than those without, owing to women's tendency to devote income to food and education for the family (Agarwal, 2018, 2022). Duflo (2003) famously observed that women are more likely than men to spend earnings on food and children's needs (Agarwal, 2018), and this is borne out in observations that women's income and employment improve overall household welfare and nutrition.

Moreover, women's involvement in farming can enhance productivity. Studies in Africa have shown that when women farmers have equal access to inputs, their yields are as high as men's—and closing the gender gap in agricultural productivity could increase total output substantially (Ibnouf, 2009). In Kenya, women contribute an estimated 70–80% of food production in smallholder farming (Thamari-odhiambo, 2021), underscoring that household food availability is largely in women's hands. However, as GAD theory highlights, women often perform this vital work under time and labor constraints. A World Bank analysis argued that *alleviating women's time constraints* – by improving their access to labor-saving technologies or redistributing domestic chores–is one of the most important ways to improve household food security, as it allows women to take advantage of new resources and opportunities to feed their families (Horenstein, 1989; Ingutia & Sumelius, 2022a). Taken together, these perspectives suggest that a household where women are active decision-makers in food production (growing crops, managing food stocks, and earning income for food) will be more food-secure than one where women's contributions are marginalized.

Additionally, empowerment theory provides a mechanism: as women gain voice and agency in household economic activities, they can influence resource allocation toward food security. Women with greater bargaining power tend to ensure that food is prioritized; indeed,

research has linked women's decision-making power to improvements in family nutrition and dietary diversity (Qureshi et al., 2015). (Quisumbing & Maluccio, 2000) noted that resources controlled by women have a larger positive impact on family food intake and children's health than those controlled by men. Therefore, empowering women in the food production sector is expected to lead to improved food security outcomes only if support, assistance, and infrastructure are available. In light of this theoretical and empirical support, we, therefore, hypothesize thus:

H1a: *Women's involvement in household food production has a negative effect on household food security without any interventional and infrastructural support.*

A growing body of literature supports the hypothesis that women heading households are positively related to financial literacy, particularly in contexts where female agency and decision-making authority are central to daily household management (Fonseca et al., 2012; Kumari, 2023). Female heads of households often assume greater financial responsibilities, including budgeting, saving, borrowing, and managing expenditures, which can develop practical financial skills and increase financial knowledge over time (Udohaya, 2025). In settings where women are empowered to control household resources and make financial decisions, studies have found a significant and positive association between women's leadership roles in the household and higher levels of financial literacy. For instance, empirical evidence from microfinance contexts, such as in rural Indonesia, demonstrates that women's empowerment—including decision-making autonomy and control over resources—has a direct and substantial positive effect on financial literacy (Lubis, 2020). This suggests that when women are structurally positioned as household heads or hold significant decision-making power, they are more likely to acquire and apply financial knowledge, driven by necessity and reinforced through experience. However, the strength and nature of this relationship may vary depending on socio-cultural, educational, and institutional factors, such as access to financial services, societal norms around gender, and exposure to financial education. Nevertheless, the consistent directionality of the findings indicates that female-headed households are a meaningful predictor of improved financial literacy, justifying their role as a mediating variable in broader models of household well-being, including food security (Millimet et al., 2018; Visser & Wangu, 2021; Wambui, 2021).

H1b: *Women-headed households have a positive effect on financial literacy*

Financial literacy, women education, and food security

Education is widely recognized as a catalyst for improving agricultural and development outcomes, a core idea in Sen's capability approach and in empowerment theory. Education enhances a person's capabilities by imparting knowledge, skills, and confidence, thereby enabling more effective use of resources. For a woman farmer or household food manager, education can translate into better farming practices, improved adoption of new technologies, and greater awareness of nutrition and health information (Chebuche & Wakhungu, 2021). An educated woman may be more adept at seeking out agricultural extension advice, interpreting weather and market information, or diversifying the family's diet. Thus, even if two women are equally involved in food production, the one with higher education is likely to secure better outcomes for her household.

Empirical evidence suggests that female education has a positive and amplifying effect on food security (Abdelhedi & Zouari, 2020; Antriyandarti et al., 2024; Mutisya et al., 2016). According to a United Nations report, improving women's education could *dramatically reduce hunger* in developing countries (Ibnouf, 2009; Larson & Larson, 2019; UNDP Africa & UNDP Africa, 2016).[1] In a Ugandan study, households with women who had at least a secondary school education produced significantly more food than households with women who had only a primary education or less (Filipponi et al., 2024; Rudolph et al., 2024). The educated women were better able to adopt improved farming techniques and manage resources, leading to higher yields and more reliable food supplies. Likewise, in Kenya, researchers have observed that rural women themselves emphasize education and training as critical for food production and household food security (Diiro et al., 2018). Educated women can imagine and implement strategies to improve farming and even move up agricultural value chains beyond subsistence farming (Giller, 2020; Rudolph et al., 2024). They are also more likely to seek non-farm income opportunities when needed, further bolstering household food access (Giller, 2020; Njuki et al., 2023).

In addition, from an empowerment perspective, education is a key resource that strengthens women's agency. It increases women's confidence in decision-making and their status within the household and community. As a result, the positive influence a woman has on household welfare through her involvement in food production is magnified if she is educated. Indeed, a scoping review of gender and food systems found strong evidence that women's empowerment, particularly through maternal education, is associated with better nutrition and dietary diversity within families (Njuki et al., 2023; Rudolph et al., 2024). Educated mothers are more likely to understand

[1]Undp, A. (2016). Africa Human Development Report 2016 Accelerating Gender Equality and Women's Empowerment in Africa (No. 267638). United Nations Development Programme (UNDP).

nutritional needs and ensure diverse diets, thereby improving the quality of food security rather than just its quantity. In Sen's terms, education expands a woman's capability set, enabling her to achieve the functioning of securing adequate food for her household (Burchi & De Muro, 2012).

Furthermore, in line with Sen's capability approach, financial literacy is a critical determinant of household food security because it enhances individuals' ability to manage resources, plan expenditures, and make informed financial decisions that support consistent access to adequate and nutritious food (Twumasi et al., 2023). In this context, women's education serves as a significant moderating factor, strengthening the impact of financial literacy on food security outcomes. Educated women are more likely to understand and apply financial principles effectively, engage in income-generating activities, and prioritize household nutritional needs. Moreover, education empowers women to participate in household decision-making processes, thereby improving the allocation of financial resources towards food and health-related needs (Rudolph et al., 2024). As such, the intersection of financial literacy and women's education creates a synergistic effect that improves food security, particularly in resource-constrained settings.

In general, theory and evidence suggest that women's education enhances the benefits of their engagement in food production by improving capabilities such as financial literacy. When a woman farmer is educated, every input she provides — labor, income, or decisions — can be used more effectively to ensure food security. Hence, we propose that:

H1c. *Financial literacy is positively related to food security*

H1d*: The positive impact of financial literacy on household food security is enhanced by the educational attainment of women in the household.*

The mediating role of financial literacy

The relationship between women's roles in the household and food security outcomes is complex and context-dependent. While women's involvement in household management and decision-making is often assumed to contribute positively to food security, this effect may not always be straightforward. In specific socio-economic contexts, particularly those characterized by poverty, limited access to resources, or entrenched gender norms, greater responsibility placed on women without commensurate support or empowerment may paradoxically correlate with reduced food security outcomes (Hendricks, 2002; Kotzé, 2003; Moon, 2024). This may occur due to constrained access to income-generating opportunities, limited mobility, or structural exclusion from financial

systems. Thus, the direct relationship between women's household involvement and food security may be negative or insignificant in the absence of enabling capabilities.

Financial literacy represents one such enabling capability. It encompasses the knowledge, skills, and confidence to make informed financial decisions and manage household resources effectively. Financial literacy has been shown to improve budgeting practices, enhance savings behavior, and enable more efficient resource allocation, all of which are critical for achieving and maintaining household food security (Grohmann et al., 2018; Lusardi & Mitchell, 2014). For women in particular, financial literacy can be a transformative tool, enabling them to exercise their roles in the household more effectively as economic agents.

In this context, financial literacy is posited to mediate the relationship between women's household roles and food security. While the direct effect of women's household involvement on food security may be negative due to structural or economic constraints, this relationship is hypothesized to become positive when mediated through financial literacy. That is, financial literacy enhances women's capacity to make more strategic and sustainable decisions regarding household resources, thereby mitigating the negative impacts of their constrained circumstances. We therefore posit that:

H2: *Financial literacy positively mediates the relationship between women in the household and food security.*

Women-headed households, women's education, and food security

Female-headed households (WHHs) are often disproportionately vulnerable to food insecurity due to constrained access to economic resources, social protection, and institutional support (Peterman et al., 2014). However, the impact of female headship on food security is not uniform; it varies depending on household-level and contextual characteristics. One such characteristic, women's educational attainment, may serve as a critical enabler, attenuating or amplifying the effects of headship on food security outcomes.

From a human capital perspective, education enhances cognitive and functional capacities that are vital for managing household welfare, securing income, and making informed decisions regarding nutrition, health, and resource allocation (Galor et al., 2009). In the context of female-headed households, where women often assume full responsibility for income generation and caregiving, educational attainment can improve employment prospects, increase financial literacy, and enhance access to public services and social safety nets. Moreover, educated women are more

likely to engage with agricultural extension services, adopt improved practices, and diversify income sources—all of which contribute to household food security.

This argument also draws from empowerment theory, which posits that education expands women's agency, autonomy, and bargaining power, thereby enabling more effective decision-making in resource-constrained households (Kabeer, 1999). Female heads with higher levels of education may be better positioned to advocate for their households, respond to shocks, and navigate institutional barriers. Consequently, the adverse effects typically associated with female headship, such as reduced access to credit, insecure employment, or social marginalization, may be partially offset when women have higher levels of formal education.

We therefore hypothesize that women's educational attainment moderates the relationship between female headship and food security: the negative association between WHHs and food security will be weaker in households with higher levels of female head education. However, this moderating effect is not expected to be universal. Its strength and direction may depend on contextual factors such as labor-market structure, educational quality, urban–rural location, and prevailing gender norms. In resource-poor or highly patriarchal settings, the transformative potential of education may be limited by external constraints that education alone cannot overcome. Hence, we hypothesize:

H3a: *The negative relationship between female-headed households and food security is attenuated by women's education***.**

Women-headed households, women's education, household land ownership, and food security

Land is one of the most fundamental resources for food production. Owning agricultural land provides a household with the means to produce food directly, reduces reliance on purchasing food, and allows long-term investments in soil quality and infrastructure. From a gender perspective, land ownership is also a source of empowerment and security. However, due to traditional inheritance systems and legal barriers, women in Kenya (and many other countries) historically own small plots of land in their own right (Ingutia & Sumelius, 2022b). Gender and Development theory highlights how structural inequality in land rights undermines women's contributions. Despite doing most of the farming, women's lack of land title or control means they cannot make strategic decisions or investments in the land (Ingutia & Sumelius, 2022a). They may also be excluded from access to credit and agricultural services, which often require land as collateral or target landowners (John, 2024).

