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Adoption of Conservation Agriculture in Uganda: A Case Study of the Lango Subregion

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Abstract: Conservation agriculture (CA) is based on three principles: minimum soil disturbance, maintaining a soil cover through mulching with crop residues or planting cover crops, and practicing crop rotations. CA is practiced in many parts of the world for its benefits to soil and ability to improve yields, among others. There is little documented information on the status of CA adoption in the Lango region in mid-Northern Uganda. This study aimed at determining the extent of CA adoption in relation to the socioeconomic status of the farming population and suggesting relevant strategies for accelerating CA uptake specific to this region. A non-discriminative snowball-sampling technique was used to gather data from 417 households spread over three districts. Semi-structured interviews were conducted using household questionnaires. Farmers' uptake of CA was related to information gained from training and the benefits that were observed in their fields. Some farm-level constraints in the region included the diminutive ratio of shared tools and equipment; the minimum presence and involvement of extension services; and seasonal rural markets that are dominated by middlemen. The impact that was attributed to the use of CA at the household level was improved yields. The strategy that was used to spread CA information to farmers also played a key role in increasing CA uptake in the region. This information is important for increasing CA adoption in this context given the socioeconomic status of the region.

Keywords: conservation agriculture; information; adoption; socioeconomic; farmers' perceptions; minimum tillage; crop rotation

1. Introduction

The population of Uganda in 2014 was 34.9 million and is forecasted to reach 40.4 million in 2020 [1]. Notable still is the high annual population growth rate of 3.2%, and the youth population, marked by 48% being people under the age of 14 [1]. This has contributed to a high dependency ratio and inevitably exerted pressure on the available resources needed for livelihoods, employment, economic development, and family welfare. Another key feature of this demography is that the proportion of the population in waged employment stands at 18.5%, and the remaining majority are engaged in agriculture.

Agriculture in Uganda is sustained by smallholder farmers, 95% of whom have landholdings of less than 2 ha. The agricultural sector is highly considered as one of three growth sectors with high job-multiplying effects, as it mainly provides livelihoods and forms the biggest household enterprises. In 2014/2015, more than 64% of the working population was employed in subsistence agriculture

and contributed 24% of the GDP in that period [1]. However, poor agricultural-land management has gradually led to reduced yields due to poor soil health and land degradation. Degradation is one of the factors impeding productivity [2]; 39% of arable land is degraded, and a further 10% is severely degraded. At the same time, farmers are already experiencing extreme-weather events in some regions [3–8]. In this regard, Uganda ranks high among the most vulnerable countries [9] and yet the least prepared [10,11]. Therefore, based on the need for sustainable land management [12], the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) considered conservation agriculture (CA) as part of the climate-smart agriculture 2015–2025 program [13] and the Agricultural Sector Strategic Plan of Uganda (ASSP).

Conservation agriculture is based on three principles, namely, minimum soil disturbance, maintaining a soil cover through mulching with crop residues or planting cover crops, and practicing crop rotations [14]. We restricted the conceptual definition of CA in this study to two principles, namely, minimum tillage (ripping and/or permanent planting basins) and crop rotation. In this region, farmers are not mulching and, hence, this principle could not be evaluated. The yield increase associated with ripping and/or permanent planting basins on degraded soils was documented by Mubiru et al. [15]. The study explored the extent of practice of these principles and related them to the socioeconomic status of the population. Other benefits of CA are documented, including soil and water conservation [16], labor reduction, recovery of degraded fields, improved food security, and soil-erosion control [15,17]. However, low adoption rates, particularly in Africa, do not seem to reflect this success. Originally, a meagre 0.3% of the land in Africa was under CA [18], but more recent studies have put the figure higher, at 1.32% [19].

CA adoption is complex because the factors influencing non-adoption are not well-studied. Nevertheless, there are several studies on the low use of CA, and these reveal context-specific constraints. These include complexities within African smallholder-farming systems, unfavorable institutional policy approaches [20], lack of appropriate extension [21], limited access to credit and underdeveloped input and output markets [22–24], competition for crop residues for use as animal fodder [25–27], the approach of CA promotion as a package [28–30], and the inappropriateness of the technology to the target group [31–33]. There are also factors that have enabled farmers to take up CA, for instance, peer influence [34–36] and information availability [37].

