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WOMEN'S AGENCY AND GENDERED ADOPTION PATTERNS OF CLIMATE-SMART AGRICULTURE IN THE IRISH POTATO VALUE CHAIN OF KURESOI NORTH SUB-COUNTY, KENYA

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Abstract: *This study examines gender dynamics influencing the adoption of Climate-Smart Agriculture (CSA) practices and technologies in the Irish potato value chain of Kuresoi North Sub-County, Nakuru County, Kenya. It challenges the prevailing "time poverty" narrative that attributes women's lower adoption rates to workload burdens and instead investigates the role of women's agency—defined by decision-making authority and control over productive resources. Using a convergent mixed-methods design, data were collected from 197 smallholder potato farmers through structured questionnaires and five key informant interviews. Quantitative analysis using chi-square and t-tests revealed no significant relationship between workload burden and CSA adoption ($\chi^2 = 8.163$, $p = 0.226$), contradicting conventional assumptions. In contrast, household decision-making patterns demonstrated that men made most agricultural and financial decisions (59.9–65.5%), while women primarily adopted labour-intensive practices that required minimal external inputs. Qualitative insights confirmed that limited access to land, credit, and household authority constrained women's capacity to adopt capital-intensive CSA technologies such as improved seed varieties. The findings highlight that structural inequalities, rather than labour demands, shape gendered adoption patterns. The study recommends promoting joint land titling, whole-household extension approaches, and strengthening women's collective financial platforms such as Village Savings and Loan Associations (VSLAs). Addressing these agency-related constraints is essential to enhance equitable CSA adoption and ensure gender-responsive agricultural transformation.*

Keywords: *Gender analysis, Women's agency, Climate-smart agriculture, Adoption, Irish potato value chain*

1. Introduction

The world food system is facing immense strain brought about by the rapid population growth, projected to reach around 9.3 billion by 2050, and the worsening impacts of climate change (Rahman, 2016). These dual pressures have led to unprecedented demands on agricultural productivity in an era when there is a massive increase in vulnerability of traditional farming systems (Arora, 2019). Climate change poses a considerable risk to food security in Low and middle-income countries (LMICs) and fragile contexts (IPCC, 2022). The negative impacts span beyond production to other aspects of the food system, along the agri-food value chains

from production to consumption, the food environments in which people live, and outcomes such as diets and livelihoods (Fanzo et al., 2018). Climate change threatens food and nutrition and nutrition on security, compounding multiple threats already faced by marginalised members of communities in LMICs (Gichuki, Gicheha & Wambu, 2020). In response to this challenge, countries all over the world have been championing a framework known as Climate-Smart Agriculture (CSA), formulated to achieve a "triple win" of increasing productivity sustainably, enhancing adaptation and resilience, and reducing greenhouse emissions where feasible (Born, 2021). In this transition to a new dispensation in agriculture, smallholder farmers play a critical role do to their significant contribution to the global food basket. Governments and institutions globally have made great efforts to scale up CSA, but the adoption of these critical practices, nonetheless, has been abysmally low and unbalanced across different farming populations (Makate, 2019). This gap in adoption is not simply a technical issue, but a matter that is deeply woven into the socio-economic and cultural contexts in which different populations of farmers operate. Therefore, an essential need for understanding the specific and localised hurdles that impede the global uptake of these practices arises because of the grave importance of attaining climate-resilient global food systems. This is a challenge that requires moving beyond techno-centric models of innovation diffusion (Long *et al*, 2015).

Sub-Saharan Africa (SSA) is the most acutely affected region by these challenges, as compared to the rest of the world and has also been identified as the hotspot for climate variability (Jayne *et al*., 2021). The region heavily relies on rain-fed agriculture and smallholder agriculture, resulting in a highly susceptible food system to the impacts of climate change, such as rainfall and prolonged droughts. To make matters even worse, this region has a compounding issue of the gender productivity gap that is deep-seated and well-documented. Research in this region shows that there is a huge productivity discrepancy between female- and male-managed farmers, where male-managed farmers tend to produce more than female-managed ones (Doss, 2018; Rodgers & Akram-Lodhi, 2019). In the development discourse, a dominant narrative has often been put forth to explain the possible reason behind this gap. The lower outcome observed in female farmers or women in agriculture has been linked to their high workload and "time poverty" (Marter-Kenyon *et al*., 2023). The same reasons have been implied to affect even the level of adoption of new technologies among women. Despite the undeniable presence of a heavy and unfair labour burden on women in the region, a mounting body of evidence implies that this focus may be improper. Recent studies argue that the variation in effort based on gender might not be the primary factor driving the productivity gap, but instead, structural inequality, such as in access to and control of primary capital used in farming, like land and input resources (Buehren, 2023). This combination of multiple factors contributes to the low overall CSA adoption rate across SSA (Autio *et al*. 2021) and necessitates a localised empirical investigation to lay bare the reality of the whole phenomenon.

