American Journal of
Environment Studies
(AJES)

Enhancing Climate-Smart Agriculture: The Role of Farm Input Accessibility in Selected Smallholder Enterprises in Lamu County, Kenya

Walter Jabali Jilani, Prof. Annie Hilda Ong'ayo, Dr. Andrew W. Wamukota

AJPO

American Journal of Environment Studies
ISSN 2790-5594 (Online)
Vol.8, Issue 1, pp 1 - 20, 2025
www.ajpojournals.org

Enhancing Climate-Smart Agriculture: The Role of Farm Input Accessibility in Selected Smallholder Enterprises in Lamu County, Kenya

Walter Jabali Jilani[1*], Prof. Annie Hilda Ong'ayo[2], Dr. Andrew W. Wamukota[2]
[1]*Walter Jabali Jilani, Department of Community Development, Pwani University, Kenya.
[1]Department of Environmental Studies (Community Development), Pwani University.

Article history
Submitted 07.02.2025 Revised Version Received 05.03.2025 Accepted 03.04.2025

Abstract

Purpose: To investigate access to different farm input and Climate-Smart Agriculture technology adoption across various agricultural value chains.

Materials and Methods: Key informant interviews, focus group discussions, and a semi-structured questionnaire were used to collect the data from 304 participants who included Lead farmers, extension officers and Smallholders farmers. The data collection exercise was carried from august to October 2022. Analysis was done using R software (v4.4.1).

Findings: High adoption rates of improved breeds across value chains: cotton (96.4%), dairy (88.4%), cashew (74.3%), and poultry (64.6%). Direct purchase was the main predominant input acquisition method, particularly among cotton (82.1%) and cashew farmers (74.3%). Alternative acquisition strategies included borrowing from peers (notably cashew at 31.4% and dairy at 28.3%), input hiring (highest in cotton at 14%), and modification of existing inputs (highest in poultry at 29.4%). Welch T-test results (t=0.632, p>0.05) indicated no significant difference between individual and group-based input acquisition approaches. Organizing farmers into value chains or producer communities did not significantly enhance input access or utilization, and therefore, had minimal impact on improving Climate-Smart Agriculture adoption outcomes.

Unique contribution to Theory, Practice and Policy: Integrate innovative targeted input subsidy programs that bundle complementary inputs (seeds, fertilizers, pesticides) into complete and accessible packages to promote holistic adoption. Implementing mobile-based inventory tracking for rural agro-dealers can prevent stockouts and provide farmers with real-time input availability via SMS alerts.

Keywords: *Q12: Access to input, Q01: Smallholders, Q16: Climate-Smart Agriculture Technologies*

INTRODUCTION

Climate is the primary determinant of agricultural productivity (Lipper et al., 2014; World Bank, 2015). Considering the critical role played by agriculture in human wellbeing, concerns over the potential effect of long-term climate change on agriculture has seen an increasing body of research, addressing possible effects of climate change on crops and livestock yields and related economic consequences(IPCC, 2019). Among the proposed interventions is the concept of Climate- smart agriculture (CSA), launched by FAO in 2010 as an adaptation and mitigation approach under climate change. Since, then, CSA has gained considerable traction around the world. The CSA approach encompasses a wide range of technologies designed to address the potential impacts of climate change by improving system resilience, lowering greenhouse gas emissions, and increasing agricultural production (FAO, 2018). The adoption of CSA technologies has become increasingly critical as climate change continues to threaten agricultural productivity, food security, and farmer livelihoods globally (FAO, 2018). However, limited access to farm inputs, particularly among smallholder farmers who constitute 80% of food producers in developing countries, remains a significant barrier to CSA adoption (FAO, 2018). In response to these challenges, governments and development partners have collaborated to address climate change through Nationally Determined Contributions (NDCs) (IISD, 2014). The NDCs establish a differentiated framework where individual sectors and actors, including smallholder farmers, contribute to greenhouse gas reduction based on their vulnerability and capacity (IISD, 2014). This framework recognizes that agricultural transformation requires both policy support and practical interventions at the farm level.

In Kenya, where agriculture contributes 33% of GDP and employs over 70% of the rural population, the NDC framework includes several input-related interventions, such as promoting improved seed varieties, irrigation infrastructure, and organic fertilizers (Autio et al., 2021). However, current approaches often prioritize farmer groups without adequately considering individual farmer circumstances and capabilities (Antwi-Agyei et al., 2021), yet the successful adoption of CSA technologies has been shown to be intrinsically linked to individual farmers' access to quality inputs (García De Jalón et al., 2017; Abegunde et al. 2019; Barnard et al. 2012; FAO, 2018), and influence farmers' ability to implement climate-adaptive practices (Abegunde et al., 2019).

In Tanzania, research shows that crop farmers in Morogoro, who received tree seedlings were more likely to establish agroforestry systems, which helped contain soil erosion and improve home cooking (Barnard et al., 2012). Studies in Kaptumo revealed that access to artificial insemination and on-farm fodder production enhanced the adoption of better breeds and reduced the impacts of large, unproductive breeds (FAO, 2018). The most notable observable success was where farmers’ needs for adopting inputs and infrastructure were aligned with scaling up or adjust existing inputs and technologies.

Between the years 2017 to 2021, the Kenyan Government supported by the World Bank trained smallholder farmers in Kenya's ASAL Counties on the adoption of CSA using the Agricultural Technologies, Innovations, and Management Practices (TIMPs) in the cashew (KALRO, 2021), dairy (KALRO, 2019a), poultry (KALRO, 2019b), and cotton value chain (KALRO, 2022). These TIMPs offered guidelines on essential farm inputs to boost productivity and strengthen farmers' resilience to climate change (KALRO, 2019b). Despite these efforts, there remains a critical knowledge gap regarding how different farm input acquisition methods affect adoption rates among smallholder farmers in different value chains. This study therefore aims to:

Assess the availability of essential farm inputs among smallholder farmers.
Examine different pathways through which smallholder farmers access farm inputs.

Analyze the relationship between farm input access methods and CSA adoption rates.

The findings will contribute to developing more inclusive and effective strategies for enhancing smallholder farmers' access to CSA-related inputs.

Problem Statement

Access to and use of farm inputs are essential for the adoption of Climate-Smart Agriculture technologies, which are key to enhancing productivity (Abegunde et al., 2019; KALRO, 2022). However, many smallholder farmers face significant barriers to obtaining these inputs, limiting their ability to fully implement CSA technologies. These barriers in accessing inputs increases the vulnerability of small-holder farmers to climate-related risks and threatens to stifle the overall impact CSA technologies. Imbalances attributed to the barriers may also weaken collective climate resilience, while slowing progress for better-resourced farmers. Assessing the extent to which access to farm inputs affects the adoption of CSA, with a focus on the most vulnerable farming communities is critical in contextualizing the interplay between the two to inform policy and or future interventions.

Theoretical Review

This study applies Rogers' Diffusion of Innovation Theory (Rogers, 2003); reviewed by Marikyan et al. 2023) alongside the Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh et al. (1994) to examine technology adoption in Climate-Smart Agriculture.

Rogers' theory explains how innovations spread through populations over time, categorizing adopters into five groups (innovators, early adopters, early majority, late majority, and laggards) and identifying key factors influencing adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Rogers' emphasis is the role of communication channels and peer influence in the adoption process Marikyan et al. (2023).

UTAUT, developed by Venkatesh et al. (1994) focuses on individual adoption behavior through four determinants: performance expectancy, effort expectancy, social influence, and facilitating conditions. It consolidates multiple technology acceptance models to explain how external and psychological factors drive adoption (Taherdoost, 2018).