When a household owns land, especially if women in the household can access or control it, the situation changes markedly. Land ownership provides a more secure platform for food production, allowing families to plan cropping cycles, adopt sustainable practices, and buffer against food price fluctuations by growing their staples. Crucially, women's agency on owned land leads to significant gains in output and food security. As is often observed among women in small-scale farming, land ownership can greatly enhance food production. This is because women farmers can invest confidently, knowing they will not risk losing the land, enabling them to support their households and communities (Berhane-Selassie, 2021; Buehren et al., 2019; Mwaura, 2017; Radel, 2011). This narrative aligns with *empowerment theory*: when women gain property rights, they are empowered to make decisions that improve productivity and resilience. Food security experts explain that women's limited land rights severely limit their capacity to make long-term investments in farming and thus constrain food production and security (Dabkiene et al., 2025; Visser & Wangu, 2021). Conversely, secure land rights encourage women to adopt innovations (like agroforestry or irrigation) that enhance yields and to cultivate a diversity of crops (including nutrient-rich vegetables for home consumption) (Dabkiene et al., 2025; Ingutia & Sumelius, 2022b).

There is robust evidence that addressing the gender gap in land ownership would have a dramatic impact on food security. The Food and Agriculture Organization (FAO) estimates that if women farmers had equal access to land and other productive resources as men do, their yields could increase by 20–30%, potentially reducing the number of hungry people globally by 12–17% (FAO, 2015, 2018). In Kenya, women currently manage about 40% of small farms but hold title to only 1–2% of land, often gaining "user rights" only through a male relative (Ingutia & Sumelius, 2022a). This mismatch between labor and land ownership is cited as a key factor in undermining food security at the household and national levels (Wambui, 2021). When households own land, it can amplify the fruits of women's labor: women can grow more food on their own plot rather than working as laborers on someone else's land or in insecure rented fields. They are also more likely to be included in agricultural extension programs if recognized as landowners, and more likely to receive credit for inputs, which together improve productivity (Wambui, 2021). Therefore, we believe that the positive influence of women's involvement on food security is significantly greater in households that own land (versus landless or tenant households). Land ownership provides the physical and economic basis for women's farming efforts to fully translate into food security gains.

It also intersects with women's empowerment, granting them greater say and stability in agricultural production. We, therefore, propose that:

H3b: *The negative effect of women's involvement in food production on household food security is enhanced when the household owns agricultural land, such that the resulting moderating effect turns positive.*

Women-headed households, financial literacy, high-endemic zones, and government support

Not all households operate under the same environmental and contextual conditions. In Kenya, certain regions—particularly the arid and semi-arid lands in the north and east—are characterized by endemic food insecurity due to recurring droughts, poor soil quality, and marginalization. We label these as "high endemic zones," meaning areas where hunger and resource scarcity are chronic problems. Ecologically and structurally, these zones present harsh conditions that can overpower even well-intentioned household efforts to achieve food security. We expect that in such high-risk environments, the positive impact of women's involvement in food production may be dampened or weakened because external stressors make it more challenging to translate effort into results.

From an ecological systems standpoint, the *macrosystem* and *chronosystem* exert a strong influence in this respect. A woman farmer might be highly capable and hardworking. However, if her family lives in a drought-prone region with degraded land and limited infrastructure, her crops may fail due to a lack of rain, or poor roads may cut off her market access (Moon, 2024; Thamari-odhiambo, 2021). In these endemic zones, factors such as climate shocks (droughts, floods), endemic diseases (e.g., malaria or livestock diseases), or conflicts over resources can severely constrain food production. Indeed, a cultural-ecological study in rural Kenya noted that women face numerous constraints in securing food for their households, which are exacerbated by climatic variability, particularly drought (Karaya et al., 2013). When drought hits, even skilled women farmers may see their harvests dwindle, making their households food insecure despite their efforts. High-endemic zones often also lack services—government support may be weakest in remote, arid areas, and the presence of NGOs might be sporadic. Hence, the burden on households (and thus on women) is extreme.

The capability approach also sheds light on this; however, capabilities depend in part on the environment. Suppose the environment is very uncooperative (e.g., no rainfall or endemic crop pests); in that case, the conversion of resources to productive use, such as converting land and labor to food output, is impaired. Women's agency is still crucial, but its efficacy is relatively lower

under such adverse external conditions. For example, in malaria-endemic zones, women and children might frequently fall ill, reducing the labor available for farming and increasing household healthcare costs, thus indirectly weakening food security outcomes. Similarly, in chronically impoverished areas, women's time may be diverted to coping activities, such as fetching water from distant sources, leaving them with fewer opportunities to improve food production (Karaya et al., 2013).

It is important to note that women's involvement remains beneficial even in high-endemic zones. However, the hypothesis is that the degree of benefit is lower than in non-endemic areas, which are more favorable. In a relatively well-resourced area, a woman's innovations or hard work might lead to a significant surplus or noticeable improvement in diet diversity (Dabkiene et al., 2025; Nurhidayah & Djalante, 2022; Qureshi et al., 2015). In contrast, in a highly challenging area, the same level of effort might avert hunger but not fully achieve food security due to ongoing shocks. This kind of interaction has been observed in studies of agricultural interventions—the impact of an intervention often varies by agro-ecological zone, being higher in better environments and lower where baseline conditions are harsh (unless the intervention specifically addresses those harsh conditions).

State institutions and policies play an important role in shaping food security outcomes, often by enabling or constraining what farmers can achieve (Nurhidayah & Djalante, 2022; Qureshi et al., 2015). In Kenya, as in many countries, governments (national or county-level) provide various forms of support that can affect smallholder farming: agricultural extension services, input subsidies (for seeds or fertilizer), credit schemes, irrigation infrastructure, and safety-net programs (cash or food transfers) for vulnerable households. Ecological Systems Theory would categorize these as part of the exosystem—external supports that indirectly influence households by improving the context in which women farmers operate. We hypothesize that when women have access to robust government support, their efforts in food production are more fruitful.

One reason is that government agricultural programs have historically underserved women. For example, only a small fraction of agricultural extension resources in Africa are directed at women farmers (Gladwin et al., 2001), in part because extension agents traditionally focused on male landowners. This gender gap in services means women often lack information on improved practices or access to technologies that could increase yields. However, when extension services become more gender-inclusive, women's productivity rises. A report on gender-inclusive extension approaches noted that when women farmers receive training and understand new tools,

they readily adopt them, leading to improved household food production and security (Kotzé, 2003; Wambui, 2021). Government support can also come in the form of subsidies or the distribution of inputs (Burchi et al., 2018). If a county government provides subsidized drought-tolerant seeds or fertilizer to small farmers, women's plots, often previously low-yield due to lack of inputs, can see significant improvements, thereby enhancing food availability for the household.

Additionally, government social support programs, such as cash transfer programs or off-season public works employment, can stabilize a household's access to food, making the outcomes of women's farming efforts more secure. For instance, a cash transfer can help a family get through a lean season, allowing the woman to keep seeds for planting rather than selling them for food. Although some studies find that receiving social assistance does not automatically guarantee higher food security (Agarwal, 2018; Doss, 2014), combining social support with women's active involvement can have synergistic effects—the assistance provides a safety net while the woman's own efforts provide food, together ensuring sufficiency (Doss, 2014).

From an empowerment theory viewpoint, supportive government policies can empower women by reducing structural barriers. For example, legal reforms in Kenya (the 2010 Constitution and subsequent laws) formally granted women equal rights to land ownership (Bassett, 2017; Kameri-Mbote, 2006). When such laws are implemented, they increase women's bargaining power in the community. Similarly, government-funded microcredit or grant programs targeted at women farmers strengthen their resource base. A World Bank policy paper argued that a combination of complementary interventions, including short-term technologies and long-term policies, is the most effective way to expand women's access to training, credit, and resources, thereby improving household food security (Horenstein, 1989). In other words, women's labor and ingenuity yield far greater results when backed by enabling policies. Unfortunately, public investment in agriculture in many African countries remains below agreed targets; for instance, Kenya had committed to spending 10% of its budget on agriculture (per the Malabo Declaration), but as of 2021, it was spending only about 3.2% (Wangusi & Muturi, 2015). This shortfall in support can slow the progress of food security initiatives. Greater allocation towards extension services, research into climate-resilient crops, and rural infrastructure—all with attention to gender inclusion—would likely amplify the benefits of women's contributions (Huyer et al., 2021).

Hence, we expect that when households receive strong support from government programs, the impact of women's involvement on food security will be magnified. Government support can take many forms (technical, financial, legal), but its common effect is to reduce the obstacles and

risks women face in food production. While financial literacy is widely regarded as a critical enabler of household economic resilience (Grohmann et al., 2018) and food security, its effectiveness may depend on contextual and structural conditions. That is, the relationship between financial literacy and food security is not necessarily uniform across settings and may be either attenuated or amplified by external environmental and institutional factors (Lusardi et al., 2014; Lusardi & Mitchell, 2014). Two such factors, endemic vulnerability and government support, are particularly salient in shaping the strength and direction of this relationship.

In areas characterized by high endemic risks, such as chronic poverty, recurrent disease outbreaks, environmental degradation, or climate-induced food shocks, the potential of financial literacy to influence food security positively may be substantially diminished (Etale & Simatele, 2024; Millimet et al., 2018). Even financially literate individuals may find themselves unable to apply their knowledge effectively due to limited economic opportunities, supply chain disruptions, or restricted access to credit and food markets. As such, in high-endemic areas, the enabling effects of financial literacy are likely to be constrained, as systemic instability overrides individual capacity for financial decision-making and planning (Figueres, 2012; Henry, 2021; Wangusi & Muturi, 2015).

Conversely, supportive government interventions can enhance the efficacy of financial literacy in achieving food security (Perdana et al., 2022; Rose, 2008; Wangusi & Muturi, 2015). These may include public policies such as social protection schemes, targeted food aid, financial inclusion programs, agricultural subsidies, or the integration of financial literacy training within broader rural development initiatives (Perdana et al., 2022; Qureshi et al., 2015): When such support mechanisms are present, they can reinforce the positive relationship between financial literacy and food security by providing the structural scaffolding that allows financially literate individuals, particularly women, to implement their knowledge and make more effective use of financial tools and services (Kyeyune & Mpeera Ntayi, 2025; Twumasi et al., 2023).