At present, greater emphasis on Sub-Saharan Africa is placed on the means of increasing the wider uptake of CA by farmers [19]. Due to country diversity, studies on reasons for CA uptake and/or hindering factors that could inform the adoption process are needed [38]. Looking at Uganda, which has several agro-ecological zones and cultural diversities, differences in adoption can be expected. For example, a study carried out in Eastern Uganda showed differences in farmers' preferences in terms of gender, costs, location, and prior knowledge of farming practices [17,39]. There is also a study on the expected profits from practicing CA in a small area, shown to make a difference in poverty reduction at the household [40]. Such information and differences in preferences affect the likelihood of adoption even within the same region.

The study aimed at determining the extent of CA adoption in the Lango subregion in relation to the socioeconomic status of the farming population and to suggest a relevant strategy for accelerating CA uptake specific to the region. The study gathered experiences and insight of farmers' perceptions on the appropriateness and impact of CA within their context. It identified the underlying factors that caused and/or prevented farmers from taking up this technology. The study site is a postwar zone, besides having one of the highest poverty rates in the country. The data captured the respondents' estimated use of CA on their land, the frequency of use, and their individual reasons for adopting CA. Other factors explored included economic and social factors to form a background for further promotion of CA in the region.

2. Materials and Methods

2.1. Description of Study Site

The Lango subregion is situated within the annual cropping and cattle-farming systems that are primarily found in Northern Uganda (2.8780° N, 32.7181° E) (Figure 1). The region is dry compared to the rest of the country and experiences one long rainy season also called the unimodal type of rainfall, yet farmers can still grow two crops in a year. Although still recovering from war and related effects, such as ecosystem degradation, the region is recognized for its potential of being the country's grain basket and in fact contributing to the GDP. Farmers grow cereal, oil crops, pulses, and root tubers, in addition to rearing cattle and small ruminants such as goats. The main cereal crops grown there are maize, finger millet, sorghum, and rice; other crops grown are cotton, sweet potatoes, and cassava. The region is also notable for growing oil crops such as sesame, sunflower, ground nuts, and other legumes, such as pigeon peas, soy beans, and beans. These provide the staple food for people beyond the region and play a role in income generation for rural households, with a substantial contribution to the national economy. Soil types are ferralsols, alisols, and plinthosols [41].

Traditionally, farmers rely on family labor, and use the rudimentary hand hoe for land opening, soil inversion, and production after burning vegetation. Under CA in the region, farmers aim for minimum tillage with either hoes to make permanent planting stations, also called basins, or oxen draft power for digging rip lines.

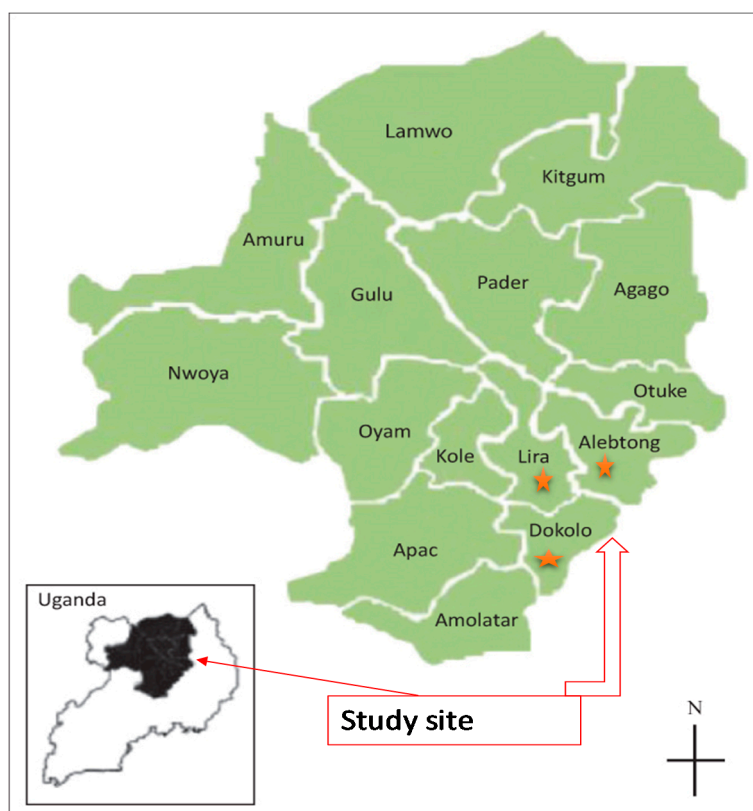


Figure 1. Study-site locations in the three districts in the Lango subregion in mid-Northern Uganda. Map source: Adapted from Kasuse et al. [42].