By combining these frameworks, the study accounts for both broad social dynamics and individual decision-making in CSA adoption. Rogers' diffusion perspective highlights the temporal spread of innovation, while UTAUT provides insight into the behavioral and infrastructural factors that shape adoption. This integrated approach offers a comprehensive understanding of how factors interplay to determine adoption of CSA technologies in farming communities.

MATERIALS AND METHODS

Study Area

This study was conducted in Bahari, Hindi, Mkunumbi, Hongwe, Witu, Kiunga, and Faza wards of Lamu County, located in the northern coastal region of Kenya (see Figure 1). The main livelihoods in the County are agriculture and fishing (County Government of Lamu, 2023). The county experiences a bimodal rainfall pattern, with long rains from March to June and short rains from November to December.

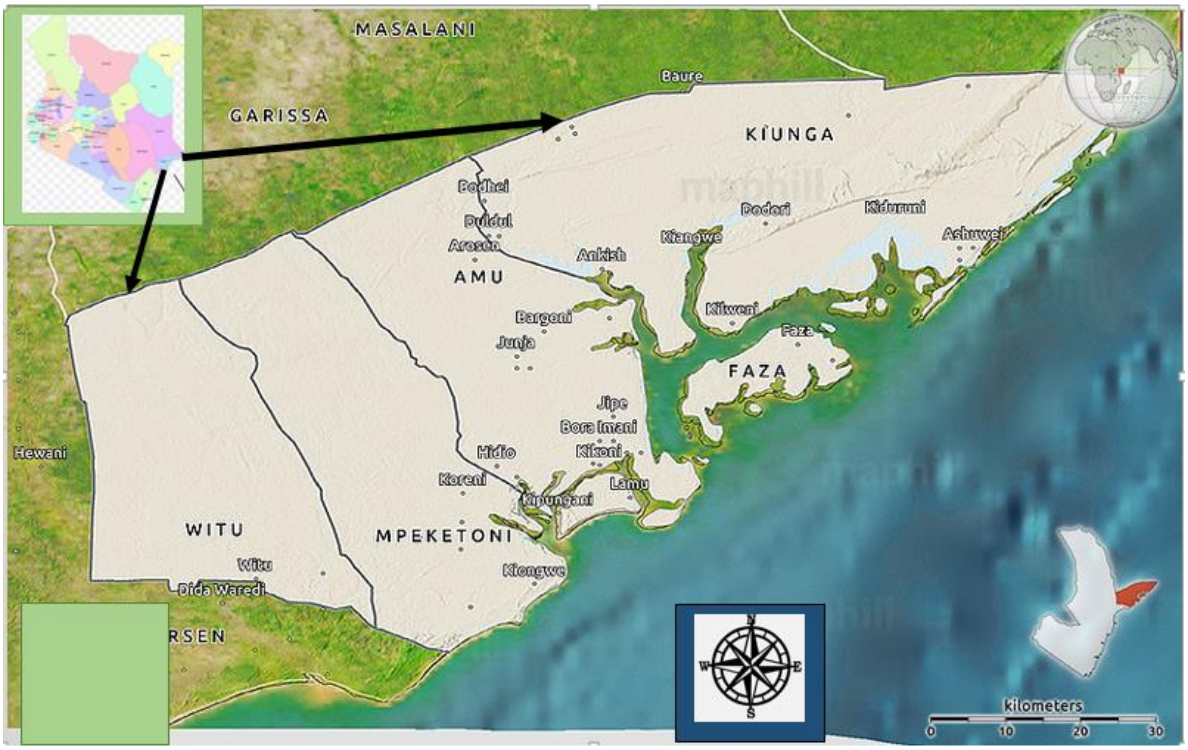

Figure 1: Map of Kenya Showing the Location of the Study Sites; Lamu County

Study Population

The study target population was farming households in the County is 20,847 (KNBS, 2019a). The accessible population was 1,200 household farmers who were having been trained on Climate Smart Agriculture between the years 2017 to 2021. Lastly, the researcher targeted the Lead farmers and agricultural extension officers since they are expected to have valuable information about the study.

Sampling and Sample Size Determination

Purposive sampling was used to select the seven wards, since these wards were where the Climate Smart Agriculture Project (KCSAP) was focused on. Proportionate simple random sampling technique was used to select the household heads from a list of beneficiaries obtained from Kenya Climate Smart Agriculture Project (KCSAP) offices-Lamu County. A Stat Trek Random-Number Generator was used to generate numbers proportional to the population size within the four value chains in each ward based on the sample size Table 1. Snowball sampling was used to select participants for the Focus Group Discussions (FGDs) through referrals by agricultural extension officers and lead farmers. Purposive sampling was used to the participants of the key informant interviews (KIIs), their selected was based on experience as members of the Community-Driven Development Committee which is a farmer's forum.

A sample size of 256 (see Table 1) was administered using a semi-structured questionnaire to the household heads. The sample size was determined following Yamane's (1967) sample size determination formula $\boldsymbol{n} = \frac{\boldsymbol{N}}{1+\boldsymbol{N}(\boldsymbol{e})^2}$ Where; $\boldsymbol{n}$ is the sample size, $\boldsymbol{N}$ is the population size, 1 is the probability of the event occurring, and $\boldsymbol{e}$ is the level of precision (0.05), 95% confidence level.

Table 1: Distribution of the Smallholders According to the Wards and Value Chain

		Value Chain				
	Ward Name	Cashew Frequency	Cotton Frequency	Dairy Frequency	Poultry Frequency	Percent (%)
1.	Bahari	7	6	18	10	16.0
2.	Faza	7	0	15	12	13.3
3.	Hindi	0	5	15	10	11.7
4.	Kiunga	0	0	15	12	10.5
5.	Mkunumbi	7	6	15	12	15.6
6.	Witu	7	5	20	12	17.2
7.	Hongwe	7	6	17	10	15.6
	Total	35	28	115	78	100

Data Collection

The adoption rate of requisite farm inputs was assessed using semi-structured questionnaires. Data on various pathways of farm input access were collected through semi-structured questionnaires, FGDs, and KIIs. Additionally, the relationship between input access methods and CSA adoption rates was examined using the same data collection methods. Due to high illiteracy levels in the study areas (KNBS, 2019b), the questionnaire was translated into Swahili and administered by the researcher and a research assistant. Four FGDs were conducted, one for each value chain cashew, cotton, dairy, and poultry. Each FGD comprised 10 household heads, including men, women, and youth. To ensure validation and enhance the depth of qualitative insights, farmers who participated in the questionnaire surveys were excluded from the FGDs. This approach allowed the qualitative data to complement the quantitative findings, providing a more comprehensive understanding of the research topic. An interview schedule was prepared and administered to two agricultural extension officer's one agronomist and one veterinarian along with eight lead farmers. Two lead farmers were selected from each value chain.

Data Analysis

Descriptive and inferential statistics, using the Welch t-test, were applied, and the results are presented in tables and figures. Qualitative data from FGDs were analyzed thematically and presented as narratives.

Welch T-Test for differences or similarities in inputs access across selected value chains

Main argument: Aggregating smallholder farmers into production communities/groups could overcome access/utility barriers for important inputs which often hinder CSA adoption. I argue that beneficiaries of capital-intensive value chains are more likely to act collaboratively translating to higher input access/utility and therefore higher CSA adoption rates.

The researcher devised an Input score for rating input access/utility (this was calculated as a percentage of essential inputs attained by the farmer). The Cashew and Cotton value chain farmers demanded high collaborations given the costly assets and inputs necessary to acquire the value addition machines for processing. Similarly, contracted cotton farmers registered under the Lake Kenyatta Cotton Farmers Cooperative found it easier to purchase subsidized seeds and sell their end-product jointly. The reverse was true for the Poultry value chain who hardly shared inputs or entered into groups for the sake of markets because of disease spread. The cashew and cotton versus poultry value chains depicted the group and individual strategies under scrutiny for CSA adoption.