This paper focuses this investigation on Kenya, a country where the agricultural sector contributes 25% of its GDP, yet faces with adverse effects of climate variability (Nyika, 2022). The study focuses on the Irish potato value chain in Kuresoi North Sub-county, which plays a critical role in the national food security and smallholder farmers' income and has seen its productivity decline due to the effects of climate change (Waaswa *et al*., 2022). At the national level, Kenya mirrors the SSA issues of low CSA adoption and gender inequality in the agricultural sector, but the specific factors at the household level that fuel these issues are still not adequately understood. This study addresses this gap using a convergent mixed-methods design that brings together a quantitative survey of 197 farmers and key informant interviews (KIIs) with five informants. Using the theoretical lenses of the Diffusion of Innovation (DOI) theory and Liberal Feminist Theory, this study empirically tests the "time poverty" narrative. This paper argues that women's agency, which is defined by their decision-making authority and control over productive resources, is a greater determinant of CSA

adoption patterns than their measured workload burden. With the aid of statistical evidence and in-depth qualitative insights, this paper aims to reconceptualise the key gender barriers to the adoption of CSA in rural Kenya. According to the World Economic Forum's Global Gender Gap Report, the global gender parity score is 68.5% (WEF, 2024). The Sub-Saharan Africa region has also advanced in terms of closing the gender gap, with a gender parity score of 68.4%, a 5.6 percentage points increase from 2006. Kenya, on the other hand, has closed 71.2% of its gender gap, which is a 0.4% improvement from 2023 (WEF, 2023) and a 6.3% improvement from 2006 (WEF, 2006). This has been supported by the current Constitution (Republic of Kenya, 2010) that safeguards women's empowerment and places great emphasis on gender equality since it is crucial for the realization of the national development goals (KNBS,2020). Despite the various remarkable legislative frameworks that have been implemented in Kenya, the country has not been able to achieve gender parity in the social, economic and political spheres (KNBS2020). These gaps in implementation relate to certain customary, traditional or religious practices that discriminate against women, underscoring the need to extend beyond the amendments of legal provisions and texts (Morsy & Youssef, 2017).

2. Problem Statement

Sub-Saharan Africa suffers disproportionately from the effects of climate change, and this has led to a decline in the growth of farm productivity and more crop production failures. This has resulted in severely impacted households of smallholder farmers in terms of their income and food, and has additionally worsened the gender productivity gaps that already exist due to the deep-rooted inequalities in access and control over productive and financial resources (Rodgers & Akram-Lodhi, 2019). Despite having CSA as a solution to the productivity crisis, the level of adoption of this critical farming practice, which could ensure the sustainability of agricultural endeavours, has been low, indicating the presence of a more serious underlying issue that could be undermining these efforts. High workload and "time poverty" are some of the fundamental issues that have been pointed out by development literature, which are primarily causing challenges with the adoption of new technologies (Marter-Kenyon *et al*., 2023). Nonetheless, the focus on these two factors might conceal the structural barriers related to household power, such as the decision-making authority and asset control that seem to be more influential in this discourse. It goes without saying that when it comes to labour, there is a serious gender division, but a significant research gap exists in empirically testing and establishing whether workload is the binding constraint on CSA adoption, or is it a symptom of an even bigger issue of agency. This study sought to uncover this matter using a mixed-method research design, where data from farmers and insights from key informants in the Irish potato value chain in Kuresoi North Sub-County, Kenya, were used to statistically establish how access and control over resources affect the adoption of CSA.

3. Objective

The objective of this study was to determine the extent to which gender workload affects the adoption of climate-smart agriculture practices on Irish potato in Kuresoi North Sub-County, Nakuru County, Kenya.

