International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

An Exploration of Goal Hierarchies that Determine Climate-Smart Soil Technologies Farmers Use in Pigeon Pea Plots in Greater Lira

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ABSTRACT:
Pigeon pea farmers in Greater Lira, fight the adverse effects of climate change and deteriorating soil fertility. They are adopting climate-smart soil technologies (CSS technologies) to maintain fertile soil and increase yields as means to production goals of food and enhanced income. The study explored how goal hierarchies affected CSS technology commitment. A sample of 39 farmers participated in laddering interviews. Data was analyzed by the means-end chain (MEC) framework and the centrality index (CI) technique. MEC results indicate that farmers predominantly linked crop diversification, addressed dietary needs, increased yields, and increased incomes. In addition, they paid less attention to maintaining fertile soils as compared to increasing seasonal yield. Results of the CI highlight goal priorities by gender subgroups with females aged at least 40 paying more attention to producing food, soil fertility, and improving health, while male farmers of the same age category were inclined to spread production risk. Results further showed that male farmers below 40 years of age tend to produce for markets and benevolent, while their female counterparts tend to maintain soil nutrients. Our overall findings could help in the development of targeted strategies to encourage a wider spread of CSS technology use for climate-smart agriculture. This could enhance agricultural resilience in the face of climate change. We recommend encouraging farmers to apply CSS technologies while considering the long-term effects they might have on soil fertility. We further recommend that farmers intensify residual retention to improve soil fertility without requiring money to purchase inorganic fertilizer.

Introduction:

In the semi-arid farmlands of Greater Lira, Uganda, a group of determined pigeon pea farmers have been waging a protracted battle against the devastating effects of climate change and deteriorating soil fertility. These farmers face numerous challenges, including soils with low organic matter, unavailable essential plant nutrients, and high acidity levels, with soil pH less than 6, which is required for optimal plant growth (Kayuki et al., 2017). Furthermore, they must contend with a single rainy season characterized by prolonged dry spells and reduced rainfall (MAAIF, 2022; NEMA, 2016).

The impact of these harsh conditions is evident in the region's agricultural productivity, with cereal yields falling 25% below the national average. Maize yield stands at 1.3 MT/ha compared to the nation's 1.4 MT/ha, sorghum at 0.3 MT/ha versus the nation's 0.5 MT/ha, and rice at 0.7 MT/ha compared to 1 MT/ha. Even the resilient bean crops yields only 0.4 MT/ha, lower than the nation's 0.5 MT/ha (UBOS, 2020). As a result, food shortages in the region are reported at an alarming 65%, significantly higher than the national average of 47% (UBOS, 2020).

Despite these challenges, the pigeon pea farmers of Greater Lira have taken proactive steps to improve their livelihoods by adopting a range of climate-smart soil technologies (CSS technologies). By growing more pigeon peas, a leguminous crop, they are adding valuable nitrogen to the soil, which is critical for carbon sequestration and reducing agriculture's environmental impact (Munera-Echeverri et al., 2022; Nkwonta et al., 2023). These farmers have also embraced practices such as legume-cereal rotation, biochar application, minimum tillage, cover cropping, and farmyard manure, all of which contribute to improving soil fertility (Davies et al., 2021; Tibasiima et al., 2023; Zizinga et al., 2022).

However, despite the multiple benefits of these CSS technologies, earlier studies in the region indicated that only a small fraction of farmland among farmers introduced to climate-smart agriculture (CSA) was being utilized for these practices (Kaweesa et al., 2018; Kaweesa et al., 2020). The studies pointed out that food security and income generation were the primary motivators for adoption, with increasing yield being central to achieving these goals (Kaweesa et al., 2018).

In this context, our study aimed to examine how farmers' goal hierarchies influence their normative commitment to CSS technologies, particularly in cases where farmers show low technology commitment. We hypothesized that different gender subgroups prioritize goals differently, which in turn impacts their commitment to CSS technologies. Goal scholarship highlights variations in goal prioritization among farmers, reflecting differences in goal abstraction levels (Deutsch & Strack, 2020; Locke & Latham, 2019). Moreover, goal hierarchies play a crucial role in influencing the choice of CSS technologies (Atieno et al., 2023; Ngigi et al., 2018).