Together, these moderating effects highlight the importance of contextualizing financial literacy within broader socio-political and environmental landscapes, and recognizing that individual capabilities require institutional and environmental support to translate into meaningful outcomes.

H3c: *High endemic zone negatively moderates the link between financial literacy and food* security

***H3d**: The negative relationship between financial literacy, endemic zones, and food security is positively moderated by government support, such that the effect is stronger when supportive government interventions are present.*

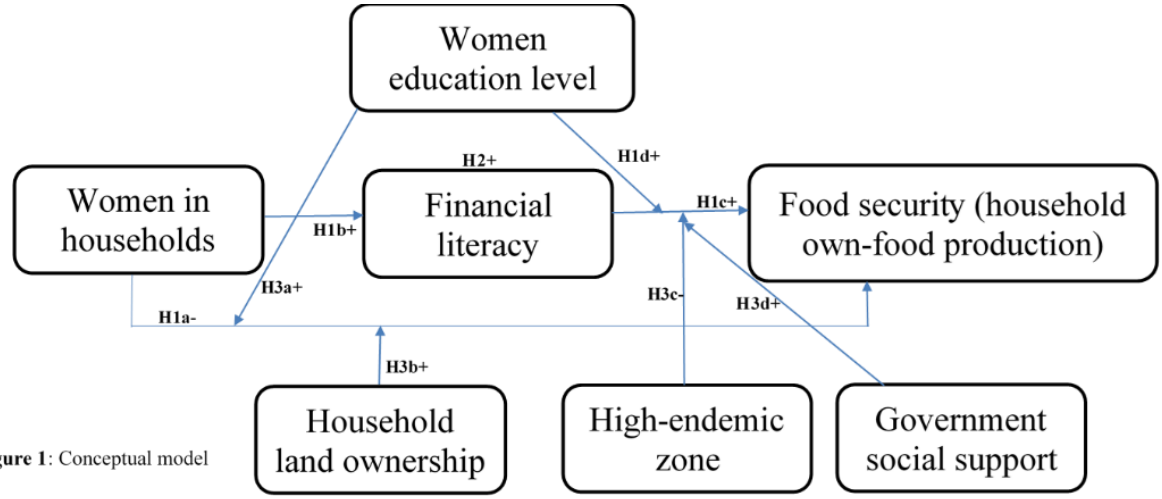


Figure 1: Conceptual model

Data and method

Data source and sample

To test our hypothesis, we analyze data from the Kenya Demographic and Health Survey (KDHS), a nationally representative household survey. We focus on the most recent DHS rounds, which include data on water, household assets, and assistance. The DHS provides comprehensive information on household characteristics, including the number of eligible women in the households, household land ownership (both agricultural and non-agricultural), the educational attainment of women, social support from national and regional governments, access to water and sanitation, and health behaviors, making it suitable for our analysis. This study uses data from the 2022 KDHS, part of the global DHS program, conducted by the Kenya National Bureau of Statistics (KNBS) with national and international partners. The survey employed a stratified two-stage cluster sampling method to ensure representativeness at both national and county levels. The dataset includes information on all household members, allowing individual-level analysis of various demographic and health indicators. KDHS collects detailed data on household demographics, socioeconomic status, access to utilities and services, and environmental health factors. Variables with over 90% missing data were excluded to ensure the quality and validity of the analysis. Following thorough data management, the sample comprises 89260 rural households.

The other variables exhibited minimal item non-response, aligning with KDHS's strict data collection standards. This dataset provides a solid empirical foundation for investigating the connection between women-headed households, land ownership, and food security in Kenya, while incorporating other contextual variables that moderate and mediate the relationship (National Bureau of Statistics, 2024).

Variable description and measurement

This study draws on nationally representative data from the 2022 Kenya Demographic and Health Survey (KDHS**)**, which provides detailed household- and individual-level information on demographic, socioeconomic, and agricultural characteristics relevant to food security analysis. All variables were harmonized and recoded according to DHS analytical standards

Dependent variable

Food security was proxied through household-level food production indicators capturing own production of cereals and grains, roots and tubers, pulses and nuts, fruits and vegetables, green leafy vegetables, dairy products, and seafood. This composite measure aligns with multidimensional approaches to household food security that emphasize dietary diversity and own production capacity (Jones et al., 2013; Smith & Haddad, 2015).

Independent variable

Female-headed households represent the number of eligible women in the survey. This is further expressed in natural logarithms. Female headship is a critical determinant of household welfare, reflecting gendered access to resources, decision-making autonomy, and vulnerability to food insecurity (C. Doss et al., 2018).

Moderating variables

Four moderators were incorporated. *Land ownership* (measured in hectares) captures whether the household owns agricultural land suitable for cultivation. *Women's education* encompasses the highest educational attainment, ranging from primary and secondary education to mid-level college, vocational, or informal education (such as madrasa/adult education), reflecting the human capital effects on household welfare. *High-endemic zones identify malaria risk categories—lake endemic, highland endemic, coastal endemic, seasonal, or low risk—*

representing environmental vulnerability. *Government support* denotes receipt of national social assistance (1 = yes).

Mediating variables

Financial literacy was proxied by indicators of digital and formal financial inclusion: mobile phone ownership, registration on a mobile money platform, use of mobile phones for financial transactions, and possession of a bank account. These measures capture households' capability to manage financial risks and improve food access (Allen et al., 2016; Klapper et al., 2016; Tsongo et al., 2024).

Control variables

Socio-demographic controls include *age of household head* (log-transformed), *household size* (log-transformed), and *marital status* (1 = married, 0 = otherwise). Economic and infrastructural characteristics comprise *electricity access*, *health insurance coverage*, and *bank account ownership* (each coded as a binary variable). These factors have been shown to influence household welfare and resilience (FAO et al., 2021).

Empirical strategy

Given the binary nature of the dependent variable—food security (proxied by household-owned food production)—we estimate the likelihood of food security using a binary logit regression. The logit regression framework is suitable for modeling the probability ***[pr (food security=1)]*** as a function of women-headed households. The general form of our model is specified thus:

$$\boldsymbol{logit}[\boldsymbol{Pr}(\boldsymbol{Food\ security_i = 1})] = \alpha + \beta_1 women_headed_household_i + \beta_2 women_education_i + \beta_3 household_land_ownership_i + \beta_4 high_endemic_zones + \beta_5 government\ support_{i(national)} + \beta_6 (women_headed_househol * women_education)_i + \beta_7 (women_headed_household * household_land_ownership)_i + \beta_8 (financial_literacy * high_endemic_zone)_i + \beta_9 (financial_literacy * women_education)_i + \beta_{10} (financial\ literacy * high_endemic_zone * government\ support)_i + \beta_{11} Controls_i + \varepsilon_i \quad (1)$$

$\beta_1 - \beta_5$ capture the unconditional effects of *women-headed households, women's education, household land ownership, high endemic zones, and government support.* At the same time, *i and j* indicate individual household heads and government support. $\beta_6 - \beta_{10}$ capture the moderating effect coefficients, $\beta_{11} illustrates\ the\ covariates$ and $\varepsilon, the\ error\ term.$ The base model

regresses the probability of a household engaging in its own food production on women-headed households and the moderating and control variables.

Although endogeneity of women's role in household food security could theoretically arise from unobserved household characteristics or reverse causality, the number of eligible women (logged) primarily reflects demographic composition, which is exogenous mainly to current food security outcomes. Given the cross-sectional nature of the data and the demographic basis of this variable, potential endogeneity is likely to be negligible. Therefore, we estimate a logit regression model without instrumental variables, focusing instead on the moderating and mediating effects. We include regional fixed effects to account for broad regional disparities. In a separate estimation, we include the interaction between survey year and county, and between county and residence status (year × county and county × residence status). In this way, we capture the individual effect associated with each county.

Results

In this study, we examine the role of women and other resource-capability factors in food security. Our analyses follow second-stage moderated mediation. The descriptive values and correlations of our estimation variables are presented in Table 1. Table 2 contains the main regression results. While financial literacy is the dependent variable in Model 3, food security is the dependent variable in the other models. Model 1 serves as a baseline model for our core dependent variable (food security), incorporating only the control variables and accounting for county fixed effects. For hypothesis testing, we employ multivariate regression models.

Table 1: Descriptive statistics and correlations of estimation variables

Variables	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Food security	0.332	0.471	1														
Women (logged)	0.69	0.402	0.006*	1													
Owned agricultural land	0.659	0.474	0.183***	0.018***	1												
Financial literacy	0.869	0.337	0.083***	0.108***	0.189***	1											
Women education	0.093	0.291	0.237***	0.169***	0.048***	0.065***	1										
Government support (national)	0.108	0.311	0.0003	-0.063***	-0.002	-0.038***	-0.026***	1									
High endemic zones	0.574	0.281	-0.085***	-0.070***	-0.243***	-0.140***	-0.051***	0.096***	1								
Household size (logged)	3.482	0.911	0.024***	0.005	0.095***	0.052***	0.023***	-0.013***	-0.075***	1							
Household head age (logged)	3.828	0.321	0.070***	-0.169***	0.173***	-0.024***	-0.043***	0.198***	-0.014***	-0.006*	1						
Male (household heads)	0.665	0.472	0.027***	0.017***	0.037***	0.102***	-0.028***	-0.080***	-0.026***	-0.001	0.008**	1					
Married	0.29	0.454	0.014***	-0.047***	0.013***	0.036***	0.156***	-0.030***	0.010***	0.005	-0.041***	0.227***	1				
Health insurance cover	0.078	0.268	0.251***	-0.004	0.065***	0.071***	0.137***	0.003	-0.003	0.021***	-0.003	0.023***	0.097***	1			
Electricity	0.236	0.425	0.038***	0.010***	0.073***	0.145***	0.047***	-0.014***	-0.047***	0.014***	0.027***	0.030***	0.036***	0.137***	1		
Mobile money literacy	0.926	0.262	0.053***	0.112***	0.106***	0.729***	0.048***	0.020***	-0.077***	0.024***	-0.014***	0.090***	0.030***	0.065***	0.116***	1	
Bank account	0.308	0.462	0.068***	0.023***	0.158***	0.166***	0.038***	0.090***	-0.025***	0.028***	0.057***	0.072***	0.049***	0.225***	0.259***	0.189***	1