4. Literature Review

Climate-smart agriculture presents the opportunity to meet the world's food demands in the face of climate variability (Totin et al., 2018). The triple win effect of CSA, which are (i) increased productivity (ii) mitigation, and (iii) adaptation, are seen as the practical solution to climate change (FAO, 2010). These initiatives are more responsive to the achievement of Sustainable Development Goals (SDGs) 2 and SDG 13 that aim at increasing productivity by adapting to climate change (Rosa, 2017). Several CSA practices have been developed globally

and among these include irrigation, deep-ploughing, crop rotation, mixed cropping, terracing, mulching, zero or minimum tillage and cover crops (Cramer et al., 2017; Imran et al., 2018; Lan et al., 2018; Zahra et al., 2019). The effect of gender on power in the agricultural sector is evidenced where women account for between 40% to 65% of the time spent producing and processing agricultural products (Sabo, 2006). The effect of gender on resources is also evident in the ability of male farmers to obtain more credit, use advanced technologies, and access agricultural extension services compared to female-managed farms (Thapa, 2008). Over 70% of women are involved in agricultural activities such as livestock rearing and cultivating commercial or subsistence crops (Kiriti & Tisdell, 2003). Despite their leading role in agriculture, female farmers display lower agricultural productivity levels than their male counterparts (Osuafor & Anarah, 2015). Gender division in agricultural activities exists in most Sub-Saharan African locations and is based on tasks, crops, or both (McPeak & Doss, 2006). Males dominate export and commercial crops because men are the primary breadwinners of most families, while women cultivate subsistence crops (Njuki et al., 2011). These arguments indicate that gender can be a complex feature in agriculture and relies on the prevailing socio-cultural setting. The dynamic nature of gender relations indicates that these relations can change to respond to innovation and commercialization (Ibnouf 2011; Sorensen, 1996) activities that may affect productivity.

Various agricultural studies that have been conducted regarding gender have consistently revealed a pattern where men and women adopt different technologies (Aduwo *et al*., 2019). This trend is normally observed even in instances where the overall adoption rate may seem to be similar (Doss, 2018). This has been characterised as men and women adopting different "portfolios" of technologies that show the difference in their control over assets and capital (Teklewold, 2023). Boudalia *et al*. (2024), in their review, found a clear and widespread pattern in the technologies used by the different genders, where men were more likely to use capital-intensive technologies, while women leaned towards labour-intensive practices. This pattern is directly linked to the power dynamics at the household level. Research confirms that men are, in most cases, in charge of major household financial decisions, and this gives them the authority and ability to invest in capital-intensive technologies (Langyintuo, 2020). This is a trend that has been confirmed to be present even in the Kenyan household, with additional revelation that even in jointly managed plots, men still maintain a higher control over financial choices, especially input purchases (Voss *et al*., 2024). This situation is aggravated by the little power that women have over farm financial resources, making it challenging for them to invest in new technologies that might help their farming endeavours (Rodgers, & Akram-Lodhi, 2019).

Kenya has responded to the global call to mitigate and adapt to climate change effects by launching a CSA strategy; which was designed as part of its development programmes that seek to achieve food security and sustainable development at the same time (GoK, 2017). Agroforestry, the use of bunds, water harvesting, composting, improved high yielding varieties, among others, have been developed as CSA technologies (Bernier et al., 2015). Nakuru County's plan to increase potato yields to 15 tons/ ha by 2022 opted for agroforestry, water harvesting, and planting of the short cycle and drought-tolerant potato varieties as significant CSA practices to achieve the desired future (GoK, 2018). Additionally, stakeholders working in the potato sector have come up and recommended several CSA practices with the aim of adapting potato production to the effects of climate change in Nakuru and elsewhere in the World. For example, use of potato apical rooted cuttings, irrigation, use of improved varieties among others (Kibe et al., 2019; Parker et al., 2019). However, studies by Leal Filho et al. (2015) and Nyasimi et al. (2017) give an overview of the bottlenecks that continue to hinder the registration of the expected success. These unveil that a gap still exists between full understanding the extent to which gender workload affects the adoption of climate-smart agriculture practices on Irish potato in Nakuru County, Kenya.

Theoretical Framework

This study was informed by two theoretical lenses. The first one was the diffusion of innovation (DOI) theory, which offered a framework for understanding the process of adopting technology, and Liberal Feminist Theory, which provided lenses for analysing the gendered power structures that mediate these processes.

Diffusion of Innovation (DOI) Theory

The Diffusion of Innovation (DOI) Theory was developed by E.M. Rogers, and it explains the process of adoption of new technology in a social system in a typical fashion that progresses through the stages of knowledge, persuasion, decision, implementation and confirmation (Manzano & Pérez, 2023). According to the theory, the communication channel and the nature of innovation have a significant influence on the rate of adoption of an innovation. In addition, the theory points out that "receiver variables" such as personal and social traits influence the proclivity to adopt a new idea for an individual (Alsheddi *et al.*, 2020). Nonetheless, in smallholder agricultural contexts in Sub-Saharan Africa, the adopter is not an individual, but a household unit that is battling dicey internal power imbalances and resource competition. This study uses the lenses of DOI as a starting point, but seeks to reevaluate it by regarding gendered power relations, especially in decision-making and control over productive assets, as critical "receiver variables." These structural variables are hypothesised to have more weight than individual attributes in determining whether the diffusion process can proceed to completion. This approach comes from the same school of thought that critiques the purely techno-centric adoption models that normally do not account for the social systems in which they are embedded (Palm, 2022).