2.2. Data Collection

There were initial consultations with members of Uganda's national climate-smart agriculture taskforce responsible for monitoring CA in the country, followed by meetings at the local government's agricultural-produce department at the sub region's administrative headquarters in

Lira. The information gathered and the discussions held led to identifying Lango as a study site because of the need for data on the region. Lango was a major area in Northern Uganda where CA was promoted and supported from August 2011 to December 2015. Primary data were collected in 2017 over a seven-month period from three districts, namely, Lira, Alebtong, and Dokolo. In Lira, data were collected from farmers in the sub-counties of Amach and Agali; in Dokolo, the respondents were chosen from the Batta and Amwoma sub-counties; and the rest were taken from the Awei sub county in Alebtong.

The snowballing nonprobability sampling technique was employed to reach the respondents. The snowball technique involves using a known contact to identify other persons to be considered as subjects in a given study. The method was employed because the area is hard-to-reach, and information about the respondents was not easily accessible [43,44]. The starting point was with a female agricultural officer identified at local government together with a project officer who introduced the researcher to the local leader of the villages where CA was implemented. He, in turn, identified the other lead farmers and, subsequently, the 417 respondents. The selection of respondents was subjective, in the sense that the predefined group sought was that of farmers that had ever experienced CA, i.e., those who had practiced it themselves or had received training on CA. The sample was heterogeneous in that it aimed at getting views, opinions, and ideas, and not so much proportionately representing the respondents' numbers.

The study made use of a semi-structured questionnaire that was organized under six different sections; these had matching questions and were a mix of multiple-choice and open-ended questions, and statements that required ranking. The six sections were: demographic characteristics and farming practices, financial support, CA knowledge, sociocultural issues, economic factors, and institutional factors. The section on the sociodemographic characteristics of the respondents included biographical data and a description of the respondents' farming practices. The aid-dependence section required information on receipt of external funding and sources of finances. The third section required a description of how respondents understood and practiced CA, the frequency of performing CA, explanations of the respondents' CA practices, and their estimated amount of land portion under CA. This section also included open-ended questions on community perceptions, benefits, and constraints at the farm level and their perceived requirements for increasing CA adoption in their community. This was followed by a section on socioeconomic issues, which, in this case, referred to land ownership, and access and control to use the land; they additionally had to rank statements on typical factors that could influence their CA uptake, such as personal decisions, farmer-group dynamics, and/or cultural expectations. The section on economic factors allowed respondents to estimate the amount of money that they invested in their venture and evaluate statements that could influence their CA uptake. The final section, on institutional factors, required information on government programs and extension services. The final open-ended question required respondents to give any additional information and/or make recommendations on how CA uptake could be increased in their region. The above sections and their subsequent questions were guided by other adoption surveys, for example, the CIMMYT 1993 survey program and Rapid Appraisal of Agricultural Innovation Systems (RAAIS), which is a diagnostic tool useful in analyzing agricultural problems [45,46].

Due to the language barrier with most respondents, interpreters were used in these cases to translate information between English and Langi and other related dialects for the exercise. Information in the coded questionnaires was cross-checked in the field to ensure that questions had duly been responded to and clearly filled in. Information from open-ended questions was summarized, categorized, and coded depending on similarity. Data were initially entered in Excel sheets before analysis using SPSS version 21.

3. Results

3.1. Sociodemographic Characteristics and Farming Practices

The farmers that practiced CA had low education and were mostly married people above 30 years of age. Out of the sample population of 417 people, two-thirds were male, and close to 90% were married. The data showed that respondents' households had 5–8 people; one-fifth of them had 1–4 people; and just under a third had ≥ 9 people. These numbers are higher than the national average household size of 4.8 and 5.1 for this region, as reported in the UNHS 2016/2017 survey. On education, more than 60% of the respondents only had primary-school-level education as the highest level of education. Thereafter, numbers drastically dropped, with rising education levels.