A Welch T-test was used to distinguish the means of the two groups (Cashew and cotton versus poultry) under the hypothesis "H0: Project mobilization to enhance input access/utility did not necessarily enhance CSA adoption".
Parameters for the T-test were i) Welch T-test because the two groups had unequal variances, ii) Two tailed test because the differences in means were sufficient to test significant differences, and iii) n-paired test because the two groups were represented by different samples

FINDINGS

Socio-Economic Characteristics of the Smallholder Farmers

Gender Distribution of the Smallholder Farmers

The results in Table 2 shows that there were more women than men in three value chains: cashew (77.1% female, 22.9% male), cotton (64.3% female, 35.7% male), and poultry (62.8% female, 37.2% male). However, gender distribution was more balanced in the dairy sector, with females comprising 51.3% and males 48.7%.

Table 2: Gender Distribution of Smallholder Farmers across the Four Value Chains

		Value chain							
Variable	**Description**	**Cashew**		**Cotton**		**Dairy**		**Poultry**	
		%	**f**	**%**	**f**	**%**	**f**	**%**	**f**
Gender	Male	22.9	8	35.7	10	48.7	56	37.2	29
	Female	77.1	27	64.3	18	51.3	59	62.8	49

%= Percentage, f= Frequency

Age distribution of the Smallholder Farmers

The results in Table 2 shows that across all value chains, the majority of participants are aged 36–60, with cashew (57.1%), cotton (85.7%), dairy (68.7%), and poultry (69.2%) being dominated by this age group. Youth participation is notably low, especially in the cotton (3.6%) and poultry (12.8%) sectors.

Table 3: Age Distribution of Smallholder Farmers across the Four Value Chains

Value chain	Age (in years)	Percent	Mean Age	Std. Dev Age
Cashew	≤35	25.7	47.4	14.4
	36≥60	57.1		
	61≥78	17.1		
Cotton	≤35	3.6	48.5	10
	36≥60	85.7		
	61≥78	10.7		
Dairy	≤35	20	45.1	12.7
	36≥60	68.7		
	61≥78	11.3		
Poultry	≤35	12.8	48.2	12.4
	36≥60	69.2		
	61≥78	17.9		

Farm Size Owned by Smallholder Farmers

The results in Table 4 shows that Farmers in all value chains show a relatively balanced distribution between small (0.25–5 acres) and large (6–10 acres) land holdings. Cashew 60.5% and poultry 58.3% farmers have the highest percentage of smallholders having small lands. The standard deviations indicate more variability in land sizes among smallholders than among those with larger farms.

Table 4: Farm Sizes of Smallholder Farmers across the Four Value Chains

Value Chain	Land Size Category(acres)	Percent (%)	Mean	Std. Dev
Cashew	0.25 - 5	60.5	3.2	1.8
	6 - 10	39.5	7.8	1.2
Cotton	0.25 - 5	50.2	2.9	1.6
	6 - 10	49.8	7.5	1.3
Dairy	0.25 - 5	55.1	3.5	2.0
	6 - 10	44.9	7.6	1.4
Poultry	0.25 - 5	58.3	3.8	2.1
	6 - 10	41.7	7.7	1.5

Adoption Rates of Requisite Farm Inputs

Results in Figure 2 shows that access to improved seeds was relatively high, with 74.3% of cashew farmers adopting them. The use of inorganic fertilizers was low (22.9%), indicating limited reliance on synthetic soil fertility management. At the same time, the adoption of organic manure was also low (22.9%), suggesting that farmers are not fully utilizing organic alternatives. Regarding pest management, 40% of cashew farmers used pesticides, showing a moderate reliance on chemical control. Access to personal protective equipment (PPE) was very low (14.3%), exposing farmers to health risks when handling agrochemicals.

Cotton farmers demonstrated high accessibility to improved seeds (96.4%), reflecting widespread adoption of enhanced seeds. Inorganic fertilizers were used by 71.4% of farmers, supporting nutrient management but also signaling a dependence on synthetic inputs. Organic manure adoption was extremely low (14.3%), showing a preference for chemical alternatives over sustainable soil fertility management. A strong reliance on pesticides (78.6%) was observed, highlighting the widespread use of chemical pest control. However, only 25% of farmers had access to PPEs (see Figure 2).

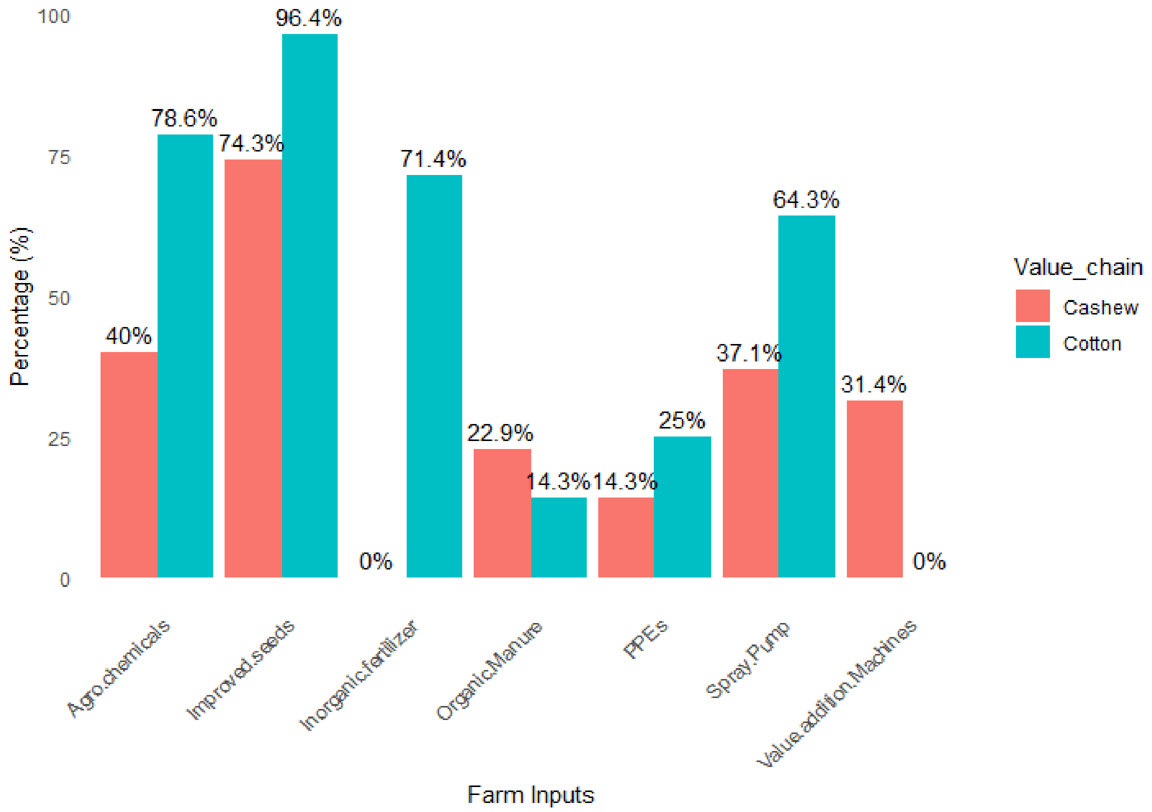

Figure 2: Access to Farm Inputs in Crops Value Chains

Further an FGD participant of cotton farmer stated that;

"The new certified cotton seeds have really done us well because they are economical to plant-requiring only one to two seeds per hole and they all germinate in addition they don't need as much pesticide/insecticide spraying to control crop diseases as the older cotton seeds we previously used to plant, which required frequent and expensive pesticide/insecticide application." (25th August 2022)

Additionally, results from FGD further revealed that it was possible to possess some inputs jointly as evident through the narration by a participant.