Liberal Feminist Theory

Liberal feminism theory is a feminist theory that emphasises the importance of equality between men and women and advocates for a fair society for both genders (Johnson, 1991). In this paper, this theory provides an outline for understanding the structural inequalities that shape the process provided by the DOI theory. According to Liberal Feminist Theory, the subordination of women

is not a product of biological or innate differences from men, but a result of factors such as norms, social structures and lack of equal opportunities (Beddoes & Borrego, 2011). The theory champions equal rights and criticises systems that deny women agency and autonomy in economic and political spheres (Marilley, 1996). This theory is highly relevant to this study as it offers a lens through which the gender productivity gap in agriculture can be analysed. Moreover, the theory lays more emphasis on the "gendered norms" that define the division of labour (McClain & Hacker, 2021), coupled with institutional and cultural barriers that restrain women's control over resources and their ability to make independent economic decisions. Through the analysis of variables such as ownership of land, access to credit, ability to make decisions and control over other farm resources, this study applies the liberal feminist framework to interpret the role gender plays in shaping the challenges faced by farmers in Kuresoi North, specifically for women. This is not meant to indicate personal failings, but an outcome of a deep-seated social system that limits their opportunities and agency (Kabeer, 2021).

5. Methodology

This study used a convergent mixed-methods research design, which brought together quantitative and qualitative data to create an empirical understanding of the relationship between workload, agency and CSA

adoption among potato farmers in Kuresoi North Sub-County, Kenya. This subcounty was selected because of its strategic importance to the national potato value chain, and the exposure of the farmers in the area to CSA practices that have been promoted in the area by the national government through the Kenya Climate-Smart Agriculture Project.

The target population of the study was the smallholder Irish potato farmers in the four administrative wards in the subcounty, which include Kamara, Sirikwa, Nyota and Kiptororo. Using a sampling frame of 45,141 houses that have been registered as smaller holder farmers with farmer-based organisations or cooperative groups, a sample of 200 respondents was calculated.

Stratified random sampling was used to sample the farmers to ensure proportional gender representation, and the study ended up with 197 farmers (113 males and 84 females), resulting in a 98.5% response rate. Additionally, five key informants were selected purposively based on their expert knowledge and diverse roles that they play within the potato value chain of the area.

A structured questionnaire and a semi-structured interview guide were used to collect data from the smallholder farmers and KIIs, respectively. The structured questionnaire was pre-tested with 20 farmers in Kuresoi South, the neighbouring subcounty, and using the reliability test of Cronbach's alpha, the tool was refined to improve its clarity and reliability.

Ethical standards were strictly adhered to throughout the study. An authorisation letter for conducting the research from the Egerton University Ethical Committee, and a research permit from the National Commission for Science, Technology & Innovation (NACOSTI) were obtained before the commencement of the study. Respondents were recruited into the study after consenting to take part in it, and their data were anonymised to ensure their privacy and confidentiality were protected. No identifying information was collected from the respondents, and their participation was purely voluntary, with the freedom to drop out of it at any point.

The analysis of the collected data was done in two different ways for the quantitative and qualitative data. The Statistical Package for Social Science (SPSS) was used to analyse the qualitative data, generating both descriptive and inferential statistics. For the descriptive statistics, frequency and percentage tables were created, and for the inferential statistics, t-test and chi-square statistics were computed. The inferential statistics were generated to compare the overall CSA adoption score by gender and the statistical significance of the association between gender and workload and CSA adoption categories. The effect size of these tests was measured using Cramer's V. On the other hand, the qualitative data were analysed using a thematic analysis approach, where recurring patterns and insights were identified and classified into coherent themes that aligned with the study objective. Afterwards, integration and triangulation of both the quantitative and qualitative results were done to come up with a detailed and evidence-based interpretation of the gender dynamics of CSA adoption.