Data on farming practices are typical of the region. Most of the respondents practice mixed-farming activities and, contrary to being subsistence-only, 94% of respondents practiced subsistence farming and sold agricultural produce. They mostly depended on household labor, but could also afford to use hired labor, for instance, from revolving community members and other community-service providers who had trained oxen for plowing. The northern farming system is characterized by rain-fed crop cultivation on generally flat land.

3.2. Financial Support

This section required information on whether the respondents were dependent on external funding and, if not, the sources of their finances. More than two-thirds (70%) used their own savings to finance their farming activities, and nearly all respondents relied on the village loans and saving schemes as their main financial institution. More than 80% of the respondent invested less than US\$50 per season on their land for either purchasing seeds or hiring labor (Figure 2). A third of the respondents received their technical advice from NGOs.

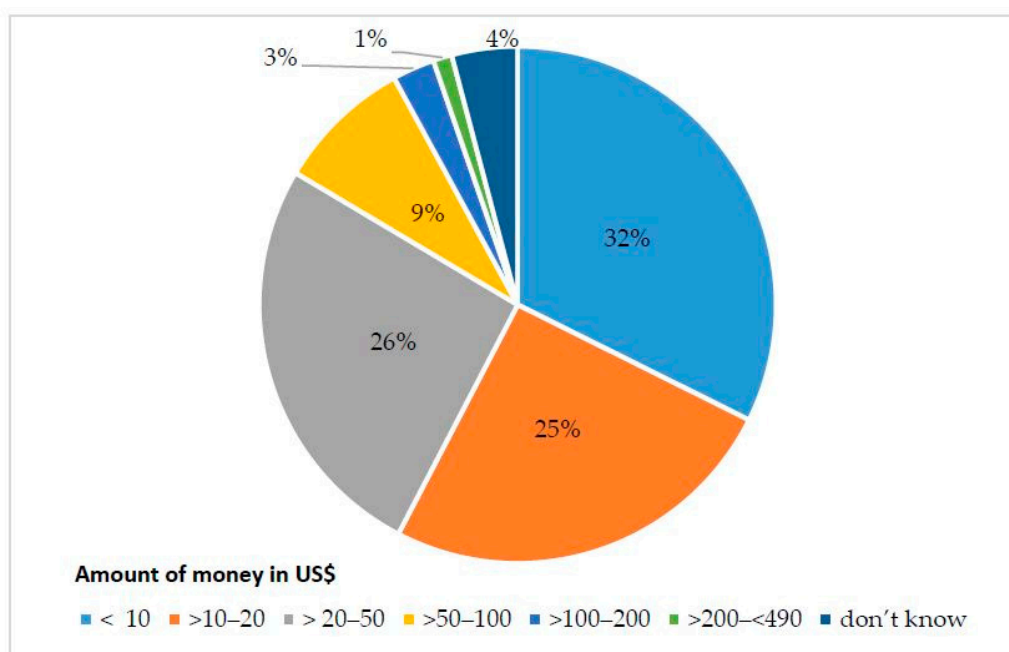


Figure 2. Amount of financial investment that respondents put into conservation agriculture (CA) farming (n = 417).

3.3. CA Package

This section gathered data on how the respondents understood and practiced CA, i.e., mentioning seasons when they did or did not practice CA. They gave explanations for their CA practices and estimated the land portion under CA; community perceptions, benefits, and constraints at the farm level; and what they perceived as important requirements for CA to be done by more members in their community.

On assessment of their knowledge and patterns of CA practices, 45% of the respondents knew all three principles of CA, although they were only able to apply two of these, i.e., crop rotation and minimum tillage. Twenty-two percent of the respondents did not know all principles of CA, while 33% neither agreed nor disagreed that they knew all three principles of CA. However, they ranked the statement on knowledge gained from training as the most important factor that motivated them to take up CA. In traditional farming practices, farmers open up their land by burning vegetation and crop residues. Farmers then carry out deep plowing, which leads to soil inversion to loosen the soil, and thereafter they sow the seeds. Under CA practices, rip lines are made into the land with the help of oxen. To practice crop rotation, depending on what farmers planted, they alternate the crops grown in the following season with either a legume or cereal different from the previous season. Under CA, new cropping patterns have been adopted, for example, pigeon peas with maize or sorghum, contrary to traditional cropping patterns where farmers grow one crop, for example sorghum or maize, for two or more consecutive seasons.