*** p<0.01, ** p<0.05, * p<0.1

Table 2: Main regression analyses

	(Mode 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)	(Model 7)	(Model 8)	(Model 9)
VARIABLES	Food security	Food security	Financial Literacy	Food security	Food security	Food security	Food security	Food security	Food security
		H1a, c	**H1b**	**H1d**	**H3a**	**H3b**	**H3c**	**H3d**	
Married	-0.079***	-0.278***	0.030	-0.279***	-0.276***	-0.278***	-0.278***	-0.279***	-0.276***
	(0.017)	(0.018)	(0.027)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Household size (logged)	-0.028***	-0.036***	0.031**	-0.036***	-0.036***	-0.036***	-0.036***	-0.036***	-0.036***
	(0.009)	(0.009)	(0.013)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Age (household heads)	0.491***	0.431***	-0.607***	0.430***	0.426***	0.431***	0.431***	0.432***	0.428***
	(0.025)	(0.027)	(0.040)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Male (household heads)	0.074***	0.144***	0.519***	0.144***	0.144***	0.143***	0.144***	0.143***	0.143***
	(0.017)	(0.018)	(0.024)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Health insurance cover	1.948***	1.868***	0.389***	1.868***	1.869***	1.869***	1.869***	1.868***	1.870***
	(0.029)	(0.031)	(0.061)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Electricity availability	-0.190***	-0.197***	0.778***	-0.197***	-0.197***	-0.197***	-0.197***	-0.197***	-0.197***
	(0.019)	(0.020)	(0.039)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Bank account	-0.117***	-0.161***	1.201***	-0.161***	-0.160***	-0.161***	-0.161***	-0.160***	-0.161***
	(0.018)	(0.019)	(0.035)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Owned agricultural land		0.543***	0.390***	0.543***	0.542***	0.474***	0.543***	0.543***	0.476***
		(0.021)	(0.028)	(0.021)	(0.021)	(0.037)	(0.021)	(0.021)	(0.037)
Women education		1.623***	0.175***	1.275***	1.485***	1.623***	1.623***	1.623***	1.156***
		(0.027)	(0.051)	(0.098)	(0.076)	(0.027)	(0.027)	(0.027)	(0.119)
High endemic zones		-0.645***	-1.614***	-0.645***	-0.644***	-0.642***	-0.559***	-0.658***	-0.576***
		(0.125)	(0.162)	(0.125)	(0.125)	(0.125)	(0.148)	(0.125)	(0.147)
Government support (national)		0.101***	0.049	0.102***	0.101***	0.102***	0.102***	0.019	0.016
		(0.027)	(0.037)	(0.027)	(0.027)	(0.027)	(0.027)	(0.047)	(0.047)
Financial literacy		***0.094******		0.069**	0.095***	0.095***	0.158**	0.079***	0.115*
		(0.028)		(0.029)	(0.028)	(0.028)	(0.065)	(0.029)	(0.065)
Women (logged)		**-0.126***	**0.724***	-0.125***	-0.136***	-0.205***	-0.126***	-0.127***	-0.213***
		(0.020)	**(0.031)**	(0.020)	(0.020)	(0.041)	(0.020)	(0.020)	(0.041)
Women*women education					**0.157****				0.152*
					(0.080)				(0.080)
Financial literacy*women education				**0.374***					0.361***
				(0.101)					(0.101)
Women*owned agricultural land						**0.101****			0.099**
						(0.046)			(0.046)
Financial literacy*endemic zones							**-0.106**		-0.100
							(0.099)		(0.098)
Financial literacy*endemic zones*government support								**0.155****	0.167**
								(0.074)	(0.074)
Constant	-2.952***	-2.832***	4.118***	-2.808***	-2.808***	-2.779***	-2.885***	-2.814***	-2.766***
	(0.113)	(0.148)	(0.211)	(0.149)	(0.149)	(0.150)	(0.156)	(0.149)	(0.158)
County dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	89260	89260	89260	89260	89260	89260	89260	89260	89260
Pseudo R^2	0.098	0.137	0.235	0.137	0.137	0.137	0.137	0.137	0.138
Chi^2	8800.2***	10627.0***	12613.1***	10623.5***	10663.0***	10619.6***	10628.0***	10631.0***	10652.1***
ll	-51187.74	-48934.871	-26501.875	-48928.217	-48932.855	-48932.502	-48934.293	-48932.681	-48921.286

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In H1, we proposed that women-headed households would be negatively related to food security. The results in Model 2 (Table 2) show that a woman-headed household was negatively associated with food security ($\beta = -0.13, p < 0.01, SE = 0.02$), supporting H1a. We further argued in H1b that women-headed households would be positively related to financial literacy (the mediator). The results in Model 3 (Table 2) show that a woman-headed household was positively and significantly related to financial literacy ($\beta = 0.72, p < 0.01, SE = 0.03$), confirming and supporting H1b. we further proposed in H1c that financial literacy would be positively related to food security. The results in Model 2 (Table 2) show that financial literacy was positively associated with food security ($\beta = 0.09, p < 0.01, SE = 0.03$), confirming H1c. In *H1d*, we proposed that women's educational attainment (primary, secondary, mid-level college, vocational, or informal) would positively and significantly moderate the link between

financial literacy and food security. The finding in Model 7 (Table 2) is positive and significant ($\beta = 0.37, p < 0.01, SE = 0.10$), supporting ***H1d***. The simple slope depicted in ***Figure 2*** also shows a steeper, positive upward effect for educated women.

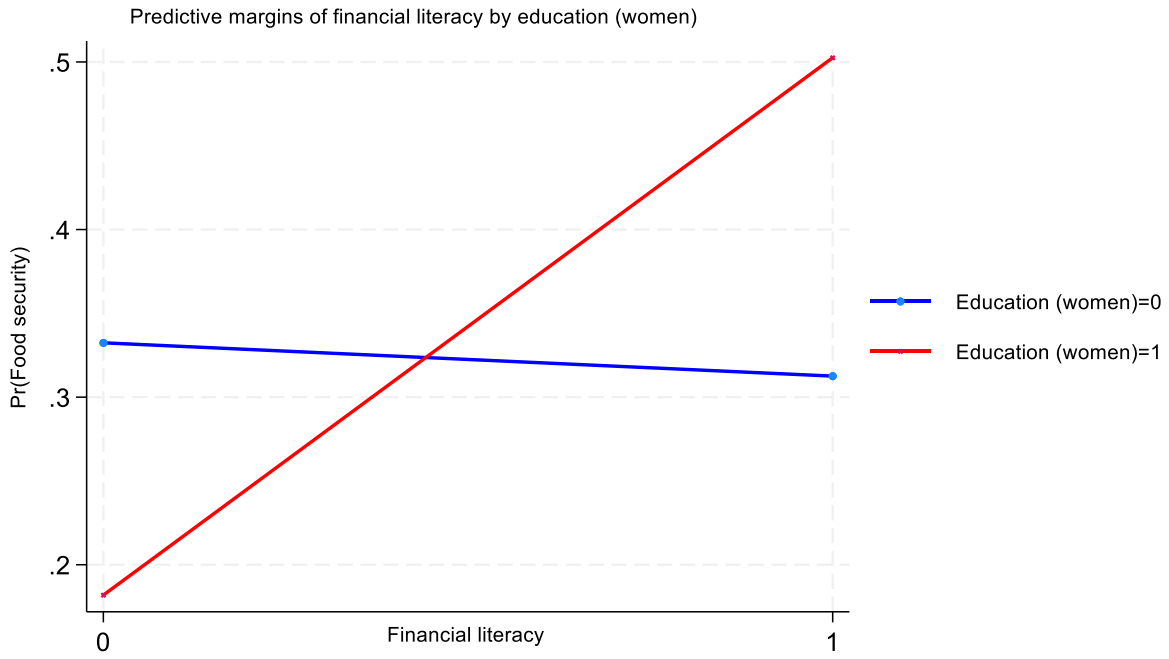


Figure 2: Interaction effect of educational attainment (women)

Furthermore, we proposed in H2 that financial literacy would mediate the relationship between women-headed households and food security. To test the mediation effect, we followed the same approach in the PROCESS macro, but implemented it in Stata 18. The interesting thing about Stata is that it offers a dual approach to mediation estimation: through SEM, we use *medsem*, which accounts for the principal mediation analysis. To further establish a cautious causal inference, we employed the parametric approach in Stata to estimate the three components of the mediation effects (direct, indirect, and total effects) (Emsley & Liu, 2013). We also performed our estimation using 10000 bootstrap replications with a 95% confidence interval. Both approaches integrate Preacher & Hayes (2004) and Baron and Kenny (1986) to address potential limitations of each.

The results in Model 1 (Table 3), which also included all control variables as in Table 2, suggest a significant and positive mediation effect of financial literacy ($\beta = 0.089, p < 0.01, SE = 0.04$). While the mediation effect is partial, specifically, we find that about 36% of the effect of women-headed households on food security was mediated by financial literacy. The indirect effect was 0.6 times as large as the direct effect of women-headed households on

food security. From the parametric mediation estimation, using Stata 18 (Table 3, Model 3), our results also suggest a positive and significant mediation effect ($\beta = 0.007, p < 0.01, SE = 0.001$), 95% CI=$[0.007, 0.008]$. **Figure 3** further confirms the mediation effect through the three-line slopes of the mediation (natural indirect), direct, and total effects. Hence, our results confirm and support H2.