6. Results and Discussions

Demographic Characteristics and CSA Awareness

The study achieved a 98.5% response rate, which was higher than the typical response rate of 70% in agricultural surveys (Weber & Clay, 2013). The characteristics of the sample in this study demonstrated a pattern consistent with what has been observed and documented in various smallholder farming populations across Sub-Saharan Africa. The gender distribution of 57.4% male and 42.6% female respondents mirrors the

leadership pattern reported by Doss (2018) across six African countries, where male-headed households make up between 60% and 70% of the farming households. The level of educational attainment in the sample included a majority of the respondents (77%) having secondary or higher education, which is relatively higher than the regional average (45%) as reported by Meinzen-Dick *et al*. (2019). This indicates a higher educational investment in Kenya, leading to a more educated population of smallholder farmers from which the study sample was taken.

Table 1: Demographic Characteristics of Study Participants

Characteristic	Male (n=113)	Female (n=84)	Total (n=197)
Age Group			
18-27 years	16 (14.2%)	10 (11.9%)	26 (13.2%)
28-37 years	29 (25.7%)	23 (27.4%)	52 (26.4%)
38-47 years	36 (31.9%)	26 (31.0%)	62 (31.5%)
48-57 years	23 (20.4%)	21 (25.0%)	44 (22.3%)
>58 years	9 (8.0%)	4 (4.8%)	13 (6.6%)
Marital Status			
Married	96 (85.0%)	47 (56.0%)	143 (72.6%)
Not Married	17 (15.0%)	37 (44.0%)	54 (27.4%)
Education Level			
No formal	7 (6.2%)	4 (4.8%)	11 (5.6%)
Primary	19 (16.8%)	15 (17.9%)	34 (17.3%)
Secondary	42 (37.2%)	33 (39.3%)	75 (38.1%)
Tertiary/University	45 (39.8%)	32 (38.1%)	77 (39.1%)
Group Membership			
Yes	83 (73.5%)	59 (70.2%)	142 (72.1%)
No	30 (26.5%)	25 (29.8%)	55 (27.9%)

Nearly all the farmers (96%-100%) indicated having an awareness of at least one CSA practice, which was higher on average than the 71%-99% reported in Uganda (Aturihaihi *et al*., 2023). Nonetheless, the adoption rates were highly variable, with soil conservation having the lowest adoption of 75% and water management having eh highest (93.4%), exposing an awareness-adoption gap of 18.3 percentage points on average. Gender and practice type made this gap wider, acknowledging Glovers *et al*.'s (2019) claim that the technology transfer model basically misunderstands adoption by believing knowledge automatically transfers to practice.

Land holdings showed typical smallholder patterns, with 87.9% operating medium-sized farms of 3-5 acres, though potato cultivation intensity varied significantly. The majority (55.8%) cultivated potatoes on less than one acre, reflecting the crop's high value but also intensive labor and input requirements. Farmer group membership reached 72.1%, substantially exceeding the 35% East African average reported by Liverpool-Tasie et al. (2020), with no significant gender difference (χ^2=0.82, p=0.365). This equal formal participation contrasts sharply with findings from Ethiopia and Tanzania where women's group membership lags men's by 20-30 percentage points (Meier zu Selhausen, 2016), suggesting formal organizational barriers may be less pronounced in Kuresoi North.

Table 2: CSA Practice Awareness and Adoption Rates by Gender]

CSA Practice	Awareness (%)		Adoption (%)		χ^2
	Male	Female	Male	Female	p-value
Improve Potato Varieties	98.2	94.0	92.0	73.8	0.001
Crop Rotation	100.0	100.0	93.8	90.5	0.549
Intercropping	100.0	100.0	85.0	84.5	1.000
Soil Conservation	100.0	96.4	77.9	71.4	0.385
Organic Manure/Compost	99.1	98.8	83.2	77.4	0.402
Water management	99.1	100.0	89.4	98.8	0.019
Weather Forecasting	99.1	100.0	88.5	89.3	1.000

Awareness of CSA practices approached saturation at 96-100%, dramatically exceeding the 40-60% reported in similar studies from Uganda (Shikuku *et al*., 2017) and Ethiopia (Teklu et al., 2024). This heightened awareness stems from farmers' direct experience with climate impacts, with 99% reporting observable weather changes, including erratic rainfall, prolonged droughts, and increased disease pressure. As one lead farmer articulated: "We used to rely on consistent rains during planting seasons, but now farmers experience either too much rain, causing rotting, or prolonged dry spells that stress the crops."

However, high awareness did not translate uniformly into adoption. Overall adoption rates varied from 75.1% for soil conservation to 93.4% for water management, revealing an awareness-adoption gap averaging 18.3 percentage points. This persistent gap across diverse practices supports Glover *et al*.'s (2019) critique that technology transfer models fundamentally misunderstand adoption by assuming knowledge automatically leads to practice.