The respondents also stated how often they practiced CA and on what portion of their fields they did this. All respondents practiced CA every season but to a different extent on their fields. They estimated the portion of their fields that was under CA to either be their entire field, three-quarters, half, or a quarter of their land. Most respondents had less than 2 ha of land available for farming, on at least half of which 30% of them applied CA. This gave an estimated total of 800 ha under CA held between the respondents that were interviewed. Respondents' perceptions on why farmers in their region use CA were attributed to knowledge and awareness of CA as a farming technique for farming ($\text{CHI}^2 = 361.424$; $\text{df.} = 8$; $p = 0.000$; Cramer $V = 0.931$).

The challenges faced when practicing CA were the lack of follow-up for tracking progress, little interaction with extension officers, for instance, when they needed to ask questions, the need for further training, and little equipment. One of the lead farmers, who was also a service provider for his peers, claimed that 105 farmers had to share one manual ripper. This not only delayed planting but also frustrated other farmers who would have been willing to join the group to take up CA and access the service. Other challenges included few pairs of oxen that were specifically trained and yoked together for ripping, and markets that were dominated by middlemen who dictated the price of produce from CA fields. Forty percent of the respondents found CA easy to apply on their land, while 16% felt that CA was not easy to apply. Overall, 46% agreed that they had enough knowledge to enable them to apply CA on their land; 40% stated increased yields as the main reason for practicing CA; and 20% noted that their reason was because CA improved soil fertility.

To increase the uptake of CA in the region, most respondents suggested the provision of training and tools (Figure 3).

Women were usually shy and did not say much unless probed, which is why at least 25% of them gave no recommendation for the above question. It was also noted during the interview process that women sat by themselves and hardly spoke in the presence of a male.

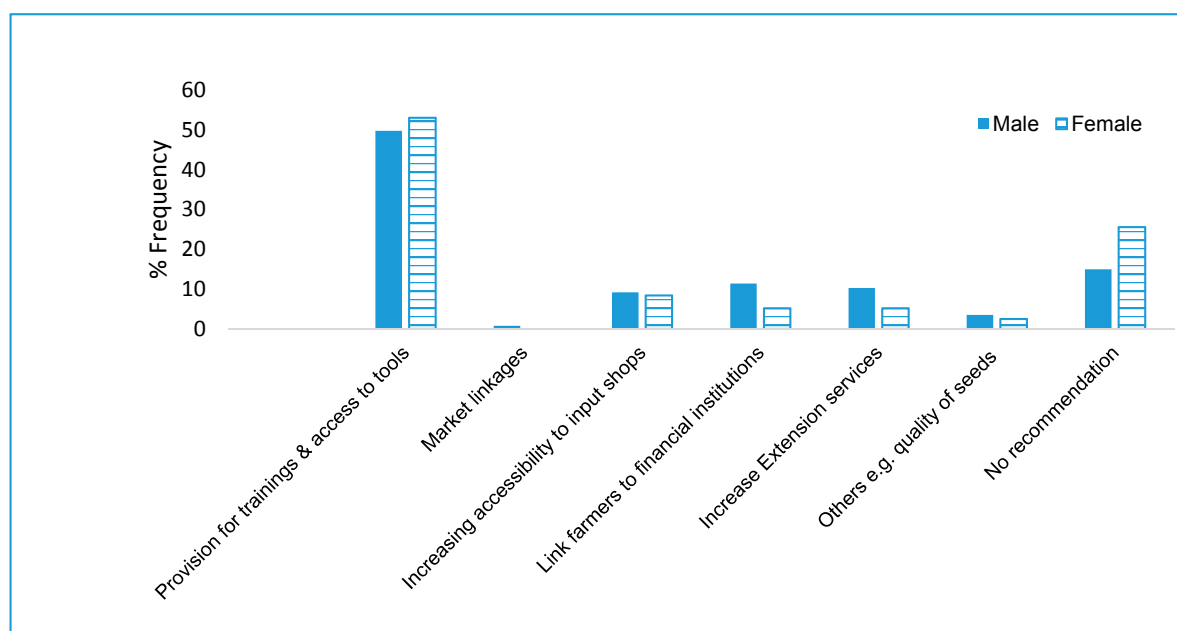


Figure 3. Gender-based recommendations for increasing CA adoption (n = 417).