Table 3: Mediation of analyses

	(Model 1)	(Model 2)	(Model 3)	(Model 4)	(Model 5)	(Model 6)
VARIABLES	Food security	Financial literacy	Paramed	Food security	Mobile money literacy	Paramed
Financial literacy	0.089***					
	(0.004)					
Mobile money literacy				0.060***		
				(0.006)		
Women (logged)	0.013***	0.084***		0.017***	0.070***	
	(0.004)	(0.003)		(0.004)	(0.002)	
Age (household heads)	0.107***	-0.013***		0.106***	0.000	
	(0.005)	(0.004)		(0.005)	(0.003)	
Male (household heads)	-0.017***	-0.069***		-0.021***	-0.047***	
	(0.003)	(0.003)		(0.003)	(0.002)	
Married	-0.015***	0.003		-0.014***	0.002	
	(0.003)	(0.002)		(0.003)	(0.002)	
Health insurance cover	0.434***	0.078***		0.437***	0.057***	
	(0.006)	(0.003)		(0.006)	(0.002)	
Women education	0.016***	0.089***		0.021***	0.052***	
	(0.004)	(0.002)		(0.004)	(0.002)	
var(e.Food security)	0.205***			0.206***		
	(0.001)			(0.001)		
var(e.Financial literacy)		0.110***				
		(0.001)				
Controlled direct effect			0.006*			0.009***
			(0.003)			(0.003)
Natural indirect effect			0.007***			0.004***
			(0.000)			(0.000)
Total effect			0.013***			0.013***
			(0.003)			(0.003)
var(e.Mobile money literacy)					0.067***	
					(0.001)	
Constant	-0.192***	0.860***		-0.168***	0.878***	
	(0.019)	(0.015)		(0.020)	(0.012)	
Observations	89,260	89,260	89,260	89,260	89,260	89,260

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

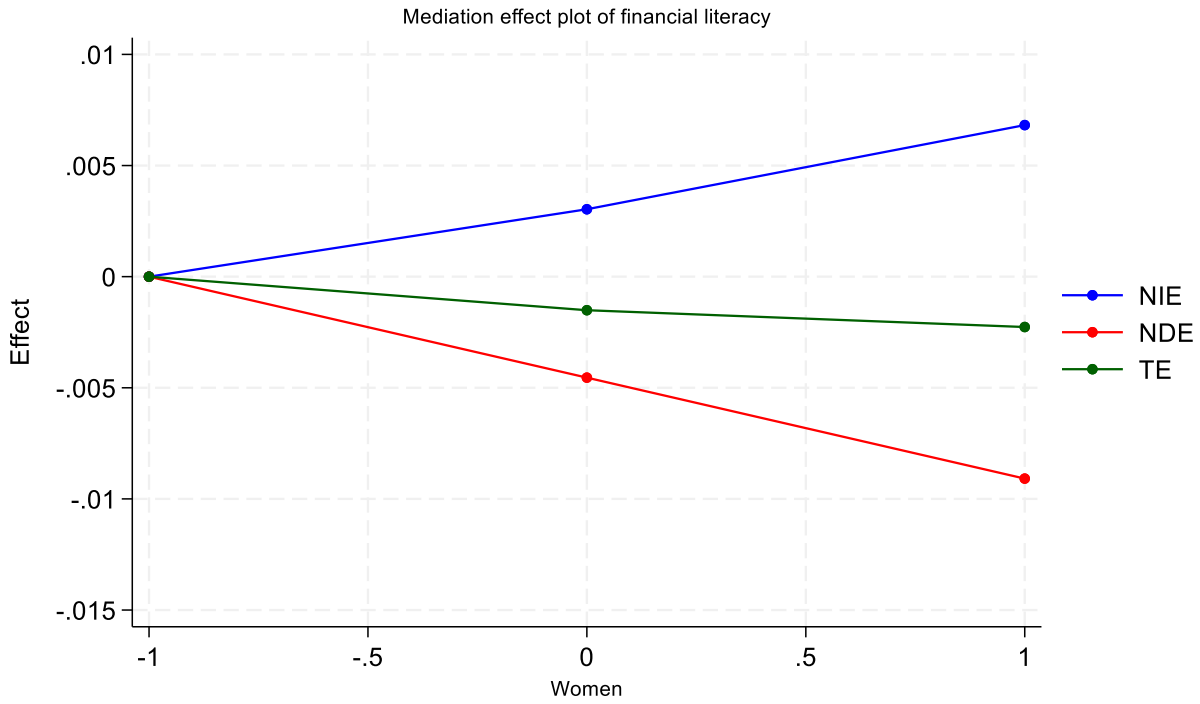


Figure 3: The mediation effect of financial literacy

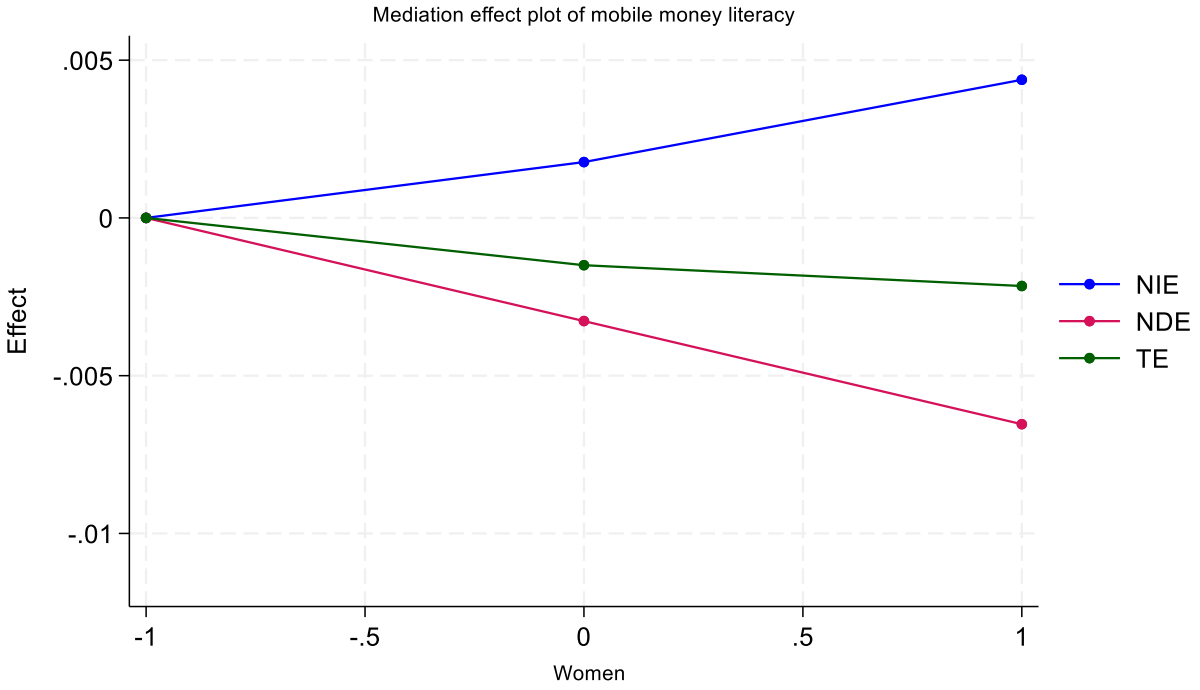


Figure 4: The mediation effect of financial and mobile-money literacy

In H3a, we proposed that women's educational attainment would positively moderate the negative link between women-headed households and food security. Our results in Model 5 confirmed the moderation effect of women's education, which was positive and significant ($\beta = 0.16, p < 0.05, SE = 0.08$). The slope of the interaction effect also reflects a positive

direction, indicating a stronger effect of education (***Figure 5***). Additionally, in H3b, we proposed that households owning land usable for agriculture would strongly and positively attenuate the initial negative relationship between women-headed households and food security. As reported in Model 6 (Table 2), the coefficient was positive and significant ($\beta = 0.101, p < 0.05, SE = 0.05$). Correspondingly, the predictive margin illustrated in ***Figure 6*** supports the proposed effect; hence, our H3b is supported. We further argued in H3c that the multiplicative effect of high endemic zones weakens the relationship between financial literacy and food security. As shown in Model 7 (Table 2), the coefficient had the expected sign but was not significant, providing partial support for H3c.

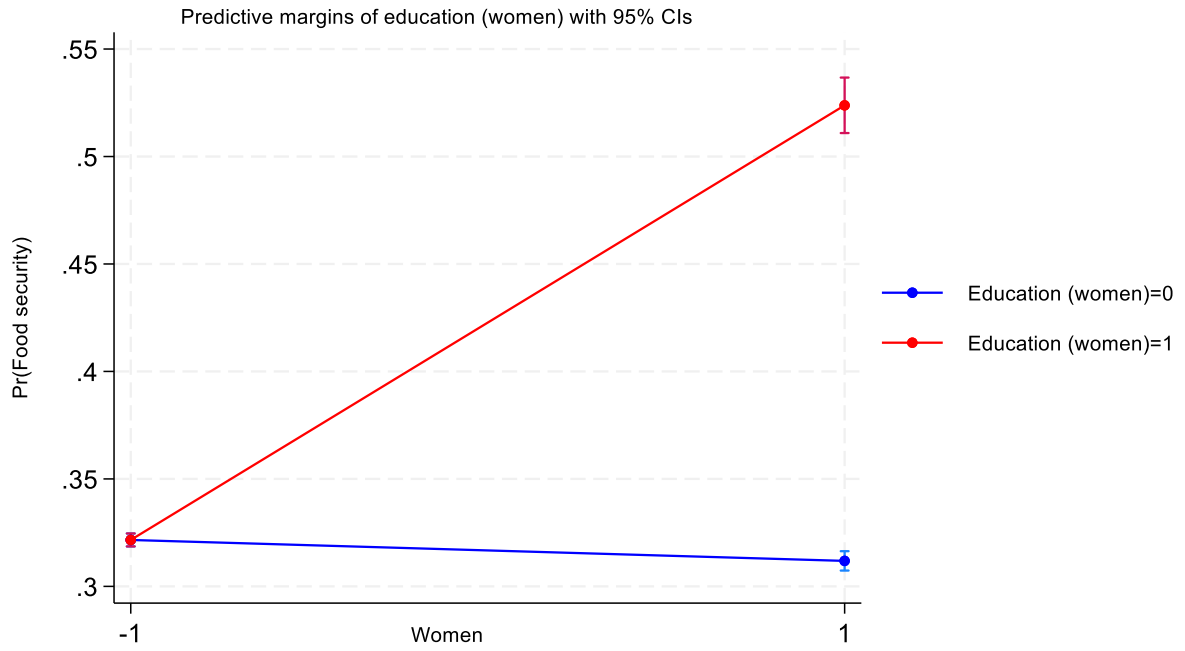


Figure 5: Interaction effect of educational attainment (women)

As a follow-up to H3c, we proposed in H3d that the weakened effect between financial literacy and food security in high-endemic zones is attenuated by government social support for households, such that the negative effect becomes positive and significant. The result in Model 8 (Table 2) confirmed the tripartite effect of government support ($\beta = 0.155, p < 0.05, SE = 0.07$). In addition to the positive and significant moderating effect of government support services, we generated the predictive margin in Figure 7. The slope of the interaction effect shows a positive upward trend in high-endemic zones when government support is present, confirming the true effect of ***H3d***. However, when government support is absent, the slope is steeper downward, indicating a perceived adverse effect of endemic-related risk on food security. Lastly, as also depicted in Figure 7, the effect becomes neutral in the presence of

government social support, even in the absence of endemicity. In entirety, our H3d is strongly supported. In the following sections, we present our findings, provide policy recommendations, and offer a conclusion. To further confirm the stability of the interactive results, we pooled the analyses in a multilevel model. As shown in Model 9 (Table 2), the interaction coefficients retain their signs and significance levels.