"Value addition machines such as a cashew nut decorator, an oil past Oster, and a pillar are largely profitable and viable when used commercially. For our case we have agreed as a group of farmers to gather all our produce (cashew nuts) and process them together rather than selling them raw to the middlemen. This ensures that we have enough raw cashew nuts available to both keep the machines running even during the off-season and to maintain the market for the processed cashew nuts. These machines can potentially become worn out if not be utilized regularly especially if owned by a single farmer who lacks sufficient raw cashew nuts." (FGD participant, 25th August, 2022).

Access to Farm Inputs in Livestock Enterprises

Results in Figure 3 shows that the adoption of improved breeds was high (88.4%), supporting CSA goals. However, vaccination access remained moderate at 49.6%, indicating that while some preventive health measures. Spray pump adoption was low (18.3%), which may hinder effective pest and parasite control. Access to PPEs was very low (11.1%), raising concerns about the safety of farmers handling agrochemicals.

Improved breeds were adopted by 64.6% of poultry farmers, vaccination access was moderate at 43.4%. For infrastructure, drinkers and troughs were moderately adopted (43.4%), showing efforts in water and feeding management. However, the availability of PPEs for safe handling of chemicals and vaccines was poor, raising concerns about occupational safety (see Figure 3). Further, inputs access was explained by a participant of the FGD through the following statement

"With the improved kienyeji chicken, you must have money to buy enough feeds and vaccinate the stock; otherwise, in the event of a disease outbreak, you risk losing the entire flock. Additionally, of late the cost of feeds is extremely high, which might make the business unprofitable and require someone to produce supplementary feeds and use feeders/troughs to reduce feed waste." (FGD participant, 26th August, 2022).

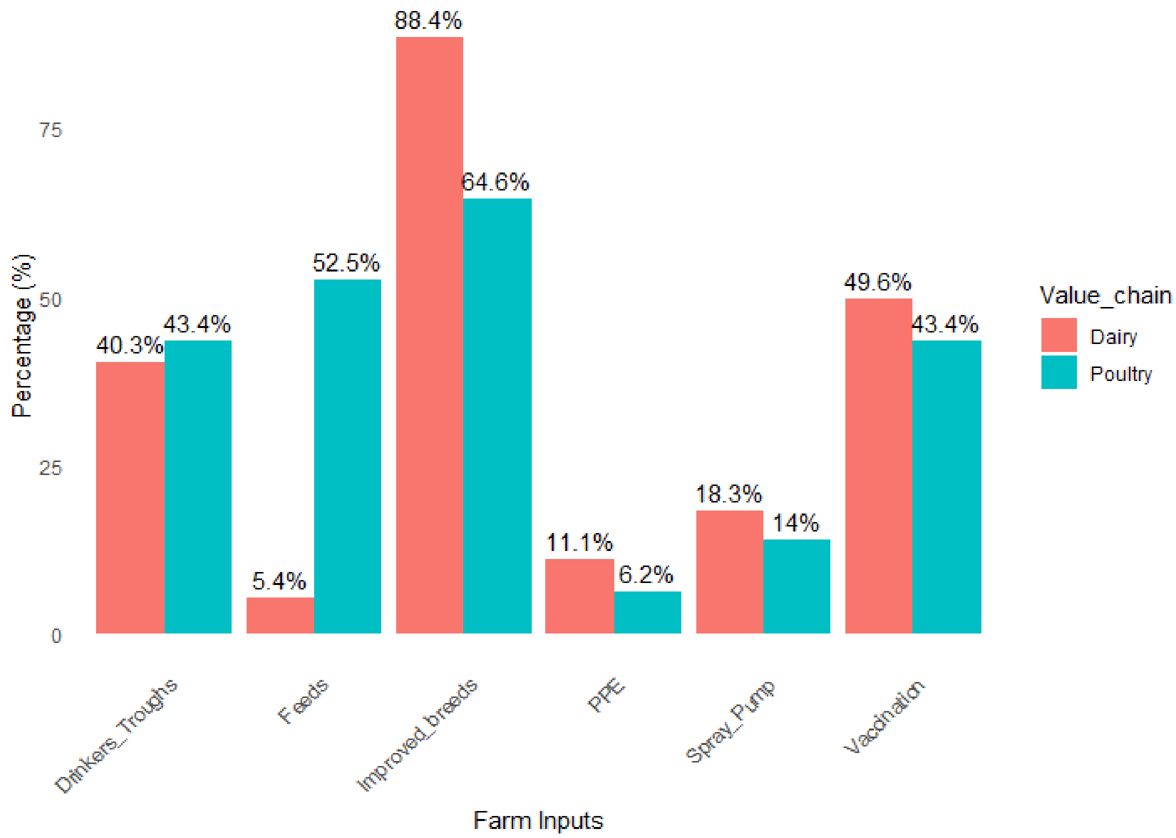

Figure 3: Access to Farm Inputs in Crops Value Chains

Means of Acquisition of Farm Inputs

Results in Figure 4 shows that farmers in the cashew sector primarily acquire their farm inputs through purchasing (74.3%). Borrowing from neighbors or friends was (31.4%). In contrast, hiring farm inputs is less common (5.7%), indicating that most farmers prefer outright purchase or borrowing over temporary access. Modifying or fabricating inputs is practiced by 14.3% of cashew farmers, reflecting some level of resourcefulness.

Purchasing of inputs among cotton farmers was higher 82.1% compared to cashew farmers, borrowing from neighbors or friends was lower (14.3%), indicating a reduced reliance on informal networks. Hiring farm inputs is more prevalent among cotton farmers (14.3%) compared to cashew farmers, suggesting a greater willingness to access inputs on a temporary basis. Modifying or fabricating inputs is less common (7.1%) compared to cashew farmers (see Figure 4).