3.4. Social Factors

Additionally, respondents ranked statements on typical factors that could influence their uptake of CA, such as partners, religious beliefs, cultural norms, technical training, and other factors as shown in Table 1.

Table 1. Social factors influencing CA uptake by individuals (frequency: subset of positive answers divided by sample size, n).

Sociocultural Issues	% Frequency (n = 417)
Partner	73.6
Religious beliefs	40.0
Cultural norms	65.5
Technical training	75.8
Market demands	63.1
Land ownership	56.8
Technical aid	56.1
Group dynamics	73.1
Group leader	27.8
Personal decision	88.7

Close to 70% of the land was owned by men, while 25% was jointly owned by a married couple and family land inherited from the man's family. Women owned only 5% of the land. Priority of access to land usage was mostly to men and the entire household that was mostly members from the man's family; only 4% of women had access to use the land. The same applied to decisions regarding which crops were to be planted in each season. Nearly all decisions on which crops to plant in each season were made either jointly between the man and the woman or solely by the man. Few decisions (8%) were made solely by the women.

The Pearson correlation of CA adoption and sociocultural factors (Table 2) in the communities where it was promoted was $r = 0.236$, p -value = 0.000. In conclusion, the correlation indicates that strength of association between the variables was low ($r = 0.236$), and correlation coefficient was significant ($p < 0.000$). It is also shown that 5.5% (0.236^2) of the variation in CA adoption is explained by sociocultural factors in the communities where it is promoted.

Table 2. Pearson correlation test (CA adoption and social factors).

Correlations			
		CA Adoption	Social Factors
CA adoption	Pearson correlation	1	0.236 **
	Sig. (two-tailed)		0.000
	N	417	417
sociocultural factors	Pearson correlation	0.236 **	1
	Sig. (two-tailed)	0.000	
	N	417	417

** Correlation is significant at the 0.01 level (two-tailed).

3.5. Economic Factors

Economic factors allowed respondents to estimate the amount of money that they invested in their venture, and mainly ranked statements that could influence their CA uptake. Respondents made payments to buy seeds themselves, and only 2% would pay for machinery such as ox plows and rippers. However, profit expectations (Table 3) from increased yields motivated the farmers to take up CA.

Table 3. Economic factors affecting CA uptake by respondents at household level.

Economic Factors	% Frequency (n = 417)
Profit expectations	84.4
Market prices	58.5
Cash at hand	72.4
Group negotiation	42.7
Donations	36
Access to loans	27.8
Nearby market	65.2
Availability of input shops	63
Social trust	57.6
Involvement of women and youth (Labor)	58.8

Most respondents were influenced by profit expectations and their available cash, and hardly relied on loans or even donations. This is contrary to the view that farmers in the region rely on aid for their livelihood. Due to previous experiences where group members left the village and the breakdown of cooperatives, half of the respondents were not so keen on trusting group negotiations for the sale of their produce or bulking. They claimed that each household had its unique set of livelihood problems that necessitated them to sell their produce whenever they felt the need, for instance, to send a child to school or access medical services for a sick household member. They sold their CA produce depending on these needs.

3.6. Institutional Factors

Institutional factors required information on government programs and extension services. Although central institutions play an important role in the uptake of technologies, the results from the region clearly showed (Table 4) that there was less involvement of these stakeholders in CA.

Table 4. Institutional factors affecting CA uptake.

Institutional Factor	%Frequency (n = 417)
Government communication on CA	24.2
Conducive political environment	81.8
Government programs on CA	16.8
Government agencies promoting CA	9.1
External assistance for promoting CA	18.9
Government responsibility on CA performance	3.1
Traditional practices encouraging CA uptake	58.3
NGOs promoting CA	64.7

The results show little evidence of government involvement and commitment to CA in the area.

4. Discussion

Adoption of CA among smallholder farmers in this region offered promising prospects for developing and enhancing effective strategies for scaling up the technology. This is crucial because each region is context-specific, thus demanding a unique understanding of what might work to achieve the required responses. The study has provided empirical evidence for the positive uptake of CA in the marginalized subregion of Lango in mid-Northern Uganda. Lango experiences increasing vulnerability to adverse weather conditions related to climate change, perverse poverty, historical inequalities besides its remoteness, and other postwar effects.