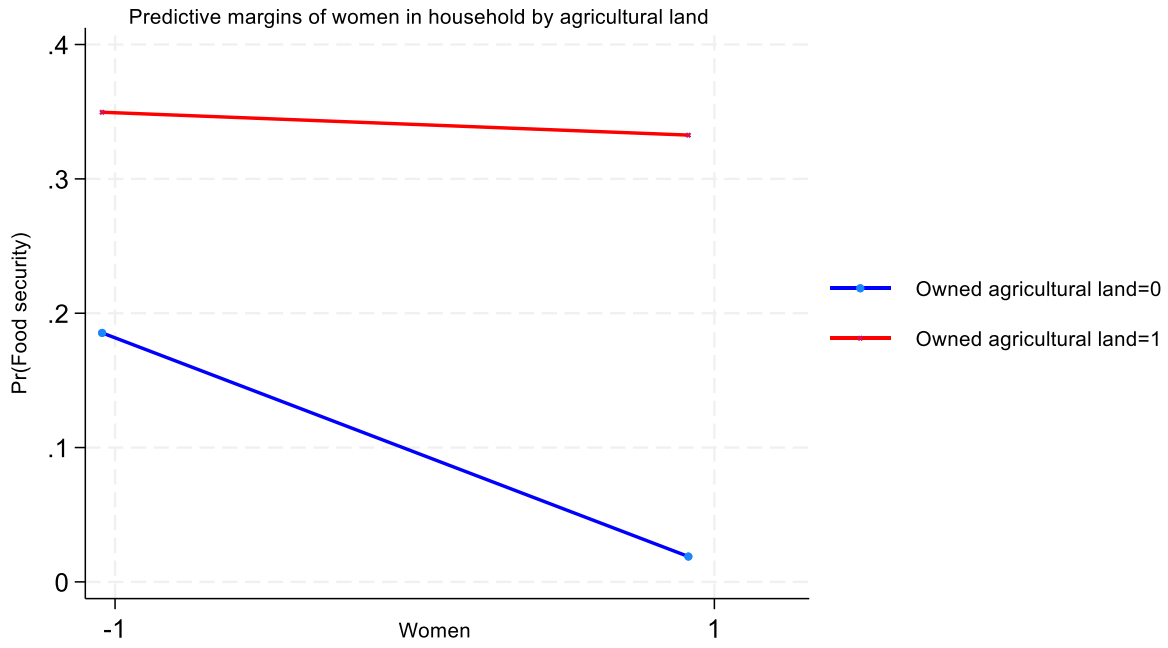


Figure 6: Interaction effect of household agricultural land

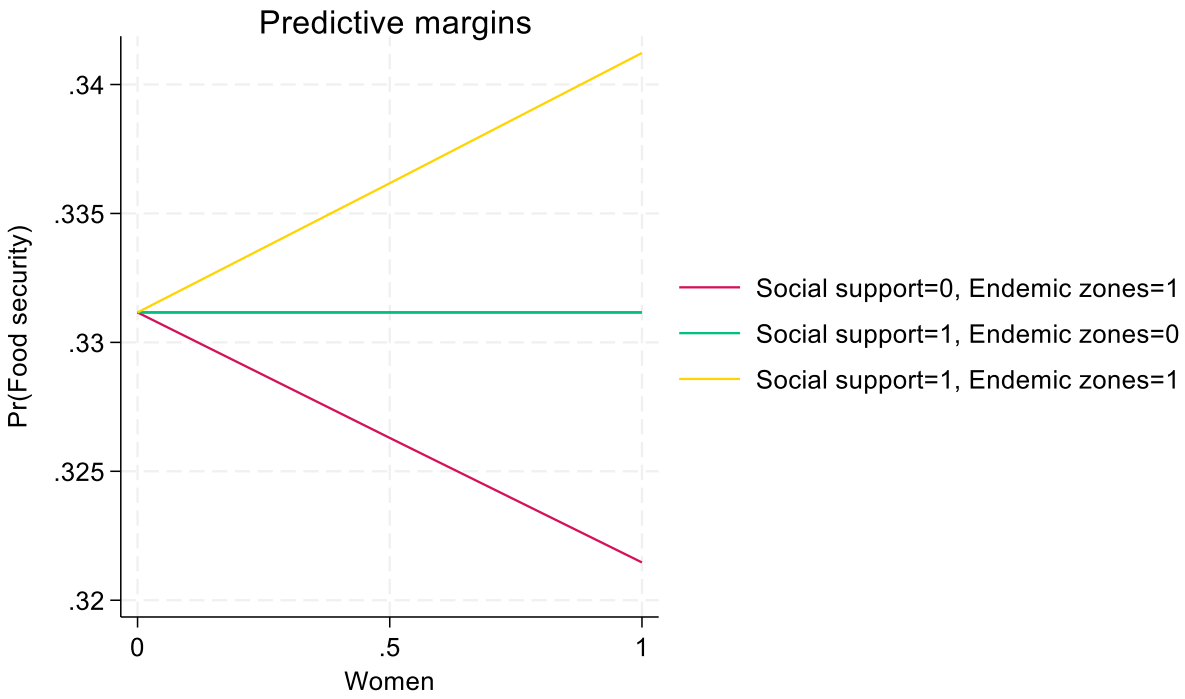


Figure 7: The tripartite effect of government support

Robustness

For robustness checks, especially regarding the mediation effect, we constructed a new mediator that captured households with bank accounts, a phone for financial transactions, and mobile money platform use. The results are reported in Table 3. We find a positive and significant mediation effect. The combined use of mobile money and financial literacy mediates 20% of the effect of women on food security. The mediation plot, shown in Figure 4, confirms that the natural indirect effect has a positive, upward slope, greater than the direct and total effects. In addition, since our primary interest was the rural communities in our sample, we ensured that the reduced sample size did not drive our results by estimating additional analyses with the full sample. Compared with our primary estimation (Table 2), we find that the coefficients and significance levels are stable and consistent. In the following sections, we discuss our findings, provide policy recommendations, limitations, and draw conclusions.

Discussion

In this study, we examine how and when women's role in household food security is shaped by mediating and several moderating factors. Our findings reveal a nuanced picture of women's roles in household food security in rural Kenya. On the one hand, households with greater female presence (such as female-headed households) tend to experience lower levels of food security. This result is consistent with evidence that female-headed or women-majority households often face heightened vulnerability. For example, during the COVID-19 shock in Kenya, living in a female-headed household increased the likelihood of adults going without food by about 10% and of children missing meals by 17% (Makate & Makate, 2023). Such disparities are frequently attributed to gender-based inequities in access to resources and opportunities. Women farmers typically have less access to land, credit, and agricultural inputs, resulting in lower farm productivity than men (Anríquez et al., 2024; Njuki et al., 2022; Quisumbing & Pandolfelli, 2010). Consequently, households that rely on women's earnings or farming may be disadvantaged in food production and income, which explains the observed negative association between women's presence and food security. Importantly, this result should not be misinterpreted as indicating that women are "worse" at ensuring food security; instead, it underscores the structural challenges women face. Prior research has shown that when women do have equal access to productive resources, their agricultural yields are as high as men's; closing the gender resource gap could raise women's farm yields by up to 30% and lift 100–150 million people out of hunger globally (Banerjee et al., 2014). Thus, the negative

effect we observed likely reflects persistent gender gaps in assets and support, not any inherent shortcoming of women.

At the same time, our study highlights key pathways through which empowered women enhance food security. We found that households with women present were significantly more likely to be financially literate and to include certain financial practices (e.g., owning a bank account or using mobile money services). This is notable given that, in many African contexts, women historically have lower access to formal financial services (Allen et al., 2016). Kenya, however, has been a leader in financial inclusion, especially via mobile money, and women have been active participants. Research on Kenya's famous M-Pesa mobile money system shows that its expansion substantially benefited female-headed households: nearly 200,000 women moved out of extreme poverty as M-Pesa enabled them to shift from subsistence farming to small business activities (Kiiti, 2019).[2] Financial literacy and inclusion can be transformative for women's economic agency, providing them with tools to save, borrow, receive remittances, and invest in their families' needs. In our results, the mediation effect is evident: women's presence in the household led to better food security outcomes primarily through increased financial literacy. In other words, having women in the family can improve food security if and when those women are financially empowered. This finding aligns with studies linking financial capabilities to improved household welfare. For instance, a recent study in Ghana found a beneficial relationship between financial literacy and food and nutrition security, with financially literate households enjoying more diverse diets and lower food insecurity (Twumasi et al., 2023). Mechanisms for this effect include more effective food budgeting, the ability to smooth consumption during lean seasons through savings or credit, and a greater likelihood of investing in productive assets or purchasing insurance. Our findings underscore the importance of promoting financial literacy and inclusion among women as a crucial pathway to enhancing household food security in rural settings.

Another important insight from our analysis is the role of human and physical capital in moderating food security outcomes. We found that the negative direct effect of women's presence on food security was significantly weakened – and even reversed – when women had higher education or when the household owned land. These positive moderating effects suggest that women's education and land ownership turn what might otherwise be a vulnerability into a household strength. Education is widely recognized as a powerful enabler of better food security and nutrition. An educated woman is more likely to adopt improved agricultural

[2] Study: Use of Mobile Money Lifts Nearly 200,000 Kenyans Out of Poverty (https://www.georgetown.edu/news/study-use-of-mobile-money-lifts-nearly-200000-kenyans-out-of-poverty/#:~:text=Study%3A%20Use%20of%20Mobile%20Money,a%20new%20study%20by)

practices, obtain off-farm income, understand nutritional needs, and make informed financial decisions, all of which contribute to food security. Indeed, women's education correlates strongly with increased household spending on food, healthcare, and children's well-being (Banerjee, 2022; Banerjee, 2014). In our study, households with more educated female members likely reaped these benefits, thereby offsetting any disadvantages associated with gender-based constraints. Land ownership, likewise, is a fundamental asset for rural households. Owning land means access to home-grown food and a form of collateral or wealth. Households with land can produce staple crops or rent out land to generate income, thereby achieving more stable food supplies. Our finding that land ownership improves the food security of households with women aligns with the broader development argument that securing women's property and land rights is vital to food security (Banerjee et al., 2014). In summary, women's human capital (education) and productive assets (land) enhance their capacity to ensure food security, thereby mitigating the challenges that female-headed or female-supported households may face. This underscores that gender is not a standalone determinant of welfare; its impact is conditioned by access to resources and knowledge.