Normative commitment, which refers to individuals' attitudes and beliefs towards technologies, might significantly affect the adoption of new technologies among farmers (Martens & Orzen, 2021; Newman et al., 1996). CSS technologies, such as soil-smart interventions, aim to enhance soil productivity, adaptability, and climate change mitigation. In semi-arid regions like Greater Lira, CSS technologies like crop diversification, residual retention, minimum tillage, and fertilizer application offer benefits such as improved soil quality and enhanced fertility (Jones et al., 2023; Ngigi et al., 2018; Turyasingura et al., 2023).

Numerous studies have demonstrated the positive impact of CSS technologies. For example, biochar application has been shown to improve soil pH and soil available phosphorus levels (Mbabazize et al., 2023). Moreover, CSS technologies like crop rotation and residue retention have been found to increase soil organic carbon content over time, improving soil health and resilience to drought (Cheesman et al., 2016; Morugán-Coronado et al., 2022; Muchabi et al., 2014).

While inorganic fertilizer application is essential in regions with nutrient-deficient soils like Greater Lira, there are concerns about its long-term impact on soil health (Inubushi et al., 2020; Ivanova et al., 2021). This raises questions about whether farmers prioritize immediate yield increases over maintaining soil fertility. Recent studies on soil fertility highlight the risks of technology misuse for increasing yield without considering environmental impacts. Inubushi et al. (2020) found higher organic matter in unfertilized plots compare to d fertilized plots over a 10-year period, recommending proper fertilizer dosages for sustained soil fertility. Similarly, Ivanova et al. (2021) highlighted the benefits of organic farming for soil fertility compared to inorganic fertilizers, emphasizing the need for sustainable soil management practices.

CSS technologies have been promoted in Greater Lira since 2011 (Kaweesa et al., 2018; REDS, 2022). Research conducted in Uganda reveals that while farmers acknowledge the benefits of CSS technologies, they prioritize economic and social goals over environmental and ecological concerns (Ebong & Mwesigwa, 2021; Egeru et al., 2022; Kaweesa et al., 2020; Namulondo & Bashaasha, 2022; Namuyiga et al., 2022).

Farmers adopt CSS technologies to meet various goals, with their choices influenced by goal hierarchies that link these technologies to food security and income generation. The concept of goal hierarchies, initially proposed by Henri Fayol, helps break down objectives into manageable sub-goals (Kumar & Pant, 2023; Voxted, 2017). Farmers consider short-term and long-term goals, contexts, and trends when pursuing different production goals, using hierarchical approaches to optimize multiple objectives (Kumar & Pant, 2023; Ngigi et al., 2018).

Various studies have used goal hierarchies and means-end chain (MEC) frameworks to analyze farmers' choices and motivations. Atieno et al. (2023) examined Kenyan farmers' seed potato preferences, finding that goals like resource efficiency, healthy crops, planting area, and pest management were at the lowest level. Increasing yields, income, and seed-saving were at the next level, while self-development, well-being, health, peace of mind, and happiness were top priorities. Ngigi et al. (2018) looked into farmers' motivations for adopting CSA practices, highlighting goals such as soil fertility, early maturity, drought resistance, crop yield, food security, income, comfort, health, and peace.

Kilwinger et al. (2020) explored perceptions of banana planting material in Uganda, emphasizing priorities like yield, marketability, growth speed, and food security, income generation, risk reduction, and energy savings. Namulondo & Bashaasha (2022) used a used a three-wave household panel dataset to assess labor-saving technologies' impact on children's nutrition in Uganda, noting benefits to farmers like increased productivity, time-saving, food security, and extra income. Factors affecting children's nutrition included diet diversity, meal frequency, and health expenses.

Researchers emphasize the importance of considering farmers' perceived benefits to motivate the adoption of CSS technologies. However, many studies lack clear goal subdivisions. To enhance planning and resource allocation, it is recommended to organize economic, social, and environmental goals into specific immediate and end goals.

Ngigi et al. (2018) found that the immediate goals of adopting climate-smart practices related to soil are to enhance soil fertility, retain moisture, prevent erosion, and maintain nutrients. Atieno et al. (2023) reported that farmers' immediate goals include efficient resource use, planting large areas, and growing healthy crops. Okello et al. (2018) in Tanzania they focused on increasing yields and reducing costs, while Kilwinger et al. (2020) found achieving high yield, marketable, and fast-growing crops.