Most critically, while overall adoption levels showed no significant gender difference (males: 87.1%, females: 83.7%; t=1.233, p=0.219, Cohen's d=0.184), this aggregate similarity masked fundamental differences in practice selection. Men's adoption of improved potato varieties significantly exceeded women's (92% vs. 73.8%; χ^2=10.74, p=0.001, Cramér's V=0.233), while women demonstrated higher water management adoption (98.8% vs. 89.4%; Fisher's exact test p=0.019). This pattern, similar overall rates but divergent practice portfolios, sets up our central inquiry, which is to establish what drives these gendered technology choices.

Testing the Workload Hypothesis

Development discourse has persistently attributed women's lower technology adoption to "time poverty", the assumption that their triple burden of productive, reproductive, and community work leaves insufficient time for agricultural innovation. This narrative has driven substantial investments in labour-saving technologies across Africa. Our data initially appear to support gendered work patterns consistent with this conventional explanation.

Table 3: Task Allocation and Workload Distribution by Gender

Task	Male	Female	Joint	Workload Pattern
Land preparation	123 (62.4%)	16 (8.1%)	74 (37.6%)	Male-intensive
Planting	76 (38.6%)	36 (18.3%)	121 (61.4%)	Shared labor
Weeding	78 (39.6%)	40 (20.3%)	119 (60.4%)	Shared labor
Fertilizer application	87 (44.2%)	37 (18.8%)	110 (55.8%)	Shared labor
Pest control	146 (74.1%)	14 (7.1%)	51 (25.9%)	Male-intensive
Harvesting	71 (36%)	29 (14.7%)	126 (64%)	Shared labor
Post-harvest processing	79 (40.1%)	37 (18.8%)	118 (59.9%)	Shared labor
Transportation	161 (81.7%)	20 (10.2%)	36 (18.3%)	Male-intensive
Marketing	145 (73.6%)	56 (28.4%)	52 (26.4%)	Male-intensive

Task allocation revealed deeply entrenched gender patterns. Male-intensive activities clustered around tasks requiring capital, equipment, or external engagement: transportation (81.7% male), pest control (74.1%), marketing (73.6%), and land preparation (62.4%). Women's highest sole participation occurred in marketing at only 28.4%, still substantially below male dominance. Notably, no single task emerged as female-intensive. Instead, women's agricultural contributions concentrated in shared activities, harvesting (64% joint), planting (61.4%), weeding (60.4%), and post-harvest processing (59.9%), suggesting their labour is embedded in collaborative household production rather than independent domains.

Quantifying workload burden revealed paradoxical patterns that challenge simplistic narratives. Male respondents reported mean individual workload scores (46.1, SD=18.3) nearly double those of females (23.9, SD=15.7; $t=9.23$, $p<0.001$), with 24.8% of men versus 14.3% of women classified as "high burden" based on performing ≥70% of tasks individually. This seemingly contradicts extensive time-use literature showing women work longer total hours when domestic responsibilities are included (Komatsu et al., 2018). However, as Blackden and Wodon (2006) argue in their seminal work, the binding constraint isn't total hours worked but rather autonomy over time allocation, women's work is more fragmented, less flexible, and constrained by simultaneous responsibilities.

Table 4: Workload Burden and CSA Adoption

Workload Burden	N	Mean CSA Adoption	Range
		86.3% (±18.31)	
High burden (≥70% individual tasks)	4172		14.3-100%
Moderate burden (40-69% individual)	3553	86.3% (±18.29)	14.3-100%
Low burden (<40% individual)	12101	85.6% (±18.87)	14.3-100%

Despite these clear gendered work patterns, testing the workload hypothesis yielded surprising results that fundamentally challenge the time poverty narrative. The Chi-square test revealed no significant association between workload burden categories and CSA adoption levels ($\chi^2=8.163$, $p=0.226$). The correlation between individual workload scores and adoption was negligible ($r=0.027$, 95% CI: 0.013-0.041), providing no evidence for a meaningful linear relationship. Remarkably, farmers with high workload burdens showed identical adoption rates (86.3%) to those with moderate burdens, while low-burden farmers had marginally lower adoption (85.6%).