We also explored how these dynamics extend to the link between financial literacy and food security. Interestingly, we found that women's education positively moderates the relationship between financial literacy and food security. In practical terms, financially literate households experience even greater improvements in food security when their female members are well educated. This is intuitive: education enhances one's ability to use financial services and information effectively. A woman with basic literacy and numeracy can keep track of mobile money transactions, understand loan terms, compare prices, or follow agricultural market information delivered via phone. Thus, education amplifies the benefits of financial inclusion – it helps translate access to financial tools into tangible benefits in terms of nutrition and food access. This result finds echoes in cross-country evidence that the impact of financial inclusion on development outcomes is often larger where education levels are higher (Tsongo et al., 2024). It also resonates with qualitative insights that women's financial autonomy is most empowering when combined with knowledge and confidence. Our study provides empirical evidence that education and financial inclusion work in tandem to enhance food security.

Finally, our analysis took into account the broader context by examining *high-endemic* zones and government support. High-endemic zones refer to chronically vulnerable areas – for example, regions with persistent drought, conflict, or poverty where food insecurity is endemic. We anticipated that in such harsh environments, the positive effect of financial literacy on food security might be undermined. Indeed, the coefficient on the interaction between financial

literacy and high-endemic-zone residence was negative (though not statistically significant). The direction of this effect is consistent with the idea that in areas of extreme deprivation or repeated shocks, simply having a bank account or mobile money may not be sufficient to overcome structural food deficits. Households in arid or high-poverty regions face challenges such as crop failure, limited market access, high food prices, and inadequate infrastructure. In these settings, financial services alone cannot fill empty granaries if there is little to buy or if prices are prohibitive. This reminds us that context matters – the efficacy of financial inclusion for improving food security may be contextually limited by factors such as climate and geography.

Notably, we found evidence that government support can mitigate these contextual challenges. A significant three-way interaction indicated that the negative moderating effect of residing in a high-endemic zone was reversed when households received national government support or assistance. In other words, with government intervention, financially literate households in vulnerable regions achieved better food security outcomes (the interaction term indicated a positive, significant effect). This three-way interaction highlights a crucial synergy between public support and private capability. Government assistance – in the form of cash transfer programs, food aid, agricultural subsidies, or other social safety nets – provides an extra cushion that allows households to leverage their financial literacy even under adverse conditions. For example, when cash transfers are paid directly to women's mobile money or bank accounts, they not only inject resources into poor households but also empower women to manage those funds for improved family nutrition (Haushofer & Shapiro, 2016, 2018).[3] Studies have documented that in Kenya, unconditional cash transfers to poor rural households led to higher food consumption and asset investments, with especially strong benefits when women were the recipients of aid (Haushofer & Shapiro, 2016, 2018). Our findings align with this evidence, suggesting that targeted government assistance in chronically food-insecure areas enables financial inclusion initiatives to yield results. Essentially, even if a woman knows how to save or borrow, she may lack anything to save or invest in a drought-prone region – but if the state provides a cash infusion or subsidized inputs, her financial acumen can translate that support into lasting food security gains. This insight reinforces the importance of comprehensive approaches: neither women's empowerment nor safety nets alone is a silver

[3] The Impact of Unconditional Cash Transfers in Kenya (https://poverty-action.org/impact-unconditional-cash-transfers-kenya#:~:text=The%20Impact%20of%20Unconditional%20Cash,recipients%20and%20those%20receiving)

bullet, but together they can create resilient, food-secure households in even the most challenging environments.

Theoretical implications

The results of this study carry several theoretical implications for understanding gender, resources, and household food security. First, our findings support theories of women's empowerment and household bargaining power. The evidence that women's education, financial literacy, and asset ownership all improve food security outcomes is consistent with empowerment frameworks, which posit that increasing women's access to resources and information enhances their agency to positively influence family welfare (Barneeje et al., 2014). Classic intrahousehold bargaining models suggest that when women control a greater share of resources (such as income, land, and financial tools), more household spending is devoted to nutrition, health, and education. Our mediated-moderation results illustrate this: women's presence alone was not enough to ensure food security – it was women's control of financial resources and knowledge that made the difference. This underscores theoretical perspectives that view gender equality in resource access as fundamental to development (Fortmann, 2006; Sarker, 2006; Scott, 2009). It also adds nuance by showing how different forms of capital (financial, human, physical) interact in this process.

Second, our study contributes to the literature by integrating contextual and structural factors (like endemic zone conditions and government support) into the analysis of food security. The significant three-way interaction indicates that macro-level context (environmental vulnerability) and policy interventions jointly moderate micro-level relationships. Theoretically, this aligns with the Sustainable Livelihoods Framework and systems thinking in food security research. The framework emphasizes that outcomes such as food security result from a combination of households' asset endowments, their capabilities, and the external environment (including institutions and shocks). Our empirical evidence concretely demonstrates this interplay: for a household to achieve food security, having female members with education and financial know-how (capabilities/assets) helps, but in high-stress contexts, institutional support (such as government aid) is also needed. Thus, we provide an example of how agency and structure interact to shape development outcomes. This suggests that theories that focus solely on household attributes or broad structural factors are incomplete – a synthesis is necessary.

Third, the findings invite a reconsideration of the role of women in food systems through an intersectional lens. The effect of women in the household on food security was not uniform;

it depended on factors such as education, land ownership, and region. This implies that the category "*women"* is not monolithic in its influence – the outcomes associated with women's roles are conditioned by other dimensions of inequality (education level, wealth, locale). Theoretically, this resonates with intersectionality, which, in a development context, means that policies must recognize that rural, uneducated women with no land face different challenges than educated women landowners, for example. Our study's confirmation of multiple moderating effects supports the idea that empowering women requires addressing multiple, overlapping constraints simultaneously.

Ultimately, our application of a moderated mediation model has theoretical significance for understanding causal mechanisms in poverty and food security research. It demonstrates that mediation (financial literacy as the pathway from women to food security) can itself be contingent on context (e.g., whether the woman is educated or receiving state support). This reinforces a dynamic view of theory – one that appreciates that causal pathways are not static but can be strengthened or weakened by external factors. In sum, the study extends theory by highlighting how gender-driven pathways to food security are enabled or hindered by resources and context, and by providing empirical support to calls for gender-sensitive and holistic models of food security ((Banerjee et al., 2014; Njoroge, 2024).

Policy implications

Our findings provide several actionable implications for policymakers, development practitioners, and stakeholders seeking to enhance food security and gender equality in rural Kenya and similar contexts. Our evidence that financial literacy mediates the positive impact of women on food security suggests that policies should prioritize financial inclusion programs targeting women. This includes expanding access to microfinance, mobile banking, savings groups, and financial literacy training for women in rural areas. Programs like Kenya's mobile money (M-Pesa) have shown success in empowering women financially (Kiiti, 2019; Twumasi et al., 2023). Policymakers should build on this by ensuring women can easily obtain mobile money accounts or bank accounts, and by delivering financial education in local languages. Financial literacy is not just about banking—it directly translates into better nutrition and food security for households (Twumasi et al., 2023). Development partners and local governments could support workshops that teach women budgeting, mobile banking, and basic business skills. Enhancing women's confidence and financial management skills will enable them to purchase food more effectively, save for lean seasons, and invest in farming inputs to improve food availability.

In addition, the significant moderating role of women's education indicates that closing the gender gap in education is crucial for long-term food security. Policies should continue to support girls' education at least through the secondary level, adult literacy programs for women who missed formal schooling, and agricultural extension services tailored to women farmers. When women are educated, they are better able to access and use information (weather forecasts, market prices, nutrition knowledge) that can avert food insecurity. Additionally, vocational training or workshops on improved farming practices and nutrition can leverage women's roles as food producers and caregivers. For instance, agricultural extension officers could be trained to reach out to women's groups and provide lessons on climate-smart agriculture or efficient food storage. Educated and informed women are the first line of defense against household hunger.

Furthermore, since land ownership enhances women's food security, policies that help women gain and secure land are crucial. Governments and NGOs should work to enforce and expand women's legal rights to inherit and own land (as mandated by Kenyan law, but not always realized on the ground). Community sensitization campaigns might be needed to overcome cultural barriers to women owning land. Facilitating women's access to other productive assets, such as livestock, farm equipment, or water for irrigation, can similarly enhance their capacity to ensure food security beyond land. Asset transfer programs or subsidized farm input schemes targeting female farmers could be considered. By increasing women's asset base, policymakers will effectively enable women to convert their effort and knowledge into greater food production and income.

More importantly, the confirmed three-way interaction implies that government support is most needed in high-risk *endemic hunger zones*. Policymakers should design social protection programs that are gender-sensitive and targeted to food-insecure regions (e.g., arid and semi-arid lands of Kenya). For example, cash transfer programs (such as the Hunger Safety Net Program) should continue to prioritize women as recipients, given evidence that cash in women's hands is more likely to be spent on food and children's needs (Haushofer & Shapiro, 2016, 2018). Moreover, linking these transfers to financial inclusion – such as disbursing payments through mobile money – can multiply their impact, as women who receive digital transfers also gain experience with financial services. Our findings suggest that when women in poor regions receive assistance, their financial literacy enables them to maximize the benefits, leading to a sustainable improvement in food security. Therefore, policies that combine short-term relief with long-term financial empowerment will yield the best results. In practice, this could mean providing matching savings contributions or micro-insurance

alongside cash transfers, or pairing public food distributions with training in household financial planning.

Overall, a recurring message is that food security interventions should integrate a gender lens at every step. Governments and development agencies should incorporate components that empower women – whether through financial, educational, or legal rights – into their agriculture and nutrition programs. For instance, a rural development project might simultaneously support women's farmer cooperatives (improving market access), offer workshops in financial management, and involve men and community leaders to champion women's decision-making. The heterogeneity in our results (different effects depending on education, land, and region) also suggests that one-size-fits-all policies will be less effective. Tailoring programs to local contexts is important. In communities with low female literacy, the initial focus might be on basic education and simple savings schemes; in communities where women have education but lack capital, facilitating access to credit and land might be a priority. Policymakers should use local data (perhaps leveraging Kenya's county-level food security monitoring) to identify which constraint is most binding for women in each context and address it accordingly.