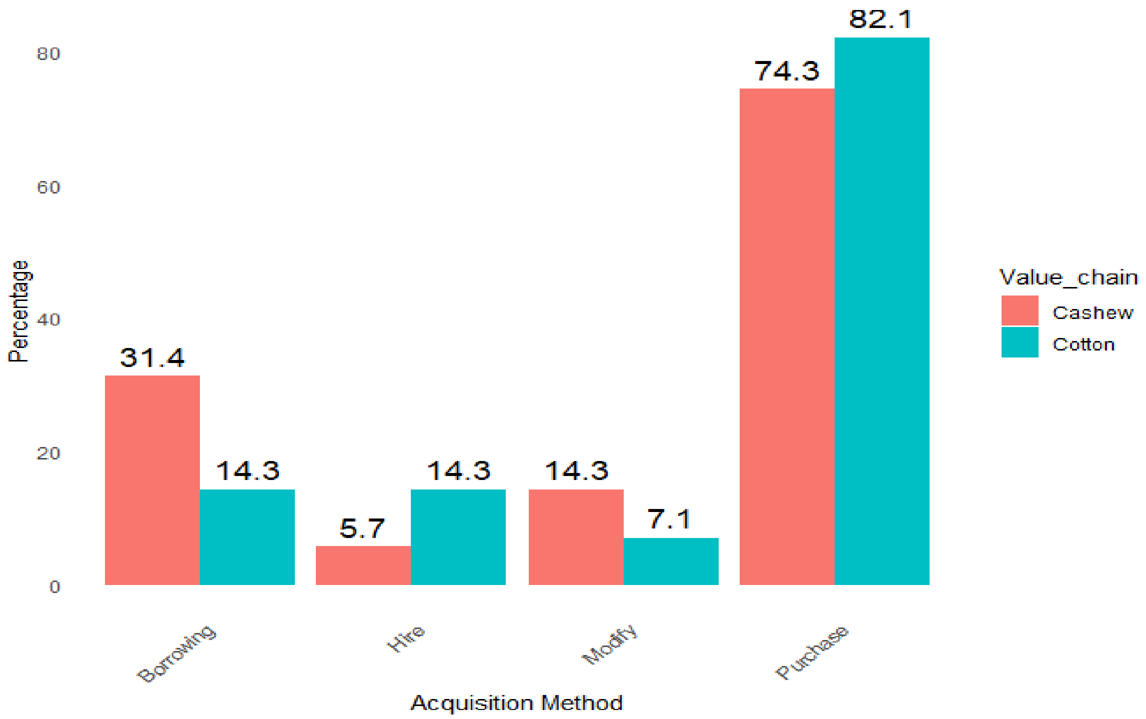

Figure 4: Means of Farm Inputs Acquisition in the Crops Value Chain

Findings in Figure 5 shows that, in dairy, purchasing farm inputs was at (54.8%), lower compared to the crop value chains, suggesting a mix of alternative sourcing methods. Borrowing from neighbors or friends is relatively frequent (28.3%). Hiring farm inputs is rare (1.7%), reflecting a preference for ownership over renting. Additionally, 9.9% of dairy farmers modify or fabricate inputs, showcasing some level of resourcefulness.

Poultry farmers exhibit the highest reliance on purchasing inputs (67.7%). Borrowing from neighbors or friends is uncommon (9.2%), suggesting a lesser dependence on social networks compared to dairy farmers. Hiring farm inputs is the least practiced method (1.3%), similar to dairy farmers. However, modifying or fabricating inputs is relatively widespread (29.4%), indicating a high level of adaptability and innovation (see Figure 5).

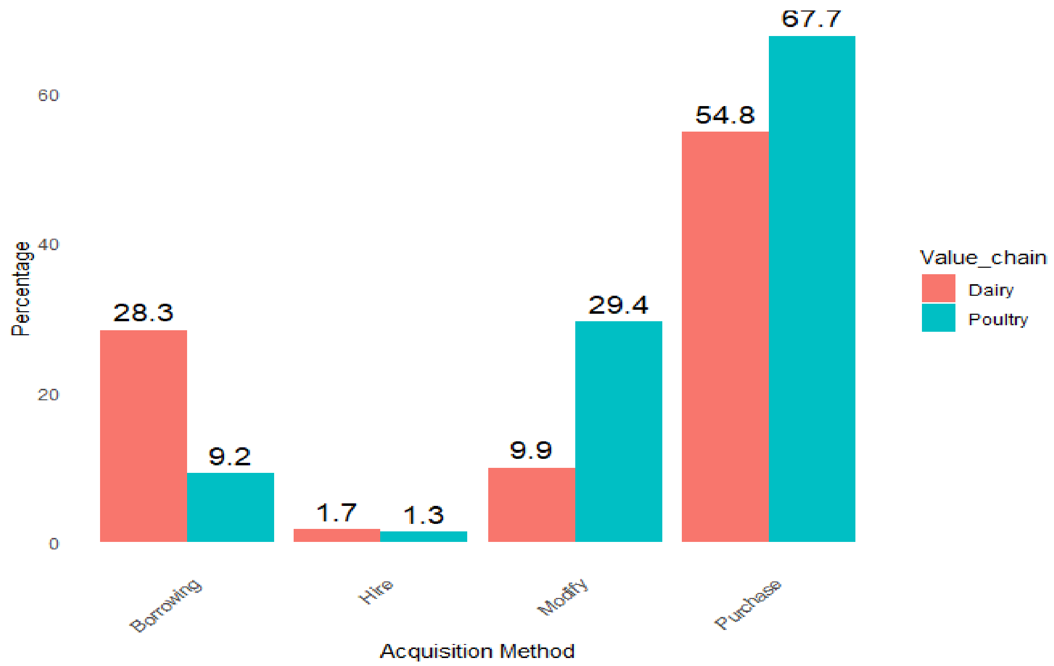

Figure 5: Means of Farm Inputs Acquisition in the Livestock Value Chain

Further results from the FGD revealed that the value chain a farmer participates in, considerably influences the method of input acquisition. The sentiments were narrated as follows,

"My preferred method of acquiring them is to borrow a bull from a friend, engage in cross-breeding, and eventually eliminate the native breeds (destocking), this is because I cannot afford to buy the breed due to its high cost. I personally disagree with the artificial insemination technology because I have heard that the calves will be a weak-breed." (FGD participant, 26th August, 2022).

Another smallholder from the FGD added;

"Contrary to other value chains, like those of cashew nuts, where one might borrow from neighbors and friends, inputs for poultry are purchased or manufactured through fabricating. Reason being that chicken are prone to sickness and therefore sharing inputs might be a way to spread infections." (FGD participant, 26th August, 2022).

The necessity to purchase or formulate inputs for poultry due to risks of disease transmission. Below is a quote from an extension officer;

"Sometimes the County government of Lamu, provides farmers with free certified seeds and lowers tractor ploughing costs, but the seeds supplies are never sufficient. Many farmers have missed the opportunity to plant on time due to an overreliance on the government. In case the rains come early and there was a delay in giving out the seeds and when the soil type in your area is muddy you will have to wait until the rains stop in order for you to plough and plant. In the worst scenarios, even after the long wait a farmer might not receive the seeds, causing him to pursue alternative solutions like borrowing money to purchase the seeds, forgoing or even switching his farming crop." (Extension officer, 25th August, 2022).

Inconsistent and insufficient government support could lead to missed opportunities for timely planting, reducing the effectiveness of CSA practices. Similarly, overreliance on government support creates vulnerability to delays and shortages.
A smallholder farmer in the cotton value chain narrated that;

“The news that the County Government plans to revive the ginnery here in Mpeketoni has made a lot of farmers want to start growing cotton, and others who want to expand up to 10 acres as it was many years ago…However we need more assurances when it comes to prices and availability the certified seeds.” (FGD participant, 25th August, 2022).

Attitudes Regarding Farm Inputs

Results in Figure 6 shows that among cotton farmers, 60.7% disagreed that their inputs are environmentally friendly, while 39.3% agreed, highlighting concerns about sustainability. Cashew farmers showed mixed opinions, with 42.8% agreeing, 28.6% neutral, and 28.5% disagreeing, indicating varied perspectives that could impact sustainable adoption. Dairy farmers exhibited the highest neutrality (49.6%), suggesting uncertainty due to limited information, with 32.1% agreeing and 18.3% disagreeing. Poultry farmers showed moderate agreement (41.0%) on eco-friendliness, but 37.2% remained neutral, and 21.8% disagreed, reflecting some uncertainty.