This finding directly contradicts earlier influential studies. Bernier et al. (2015) reported significant negative correlations between women's labour burden and technology adoption in Senegal, while Ndiritu et al. (2014) found similar patterns in Kenya using less rigorous analytical approaches. However, our results strongly align with recent sophisticated analyses employing better identification strategies. Chimoto and Grootaert's (2023) panel data analysis from Tanzania found that when controlling for resource access and decision-making power, the workload effect became statistically insignificant. Similarly, Van Campenhout *et al.*'s (2021) randomized controlled trial in Uganda found that providing labour-saving tools did not increase adoption of other agricultural practices unless combined with interventions addressing decision-making constraints.

Key informants unanimously dismissed workload as the primary adoption barrier, providing powerful explanations for our statistical findings. Jennifer Rono, the potato value chain trainer, explained: "Even if women attend training and learn, they don't have the capacity or the authority to make such decisions. So adoption goes down." Daniel Kamiti, a lead farmer, offered particularly revealing insight into household dynamics: "It has made adoption go slow because the woman, seeing that perhaps the work she is doing does not benefit the family, she still becomes lazy in that work." This frames the issue not as time shortage but as rational economic response to lacking control over the benefits of one's labor, a fundamentally different problem requiring fundamentally different solutions.

Agency as the Determining Factor: Unveiling Structural Reality

If workload doesn't explain gendered adoption patterns, what does? Our analysis points decisively to agency, operationalised as decision-making authority and control over productive resources, as the binding constraint shaping women's agricultural innovation capacity.

Table 5: Household Decision-Making Patterns

	Who Makes the Final Decision					
	Male		Female		Joint	
Decision	n	%	n	%	n	%
Which potato variety to plant	118	59.9	36	118.3	79	40.1
How much land to use for potatoes	123	62.4	33	16.8	74	37.6
To buy inputs (seeds, fertilisers)	129	65.5	26	13.2	68	34.5
To adopt new farming technology	122	61.9	42	21.3	75	38.1
When and where to sell potatoes	116	58.9	36	18.3	81	41.1
How to use income from potato sales	108	54.8	37	18.8	89	45.2

The data reveals male dominance across all agricultural decision domains, with particularly pronounced control over financially-oriented choices. Men made sole decisions about input purchases in 65.5% of households versus only 13.2% for women, technology adoption (61.9% vs. 21.3%), and land allocation (62.4% vs. 16.8%). Even decisions about income utilisation, where women's labour contributes substantially to production, remained under male control in 54.8% of households, with only 18.8% under women's sole authority. Joint decision-making was highest for income use (45.2%) and marketing timing (41.1%), suggesting some consultation occurs for market-related decisions while production decisions remain firmly male-dominated.

This pattern precisely mirrors Anderson et al.'s (2021) comprehensive meta-analysis of 38 studies across Sub-Saharan Africa, which found male-only decision-making in 60-75% of households for production decisions

and female-only decision-making rarely exceeding 20% for any agricultural choice. The consistency across contexts suggests deeply embedded structural patterns rather than location-specific anomalies.

The mechanism linking decision-making authority to technology choice emerged powerfully through qualitative insights. Paul Kariuki, a lead farmer with decades of experience, explicitly stated: "Male farmers tend to invest more in capital-intensive practices like purchasing certified seeds. Women struggle to access these due to limited control over household finances." Ruth Kabiru, Director of the local AgriHub, was even more direct when asked about capital-intensive technology adoption: "It's men. It's men." Daniel Kamiti illustrated the household dynamic succinctly: "The woman brings a proposal, but the decision comes from the man."

This decision-making structure directly explains the gendered technology portfolios observed in our quantitative data. Men's control over financial decisions enables the adoption of improved potato varieties requiring upfront cash investment averaging 15,000 Kenyan shillings per acre. Conversely, women adopt water management practices like mulching and water harvesting that require primarily their own labour, essentially the only resource they control autonomously. This creates what Acosta et al. (2020) term "responsibility without authority", women bear responsibility for household food security but lack authority over resources needed to fulfil this responsibility effectively.

7. Conclusions

This study set out to examine whether women's adoption of climate-smart agriculture practices in Kenya's Irish potato value chain is primarily constrained by workload burden or by limited agency. Through mixed-methods analysis of 197 farmers in Kuresoi North Sub-County, the evidence decisively demonstrates that agency, defined as decision-making authority and control over productive resources, rather than time poverty, shapes women's agricultural innovation capacity.

The findings reveal a critical paradox: while women and men show similar overall CSA adoption rates (83.7% and 87.1% respectively), they adopt fundamentally different technology portfolios. Men concentrate on capital-intensive practices like improved potato varieties (92% adoption), while women focus on labour-intensive practices like water management (98.8% adoption). This divergence cannot be explained by workload differences. Despite a clear gendered division of labour, no significant relationship emerged between workload burden and CSA adoption (χ^2=8.163, p=0.226). Farmers with high workload burdens showed identical adoption rates to those with moderate burdens, definitively challenging the time poverty narrative that has dominated development discourse for decades.