By pursuing these policy directions, Kenya's government and its partners can enhance women's capacity to act as change agents for food security. The payoff from such investments is not only increased food availability in the short run, but also inter-generational benefits – children who grow up in food-secure, women-empowered households are likely to be healthier and more productive in the future (Anríquez et al., 2024; Banerjee et al., 2014). These policy measures, therefore, contribute to broader development goals, including poverty reduction, improved nutrition, and gender equality.

Limitations

Like other studies, our findings have limitations that we acknowledge when interpreting the results. First, our data are cross-sectional, capturing a single snapshot in time. However, the survey had several rounds that could also be used to invoke a panel structure. Given that the year is a priority, we have decided to interpret our findings with the cross-sectional nature of the data in mind. This limits our ability to draw causal inferences. While we employed theoretical reasoning to posit mediation and moderation (second-stage) pathways, the observed relationships should not be interpreted as strict causation. For example, it could be that food-secure households enable women to become more financially literate (reverse causality), rather than financial literacy always leading to food security. Longitudinal or panel data would be

valuable in future research to establish the direction of effects and observe dynamics over time. Nonetheless, we have provided a comprehensive study with significant policy implications.

While our women indicator captures eligible women in the household, they were treated in a simplified manner (as the number of eligible adult females), without distinguishing nuances such as women's age, decision-making power, or marital status – all of which could influence food security; however, those indicators were captured as part of the control variables, further strengthening our analyses. Similarly, our financial literacy measure (e.g., having a bank account or phone for mobile money) captures access but not necessarily actual financial knowledge or usage intensity. A household may have a mobile money account but use it minimally; conversely, a financially savvy woman might not have a formal account but skillfully manage informal savings. Future studies could refine these measurements (e.g., using a multi-item financial literacy scale or qualitative assessments of women's household authority) to ensure robust findings.

Furthermore, despite controlling for various factors (such as whether the household is male-headed, household size, health insurance cover, marital status, and county fixed effects), there may be other unobserved variables influencing food security. Cultural norms, intrahousehold power dynamics, or support networks (such as extended family and community groups) could all affect both women's status and food security, but were not explicitly measured in our dataset. Omission of such factors might bias some estimated relationships. For example, more progressive households might both empower women and achieve better food security, creating the appearance of a direct link between women and food security, which is partly due to progressive attitudes. So, caution is warranted in attributing effects solely to the variables we examined.

Our research focuses on rural Kenya, and while many findings may apply to similar developing-country contexts, caution should be exercised when generalizing to urban settings or other countries without validation. Rural Kenya has distinct features – for instance, very high mobile money penetration and certain gender norms – that may differ from those found elsewhere. The "high endemic" zones in our study likely correspond to Kenya's arid counties; in other countries, the nature of food insecurity hotspots might be driven by different factors (conflict, extreme remoteness, and others). Thus, policy implications should be tailored to local conditions. We encourage similar studies in other regions (e.g., West Africa and South Asia) to determine whether these interactive effects are broadly applicable.

While we found several statistically significant moderation effects (women's education, land ownership, government support), one hypothesized moderator – high endemic zone – was

not significant in isolation. One could assume the lack of significance is due to an insufficient sample size or high variance within that subgroup. However, we analyzed the full sample, and our findings remain the same. Indicating that the reduced sample did not drive the results.

Our data on food security likely come from self-reported survey responses. Self-reported data can be affected by recall errors or intentional underreporting/overreporting (possibly due to stigma surrounding food insecurity). If any systematic bias correlates with our key independent variables (for instance, female-headed households might underreport hardship due to social desirability or because women are often more likely to answer surveys), it could affect the results. While we have no evidence of severe bias, it remains a caution in interpreting the exact levels of food security reported. By acknowledging these limitations, we offer a more comprehensive and balanced view of our study. These caveats do not undermine the core insights but suggest that conclusions should be drawn carefully and that further research is needed to deepen and validate our findings. In particular, future research could employ mixed-methods approaches (qualitative interviews with households) to explore the suggested mechanisms, or experimental approaches (e.g., randomized financial literacy training) to test causality. Despite the limitations, we believe the consistency of many results with existing theory and evidence lends credibility to our conclusions.

Conclusion

This study contributes to a deeper understanding of how women's roles and empowerment within rural households influence food security outcomes. In rural Kenya, we found that households with a female head or greater female involvement are more food insecure, reflecting enduring gender gaps in access to resources. Nevertheless, encouragingly, our results also show that women are key to the solution: when women are given the tools – education, financial literacy, land and asset ownership, and supportive policies – they substantially improve household food security. Financial literacy emerged as a vital mediator, indicating that women's financial empowerment translates into better nutrition and food stability for their families (Twumasi et al., 2023). Moreover, the benefits of women's financial inclusion are magnified when women are educated and further amplified by government assistance in challenging environments.

From a theoretical standpoint, the findings reinforce gender empowerment theories and the notion that food security is a multifaceted outcome shaped by the interaction of human, financial, and social capital with structural conditions. From a policy perspective, the message is clear: addressing rural food insecurity in Kenya (and similar contexts) requires gender-

responsive strategies. These include investing in women's education and skills, promoting equal access to financial services, strengthening women's land rights, and deploying safety nets that specifically support and empower women in vulnerable regions. Such interventions can transform the observed negative correlation between women and food security into a positive force for change. Indeed, women – often the primary caregivers and food managers in households – can be the cornerstone of food security if they are empowered with the right resources.

In conclusion, rather than viewing women's greater presence in households as a risk factor for food insecurity, policymakers and practitioners should see it as a call to action—a signal to channel resources and support to households so that women can fully exercise their potential to secure food and nutrition for all. By doing so, rural communities can break the cycle of food insecurity and move toward a future where all members — women, men, and children — are nourished and resilient. The path to zero hunger in such contexts is inextricably linked with the path to gender equality (Anríquez et al., 2024; Banerjee et al., 2014). Our study provides empirical evidence for this linkage, highlights leverage points for interventions, and acknowledges the need for ongoing research. Ultimately, empowering women is not just a matter of social justice but a pragmatic strategy for achieving sustainable food security and broader development goals. Lastly, education should not be treated as a unidimensional variable. Differences in the type, quality, and applicability of education — such as vocational skills, health literacy, or agricultural training—may influence its effectiveness in enhancing food security. Future empirical analyses could consider these nuances while accounting for potential endogeneity and heterogeneity within women-headed households.

Table A1: Full sample analyses

VARIABLES	(Model 1) Food security	(Model 2) Food security	(Model 3) Financial literacy	(Model 4) Food security	(Model 5) Food security	(Model 6) Food security	(Model 7) Food security	(Model 8) Food security	(Model 9) Food security
		H1a, c	**H1b**	**H1d**	**H3a**	**H3b**	**H3c**	**H3d**	
Married	-0.084***	-0.272***	0.012	-0.273***	-0.270***	-0.272***	-0.272***	-0.273***	-0.269***
	(0.016)	(0.017)	(0.024)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Household size (logged)	-0.035***	-0.043***	0.024**	-0.043***	-0.044***	-0.043***	-0.043***	-0.043***	-0.043***
	(0.008)	(0.008)	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Age (household heads)	0.625***	0.561***	-0.504***	0.561***	0.556***	0.562***	0.561***	0.562***	0.558***
	(0.023)	(0.025)	(0.035)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Male (Household heads)	0.099***	0.169***	0.522***	0.170***	0.169***	0.168***	0.169***	0.169***	0.167***
	(0.016)	(0.016)	(0.022)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Health insurance cover	1.775***	1.670***	0.430***	1.669***	1.671***	1.670***	1.670***	1.669***	1.672***
	(0.024)	(0.025)	(0.053)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Electricity	-0.255***	-0.268***	0.739***	-0.268***	-0.268***	-0.268***	-0.268***	-0.268***	-0.268***
	(0.018)	(0.018)	(0.031)	(0.019)	(0.019)	(0.018)	(0.018)	(0.019)	(0.019)
Bank account	-0.093***	-0.144***	1.080***	-0.145***	-0.143***	-0.145***	-0.145***	-0.144***	-0.144***
	(0.017)	(0.017)	(0.030)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Owned agricultural land		0.587***	0.323***	0.587***	0.586***	0.499***	0.587***	0.587***	0.498***
		(0.019)	(0.026)	(0.019)	(0.019)	(0.034)	(0.019)	(0.019)	(0.034)
Women education		1.460***	0.208***	1.232***	1.326***	1.462***	1.461***	1.461***	1.104***
		(0.024)	(0.045)	(0.090)	(0.061)	(0.024)	(0.024)	(0.024)	(0.105)
High endemic zones		-0.726***	-1.735***	-0.728***	-0.725***	-0.723***	-0.652***	-0.738***	-0.665***
		(0.120)	(0.154)	(0.120)	(0.120)	(0.120)	(0.142)	(0.120)	(0.142)
Government support (national)		0.105***	0.089**	0.105***	0.105***	0.106***	0.106***	0.028	0.025
		(0.025)	(0.035)	(0.025)	(0.025)	(0.025)	(0.025)	(0.045)	(0.045)
Financial literacy		***0.110******		0.092***	0.110***	0.111***	0.164***	0.096***	0.132**
		(0.027)		(0.028)	(0.027)	(0.027)	(0.063)	(0.028)	(0.063)
Women (all eligible women in households)		***-0.091******	**0.656***	-0.090***	-0.102***	-0.187***	-0.091***	-0.091***	-0.201***
		(0.018)	**(0.028)**	(0.018)	(0.019)	(0.036)	(0.018)	(0.018)	(0.037)
Women*women education					0.154**				0.161**
					(0.064)				(0.064)
Financial literacy*women education				0.243***					0.234**
				(0.093)					(0.093)
Women*owned agricultural land						0.127***			0.129***
						(0.041)			(0.041)
Financial literacy*endemic zones							-0.091		-0.088
							(0.095)		(0.095)
Financial literacy*endemic zones*government support								0.145**	0.155**
								(0.071)	(0.071)
Constant	-5.939***	-5.719***	3.924***	-5.704***	-5.690***	-5.656***	-5.765***	-5.703***	-5.636***
	(0.161)	(0.189)	(0.203)	(0.189)	(0.189)	(0.190)	(0.194)	(0.189)	(0.196)
County dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	115164	115164	115164	115164	115164	115164	115164	115164	115164
Pseudo R2	0.14	0.176	0.243	0.176	0.176	0.176	0.176	0.176	0.176
Chi2	13719.576	15641.592	16288.635	15642.059	15663.662	15625.729	15640.324	15646.289	15647.488
ll	-58963.492	-56541.535	-32486.406	-56538.267	-56538.67	-56536.907	-56541.078	-56539.416	-56527.984

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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