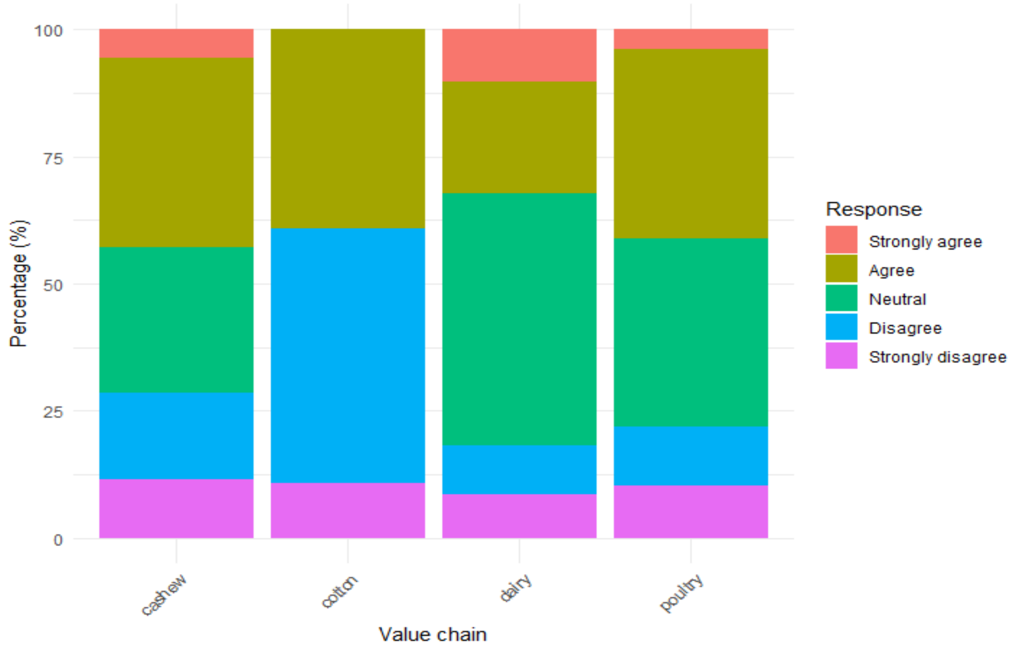

Figure 6: My Farm Inputs (fertilizers, agro-chemicals) are Eco-friendly

The FGD discussions highlighted that while cattle keeping has been increasingly embraced, it has also intensified competition for resources, particularly during droughts. One participant noted:

"During droughts, we see large herds of cattle arriving from neighboring counties like Tana River and Garissa in search of water and pasture. Unfortunately, this forces us to share streams and water pans with the animals, leading to water contamination and potential health risks." (FGD participants, personal communication, 26th August, 2022).

In particular, cotton farmers highlighted challenges associated with spraying cotton, noting that while the new seeds produce larger canopies and more flower buds under proper management, pesticide application becomes more demanding. One farmer explained:

"When planted in good soil and properly taken care of, the cotton develops a larger canopy and many flower buds compared to the seeds we used before. The challenge arises during spraying, as you have to ensure the pesticide gets to every part of the plant, often resulting in wetting your body with the pesticides after spraying. When done, I have to drink milk or a raw egg and take a shower to prevent allergic reactions." (FGD participants, personal communication, 25th August, 2022).

Figure 7 illustrates smallholders' attitudes of input source reliability across four value chains. High disagreement levels indicate that input shortages hinder CSA adoption, particularly among cashew (82.9%) and poultry (57.7%) farmers. Cotton (42.9%) and dairy (42.6%) farmers also face challenges, though dairy farmers show slightly better access, with 35.7% agreeing. Moderate neutrality is observed in cotton (35.7%) and dairy (21.7%), suggesting some uncertainty.

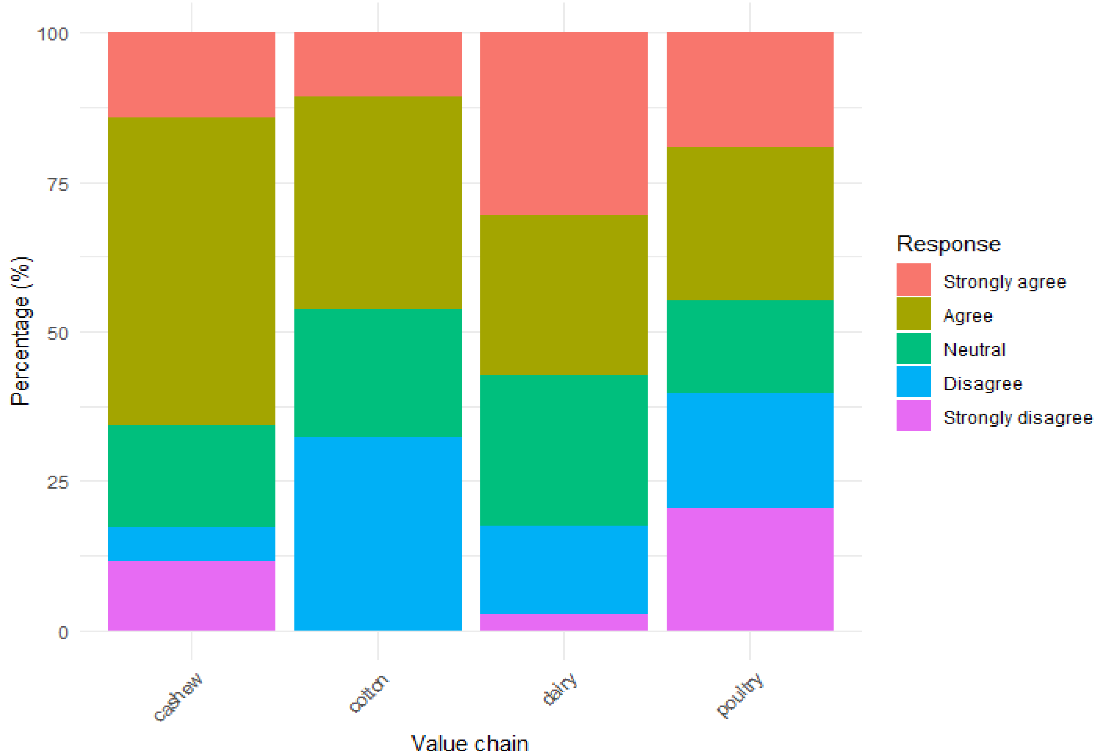

Figure 7: Am Confident that my Input Sources will Consistently Meet My Needs

The FGD discussions revealed significant challenges in accessing essential farm inputs, particularly during critical periods such as the planting season or when livestock feed is urgently needed. One farmer explained:

"Sometimes we suffer as farmers. We need inputs like seeds at planting time or and often feeds for our chicken, but they are often unavailable in agro vet stores. This was especially common after the Al-Shabaab attacks in 2014, since then the supply trucks are hesitant to make frequent deliveries. Additionally, before our roads were tarmacked, heavy rains would wash them away, disrupting transport for weeks or even months." (FGD participant, 25th August, 2022).

Farm Input Acquisition through Individual and Group-Based Approaches

Table 5: Comparison of Farm Input Acquisition through Individual and Group-Based Approaches

Means of Acquiring Inputs	Mean	Variance	Std. Dev	n
Through a Group *	0.47	0.05	0.22	63
Individually **	0.45	0.03	0.16	78

t= 0.63, df= 113, p-value= 0.529, 95% confidence interval: [-0.04, 0.09]

Note

* Cashew and Cotton

** Poultry

Given the high p-value ($p > 0.05$) and the fact that the 95% confidence interval includes 0, we fail to reject the null hypothesis. This suggests that there are no statistically significant differences between the Input scores of the cashew and cotton versus the poultry groups based on the data provided. The observed difference in means (0.469 for cashew and cotton versus 0.448 for poultry) is not sufficient to conclude that there is a true difference in the population means.