The major reason for adoption of CA in this region was attributed to the information gained through training provided by Rural Enterprise Development Services (REDS), a nongovernmental organization. It is evident that exposure to information played a key role in enabling uptake of CA. The knowledge that farmers gained about CA enabled them to understand why and how to practice CA, unlike other programs that simply required them to follow instructions. The farmers grasped the technical information about CA, thus providing a contrast with other findings suggesting that CA knowledge was too complicated a package for ordinary rural small-scale farmers to understand. The results showed that it was about providing learning opportunities and exposure to people to enable technology uptake. These low education levels could reflect the interruptions caused during the conflict and insecurity period of 1986–2006.

The farming system of mid-Northern Uganda was dominated by annual cropping and cattle raising; farmers practiced subsistence agriculture but also sold their produce. This showed an attempt at striking a balance between providing food for their households and earning an income. However, keeping livestock presents challenges related to the competitive use of plant residues for fodder versus mulching. This probably explains, to an extent, why farmers easily applied the other principles of crop rotation and minimum tillage. Farmers desisted from cutting and carrying mulch between fields due to an incident when one of them was bitten by a poisonous snake that was hiding in the material.

The meager financial investment that the farmers put into their CA activities reflects poverty in the region. The use of Village Savings and Loans Associations (VSLA) offered group accountability and generally meant lower risks of loss of capital assets in the case of a failure to repay loans. Farmers could hardly afford mainstream financial institutions such as banks, located more than 60 km away in the main town of Lira. Poor infrastructure (road coverage estimate = 19%) and lack of public transport meant that most services were out of reach for these farmers. This implied high transportation costs and, perhaps, the encouragement of middlemen to take advantage of the situation. It is worth noting that Uganda has a high cost of credit, ranking 125th out of 137 countries in affordability of financial services [47]. These factors imply that there is a high financial barrier for smallholder farmers that needs to be addressed. Promotion of increased CA uptake in the Lango region would require better financial investment, as the work of Sims and Heney [48] explicitly showed.

The social perspective explored in the study seems to be supportive of CA uptake. Social issues are already known to be useful in changing attitudes and gradually causing a shift away from conventional agriculture over time. Institutional support and incentive programs could certainly be used in this region to effectively increase further adoption in the region, for instance, in providing access to machinery, social learning, social development, and other social benefits. Further empirical studies are needed to further explore the role of social networks in the adoption of CA in similar areas and which social factors are at play in the region. Land-access rights, particularly for women and the youth, need to be further explored.

In terms of economic factors, further CA uptake can be motivated upon seeing profits from extra produce that normally arise from applying the technology. For farmers to benefit from market prices, they would need to improve their group negotiation power, as opposed to letting middlemen take advantage of them. However, given the high poverty levels and heterogeneity of households, exploitation by middlemen is a risk unless there is market regulation through government and private-sector engagement. To add value at the village level, other actions, such as agro processing plants, have the potential to increase farmers' selling options and prices for CA produce. These small-income increments could further motivate CA uptake.

Finally, the role of government institutional factors in implementation needs to be more visible. The adoption pattern would be a good opportunity for the government to show its commitment to the rural farmers of this region through, for instance, supporting CA scaling-up, as highlighted earlier. A key institutional factor for increasing CA uptake in the area is improving extension-service delivery. Because the region is postwar, the community appears reluctant toward the new arm of extension-service deliveries. In addition to limited coordination and coverage of extension services, Operation Wealth Creation (OWC), formerly the National Agricultural Advisory Service (NAADS), the current model of the Uganda Peoples Defence Forces (UPDF) undertaking input and service delivery, is still unclear to the farmers in the region. This is perhaps due to the postwar history and would thus need further research. The government extension system would have to streamline CA into their program in the region.

5. Conclusions

The CA adoption pattern in the region presents a promising attempt at CA uptake that is steady enough to be built upon and sustained. The demand for more CA training, extension services, equipment, and machinery provide a timely opportunity for institutional support to be provided through appropriate partnerships to enable the purchase of capital assets that can be shared within the communities. This will allow smallholder farmers to take advantage of the technology and eventually scale up. CA may even become more attractive if future research provides quantification of annual yield increases, reduced input/labor costs, and increased financial returns. Further research also needs to consider factors such as social networks in this postwar area, gender issues, land issues, machinery-sharing options, and viable markets that could absorb CA produce.

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