Instead, the evidence points to structural constraints rooted in patriarchal household dynamics. Men control key agricultural decisions in the majority of households, particularly input purchases (65.5%) and technology adoption (61.9%). Even income from potato sales, where women's labour contributes substantially, remains under male control in 54.8% of households. This decision-making structure is underpinned by unequal resource control, particularly land ownership, which serves as collateral for formal credit. The resulting pathway, from land rights through credit access to technology adoption, creates an inexorable sequence that determines what innovations women can adopt regardless of their knowledge, willingness, or available time.

The theoretical implications are profound. These findings demonstrate that Rogers' Diffusion of Innovation model fails in contexts where adopters lack autonomy within household political economies. Women may complete awareness and persuasion stages but remain perpetually stalled at the decision stage without requisite

authority. This validates Liberal Feminist Theory's emphasis on structural inequalities over individual constraints, while revealing how women exercise agency within these constraints through collective action and strategic technology choices.

The study's most significant contribution lies in empirically disproving the assumption that reducing women's workload will automatically enhance their capacity for agricultural innovation. This challenges fundamental premises underlying numerous development interventions and suggests that resources directed toward labour-saving technologies may be misdirected if not accompanied by efforts to transform household power dynamics. The success of interventions like Village Savings and Loan Associations and whole-household extension approaches demonstrates that effective strategies must address agency constraints rather than simply attempting to create more time.

8. Recommendations

Based on these findings, several critical interventions are needed to address the structural barriers limiting women's adoption of climate-smart agriculture in Kenya's potato value chain. The Ministry of Lands should prioritize joint land titling initiatives that ensure both spouses are registered as co-owners, accompanied by public awareness campaigns through chiefs' barazas and community meetings to educate couples on the economic benefits of joint ownership for household credit access and agricultural productivity. Administrative procedures should be simplified and subsidized to encourage voluntary joint registration, while the Central Bank of Kenya, in collaboration with financial institutions, should develop guidelines for alternative collateral mechanisms that don't disadvantage women, including group-based lending, savings history, and movable asset collateral formalized through policy support.

National and county governments must mandate that all agricultural programs receiving public funding demonstrate how they address household decision-making dynamics beyond simply including women as participants, with performance indicators moving from counting female beneficiaries to measuring changes in women's decision-making authority over agricultural resources. Extension services should redesign their delivery models to require participation of both spouses in training programs, explicitly inviting couples rather than targeting "household heads," scheduling sessions at mutually convenient times, and including modules on joint planning and decision-making alongside technical content. Training curricula must incorporate gender-transformative content that explicitly addresses household negotiation and communication skills, using local success stories and role models to challenge traditional norms, while specific efforts should target men as allies in women's agricultural empowerment through peer networks of male champions who practice equitable household decision-making.

Development organizations and NGOs should prioritize strengthening women's groups and Village Savings and Loan Associations as platforms for collective bargaining and alternative credit access, supporting these groups not just for savings but as mechanisms for bulk input purchase, knowledge sharing, and market negotiation. Programming focus must shift from providing labor-saving technologies to addressing underlying power imbalances, conducting household-level gender analyses before designing interventions to understand local decision-making patterns and resource control dynamics rather than making assumptions about time poverty without empirical verification. Research institutions should invest in longitudinal studies tracking how changes in women's agency affect technology adoption over time to establish causal relationships beyond current correlational evidence, while developing and validating standardized tools for measuring intra-

household decision-making and resource control that enable better comparison and meta-analysis across studies.

The private sector must develop gender-responsive marketing strategies that recognize women as agricultural decision-makers rather than just laborers, including packaging inputs in smaller, affordable quantities and creating payment plans aligned with women's income streams, while establishing formal partnerships with women's agricultural groups for input distribution as legitimate market actors. The interconnected nature of these recommendations requires coordinated action, with three interventions prioritized for immediate implementation: joint land titling initiatives that address the foundational constraint, whole-household extension approaches that can be implemented within existing programs, and strengthening VSLAs that have demonstrated effectiveness and can be rapidly scaled. Success requires recognizing that transforming gender relations in agriculture is not about helping women cope better within existing constraints but about fundamentally restructuring those constraints, as the evidence clearly shows that women do not need more time but more power, necessitating agricultural development interventions to evolve from technical fixes to structural transformation to achieve equitable and sustainable impact.

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