Summary of Findings

Women play a significant role in the cashew, cotton, and poultry value chains, while the dairy sector shows nearly equal gender participation. This high involvement highlights women's empowerment, particularly in cash crop farming (cashew and cotton) and livestock production (dairy and poultry). These results align with Abegunde et al. (2020), who found that women dominate South Africa's agricultural sector, strengthening their economic contribution. However, they contrast with Mwaura et al. (2021), who reported that men lead most farming households in Central Kenya and make the majority of farm-related decisions. These findings suggest a growing shift toward women's active participation in agriculture, reinforcing their role in economic development. Youth involvement in agriculture appears limited due to multiple interconnected barriers. While land access constraints with ownership often tied to inheritance and prolonged education periods delay agricultural entry, these factors represent only part of a complex challenge. Young people also face significant financial limitations, with restricted access to credit and capital necessary for agricultural investment (FAO, 2019). Limited youth-focused extension services, negative perceptions of farming as unprofitable or low-status work, and institutional barriers further discourage youth participation. These multidimensional challenges align with research by Mwaura, (2017), emphasizing the need for comprehensive approaches to youth agricultural engagement that address both economic and sociocultural constraints. build social and physical capital, highlighting their critical role in agricultural sustainability. Farm size distribution further underscores the role of smallholder farmers. The dominance of small farms in cashew, cotton, and dairy farming highlights their importance in these sectors. In contrast, poultry farming has a relatively higher proportion of medium-sized farms, likely due to the space required for poultry housing or grazing. Land ownership remains a key factor influencing CSA adoption. With an average land area of four acres in Lamu and a maximum of ten acres within settlement schemes (County Government of Lamu, 2023)**.**

The prioritization of improved seeds by cotton and cashew farmers is expected to boost crop yields due to their enhanced disease resistance and ability to cope with harsh weather. This approach aligns with the goals of CSA. However, sustainability concerns may arise as it lacks a holistic view of agricultural productivity and safety. The benefits of CSA may be limited by an imbalance, where improved seeds are adopted more frequently than machines, PPEs, inorganic fertilizers, and pesticides. The moderate to low agreement levels across sectors may be due to input unavailability, supply chain disruptions, and affordability challenges. While the adoption of these additional inputs can help manage pest-related risks, their underuse or overuse could undermine environmental goals. This aligns with Regassa et al. (2023), who documented similar constraints in sub-Saharan Africa, particularly regarding chemical fertilizer access. A study by Zerssa et al. (2021) further supported these findings, highlighting how supply chain inefficiencies can impede CSA adoption.

The high adoption of improved livestock breeds aims to boost productivity due to their resilience to diseases and harsh weather. However, as seen in crop value chains, the adoption of essential inputs like vaccinations, PPEs, and spray pumps remains moderate. Limited PPE use in poultry farming poses health risks, highlighting the need for better access to safety equipment. Similarly, the low availability of spray pumps hampers effective pest management, which is crucial for livestock health under climate variability. Negative attitudes toward artificial insemination, particularly the belief that it produces weak calves, may hinder adoption. Misinformation or lack of awareness about its benefits contributes to resistance. While farmers recognize the importance of these inputs, factors such as high costs, limited availability, environmental and health concerns, and knowledge gaps restrict their widespread use. These findings align with Autio et al. (2021), who observed similar trends in Southeast Kenya.

This reliance on purchasing creates significant equity implications for CSA adoption. Wealthier farmers can consistently acquire inputs and implement technologies, potentially widening productivity gaps. Their financial advantage enables risk mitigation when experimenting with new technologies, while resource-constrained farmers often face adoption barriers. However, this economic determinism is increasingly being challenged by innovative financing models. Micro-credit schemes, rotating savings and credit associations, and agricultural insurance products have demonstrated success in facilitating technology adoption among smallholder farmers (Dixon et al., 2021). Public-private partnerships offering subsidized inputs or pay-as-you-go models have also shown promise in increasing accessibility, as demonstrated by Chiturike et al. (2024) in Zimbabwe, where resource-poor farmers achieved high CSA adoption rates through such innovative financing schemes.

Additionally, digital financial services are emerging as powerful tools for democratizing input access. Mobile money platforms that offer flexible payment terms and eliminate traditional banking barriers have expanded financial inclusion in agricultural communities (Murray et al., 2020). Group purchasing arrangements, where farmers pool resources to access bulk discounts, further illustrate how collective action can overcome individual financial limitations. These alternative financing pathways suggest that with appropriate institutional support and financial innovation, economic status need not determine adoption patterns, aligning with Alvi, (2021) findings that social networks often prove more influential than economic status in shaping input access.

Farmers' concerns about environmental impacts of agricultural inputs or their lack of awareness can significantly restrict resource access and utilization. Cotton farmers spraying large canopy plants with minimal PPEs face serious health risks, raising sustainability concerns beyond mere productivity. The uncertainty surrounding input eco-friendliness suggests that smallholders' attitudes are shaped by awareness, information access, and perceived trade-offs between productivity gains and environmental impacts. While CSA promotes inputs like inorganic fertilizers, pesticides, and vaccines, farmers often struggle to balance productivity objectives with environmental considerations. Limited knowledge about proper input application can lead to hesitation, particularly regarding soil health and chemical dependency. This aligns with research by Muhie, (2022), who highlights challenges in balancing agrochemical use with environmental stewardship. Similarly, Kassa & Abdi, (2022) found that knowledge gaps significantly reduce adoption rates. However, Rahaman et al. (2021) challenged the primacy of environmental concerns, demonstrating that economic benefits often take precedence in smallholder decision-making processes.

There is no clear evidence that joining farmer groups for input purchases enhances CSA adoption compared to individual ownership. While groups are formed to strengthen collective bargaining, improve input access, and share resources, challenges such as lack of cohesion, unequal participation, and conflicting priorities often undermine their effectiveness. When these dynamics fail, benefits like bulk purchasing and knowledge-sharing are diminished, limiting their impact on CSA adoption. Our findings align with Ong'ayo et al. (2016) in Kenya, who reported limited success in group-based approaches. However, they contrast with Agarwal, (2018) in India and Martin & Tabe-Ojong, (2024) in West Africa, where strong institutional support facilitated better input access and CSA adoption, particularly for women farmers.

CONCLUSIONS AND RECOMMENDATIONS

Farmers show inconsistent adoption patterns for essential agricultural inputs, strongly favoring improved seeds and breeds while neglecting other crucial inputs. This selective adoption is complicated by environmental concerns about certain inputs and perceived local availability shortages. While farmer groups enhance input access, individual farmers must be able to consistently acquire and maintain these inputs throughout the production cycle for effective CSA implementation.

The study recommends integrated input subsidy programs that bundle complementary inputs (seeds, fertilizers, pesticides) into complete packages to promote holistic adoption. Implementing mobile-based inventory tracking for rural agro-dealers can prevent stock outs and provide farmers with real-time input availability via SMS alerts. Additionally, fostering public-private partnerships would enhance distribution networks, ensuring better access for underserved farming communities.

Institutional Review Board Statement

The study was approved by the Ethics Review Committee (ERC) of Pwani University, Kenya (ERC/PhD/005/2022).

The work forms part of the requirements for the Doctor of philosophy degree (PhD) of Pwani University.

REFERENCIES

Abegunde, V. O., Sibanda, M., & Obi, A. (2019). The Dynamics of Climate Change Adaptation in Sub-Saharan Africa: A Review of Climate-Smart Agriculture among Small-Scale Farmers. *Climate*, *7*(11), Article 11. https://doi.org/10.3390/cli7110132

Abegunde, V. O., Sibanda, M., & Obi, A. (2020). Determinants of the Adoption of Climate-Smart Agricultural Practices by Small-Scale Farming Households in King Cetshwayo District Municipality, South Africa. *Sustaina*, *12*(195), 1–27. https://doi.org/doi:10.3390/su12010195

Agarwal, B. (2018). Can group farms outperform individual family farms? Empirical insights from India | CGIAR GENDER Impact Platform. *World Development*, *108*, 57–73. https://doi.org/10.1016/j.worlddev.2018.03.010

Alvi, I. (2021). College students' reception of social networking tools for learning in India: An extended UTAUT model | Smart Learning Environments | Full Text. *Springer Nature Link*, *8*(9). https://doi.org/10.1186/s40561-021-00164-9

Antwi-Agyei, P., Abalo, E. M., Dougill, A. J., & Baffour-Ata, F. (2021). Motivations, enablers and barriers to the adoption of climate-smart agricultural practices by smallholder farmers: Evidence from the transitional and savannah agroecological zones of Ghana. *Regional Sustainability*, *2*(4), 375–386. https://doi.org/10.1016/j.regsus.2022.01.005

Autio, A., Johansson, T., Motaroki, L., Minoia, P., & Pellikka, P. (2021). Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya. *Agricultural Systems*, *194*, 103284. https://doi.org/10.1016/j.agsy.2021.103284

Barnard, J., Manyire, H., Tambi, E., & Bangali, S. (2012). *Barriers to scaling up / out climate smart agriculture and strategies to enhance adoption in Africa*.

Chiturike, P., Gotosa, J., Nyakudya, I. W., Madamombe, S. M., Mandumbu, R., Chirinda, N., Kugedera, A. T., & Nyamadzawo, G. (2024). The effects of contour-based rainwater harvesting and integrated nutrient management on maize yields in semi-arid regions of Zimbabwe. *CABI Agriculture and Bioscience*, *5*(1), 41. https://doi.org/10.1186/s43170-024-00233-2

County Government of Lamu. (2023). *Lamu County Integrated Development Plan September 2023-2027*. County Government of Lamu. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://repository.kippra.or.ke/xmlui/bitstream/handle/123456789/4557/Lamu%20county%20approved-CIDP-2023-27-.pdf?sequence=1&isAllowed=y

Dixon, J., Gulliver, A., Gibbon, D., & Hall, M. (2021). *Farming systems and poverty: Improving farmers' livelihoods in a changing world* (2nd ed., Vol. 1). Food and Agriculture Organization of the United Nations.

FAO. (2018). *Climate-Smart Agriculture Case Studies 2018. Success approaches from different regions.* 44.

García De Jalón, S., Silvestri, S., & Barnes, A. P. (2017). The potential for adoption of climate smart agricultural practices in Sub-Saharan livestock systems. *Regional Environmental Change*, *17*(2), 399–410. https://doi.org/10.1007/s10113-016-1026-z

IISD. (2014). *A Reporting Service for Environment and Development Negotiations*. IISD Earth Negotiations Bulletin. http://enb.iisd.org/united-arab-emirates-climate-change-conference-cop28-summary

IPCC. (2019). *Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* (p. 36). Intergovernmental Panel on Climate Change. https://doi.org/10.1017/9781009157988.001

KALRO. (2019a). *Inventory of Climate Smart Agriculture Dairy Technologies, Innovations & Management Practices*. Kenya Agricultural and Livestock Research Organization under KCSAP.

KALRO. (2019b). *Inventory of Climate Smart Agriculture Indigenous Poultry Technologies, Innovations & Management Practices* (1st Ed.). Kenya Agricultural and Livestock Research Organization under KCSAP.

KALRO. (2021). *Cashew Technologies, Innovations and Management Practices for Climate Smart Agriculture Project*. Kenya Agricultural and Livestock Research Organization under KCSAP.

KALRO. (2022). *Inventory of Climate Smart Agriculture Technologies, Innovations and Management Practices for Cotton Value Chain* (1st Ed.). Kenya Agricultural and Livestock Research Organization under KCSAP.

Kassa, B. A., & Abdi, A. T. (2022). Factors Influencing the Adoption of Climate-Smart Agricultural Practice by Small-Scale Farming Households in Wondo Genet, Southern Ethiopia. *SAGE Open*, *12*(3), 215824402211216. https://doi.org/10.1177/21582440221121604

KNBS. (2019a). 2019 Kenya Population and Housing Census Volume 1: Population by County and Sub-County. In *2019 Kenya Population and Housing Census: Vol. I* (Issue November). https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county

KNBS. (2019b). *2019 Kenya Population and Housing Census Volume IV: Distribution of Population by Socio-Eonomic Characteristics*. Government of Kenya.

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., Mccarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P. T., … Emmanuel, F. (2014). Climate-smart agriculture for food security Climate-smart agriculture for food security. *Nature Climate Change*, *4*(12), 1068–1072. https://doi.org/10.1038/nclimate2437

Marikyan, D., Papagiannidis, S., & Stewart, G. (2023). Technology acceptance research: Meta-analysis. *Journal of Information Science*, 01655515231191177. https://doi.org/10.1177/01655515231191177

Martin, P., & Tabe-Ojong. (2024). Climate-smart Agriculture and Food Security: Cross-country Evidence from West Africa | African Economic Conference (AEC) | African Development Bank. *African Economic Confrence*, 23–25. https://aec.afdb.org/en/papers/climate-smart-agriculture-and-food-security-cross-country-evidence-west-africa-653.

Muhie, S. H. (2022). Novel approaches and practices to sustainable agriculture. *Journal of Agriculture and Food Research*, *10*, 100446. https://doi.org/10.1016/j.jafr.2022.100446

Murray, S., Kopicki, R., & Korotoumou, C. (2020). *Digital financial services in agriculture: Lessons from Kenya*. (p. 17). World Bank Group, Finance, Competitiveness and Innovation Global Practice.

Mwaura, G. (2017). Just Farming? Neoliberal Subjectivities and Agricultural Livelihoods among Educated Youth in Kenya. *Development and Change*, *48*(6), 1310–1335. https://onlinelibrary.wiley.com/doi/full/10.1111/dech.12342

Mwaura, G. G., Kiboi, M. N., Bett, E. K., Mugwe, J. N., Muriuki, A., Nicolay, G., & Ngetich, F. K. (2021). Adoption Intensity of Selected Organic-Based Soil Fertility Management Technologies in the Central Highlands of Kenya. *Frontiers in Sustainable Food Systems*, *4*, 570190. https://doi.org/10.3389/fsufs.2020.570190

Ong'ayo, A., Onyango, C., & Ochola, W. (2016). Small-Scale Farmers' Perceptions towards Demand Driven System of Agricultural Extension Service Delivery. Case Study of Siaya and Kilifi counties in Kenya. *International Journal of Agricultural Extension*, *4*(1), 1–10. http://www.escijournals.net/IJAE

Rahaman, M. S., Rahman, M. M., Mise, N., Sikder, M. T., Ichihara, G., Uddin, M. K., Kurasaki, M., & Ichihara, S. (2021). Environmental arsenic exposure and its contribution to human diseases, toxicity mechanism and management. *Environmental Pollution*, *289*, 117940. https://doi.org/10.1016/j.envpol.2021.117940

Regassa, M. D., Degnet, M. B., & Melesse, M. B. (2023). Access to credit and heterogeneous effects on agricultural technology adoption: Evidence from large rural surveys in Ethiopia. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, *71*(2), 231–253. https://doi.org/10.1111/cjag.12329

Rogers, M. (2003). *Diffusion of innovations* (5th Ed.). Free Press.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960–967. https://doi.org/10.1016/j.promfg.2018.03.137

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (1994). User Acceptance of Information Technology: Towards a Unified View. *MIS Quarterly*, *27*(3), 425–478. https://doi.org/10.1006/mvre.1994.1019

World Bank. (2015). *Future of Food: Shaping a Climate-Smart Global Food System*. World Bank.

Zerssa, G., Feyssa, D., Kim, D.-G., & Eichler-Löbermann, B. (2021). Challenges of Smallholder Farming in Ethiopia and Opportunities by Adopting Climate-Smart Agriculture. *Agriculture*, *11*(3), Article 3. https://doi.org/10.3390/agriculture11030192