These studies emphasize increasing yields, maintaining fertile soils, providing food, and boosting income as the ultimate goals. Food and income are key motivators for farmers adopting CSS technologies in various studies. Thus, goal hierarchy for CSS technologies includes immediate goals of adding soil nutrients, maintaining moisture and nutrients, and intermediate goals of fertile soils and increased yield, leading to end goals of food provision and income increase.

Validating goal constructs is recommended given variations in individual goals and by elicitation methods. Goal Hierarchy Theory by Locke and Latham highlights the importance of clear goal hierarchies for achieving objectives. Although Goal Theory has limitations in focusing on the outcome rather than the process, it provided a framework for understanding farmers' production goals. The means-end chain framework by Gutman (1982) helped the researchers to understand how individuals make decisions to reach their goals, suggesting that individuals assess actions based on achieving desired outcomes. A centrality index measured the importance of a node in a network by showing its connectivity and influence (Kupilas et al., 2022). While Bringmann et al. (2019) questioned the relevance of traditional centrality measures in psychological networks, proposing tailored measures, in our study of goals, we used the centrality index to evaluate the importance of sub-goals in the hierarchy (Kupilas et al., 2022).

We found the means-end chain framework and centrality index useful for analyzing decision-making processes and subgroup differences without extensive data requirements (Kupilas et al., 2022). Technology use is influenced by the ability to implement actions for goal achievement (Locke & Latham, 2015). Sex and age impact what farmers can do in Greater Lira, affecting technology adoption (Ebong & Mwesigwa, 2021; Kaweesa et al., 2018; Namuyiga et al., 2022).

Sex and generally gender disparities in agricultural technology adoption persist due to sociocultural norms and resource constraints. Recognizing and addressing these disparities is crucial for sustainable agriculture in Uganda (Kaweesa et al., 2020). Female and young farmers face barriers like limited resources and education, impacting their technology adoption (Pellegrina, 2023; Zaman et al., 2023). Male farmers prioritize technologies that enhance income and respond to market demands (Ikendi et al., 2023; Kaweesa et al., 2020). Female farmers have less access to agricultural resources, markets, and decision-making power due to traditional norms (Namuyiga et al., 2022; UBOS, 2020).

The study further explored how the motive for maintaining fertile soils affects the choice of CSS technologies among pigeon pea farmers in Greater Lira. This knowledge enriches the primary motives behind CSS technology commitment beyond the known. Was it to increase yield instead of long-term soil fertility concerns espoused in climate-smart agriculture? Further to this, the researchers applied centrality index technique to highlight goal priorities by gender subgroups. The overall output could help in the development of targeted strategies to encourage a wider spread of CSS technology use for food insecurity and enhance agricultural resilience in the face of climate change in Greater Lira.

Methods and Materials:

The study adapted the Means-End Chains (MEC) framework to analyze differences in CSS technology use attributed to production goals among pigeon pea farmers. MEC is widely used to generate a hierarchical model of attributes, consequences, and values (Kilwinger & van Dam, 2021; Reynolds & Phillips, 2017). We modified the hierarchical model to include technology, immediate consequences, and end goals.

To match a behavior/action consequence framework (Deutsch & Strack, 2020), the model was modified. Our model consists of CSS technologies, immediate goals, consequent goals and end goals. Pigeon pea farmers choose CSS technologies to add soil nutrients, maintain soil moisture and nutrients. These nutrients are vital for improved soil fertility, increased yields needed for food, and as a source of income. This adjustment was further justified by the fact that these farmers had previously reported food and income to motivate their adoption decisions (Kaweesa et al., 2018). We also validated other benefits not related to soil included in Table 1.

We further highlighted contextual differences among farmers based on sex, age, years of education, household size, farm size (acres), years of CSA experience, and monthly income. Our innovative use of the centrality index made it possible to report on goal hierarchical differences for gender subgroups. This broke the norm of HVM comparisons between men and women. We believe that our analysis enriches our understanding of gender subgroups (Bananuka et al., 2022) since a young female is contextually different from an old female (Horng et al., 2001). Contextual differences affected adoption and commitment in similar studies (Atieno et al., 2023; Kilwinger et al., 2020; Ngigi et al., 2018). Figure 1 summarizes the overall analytical framework.

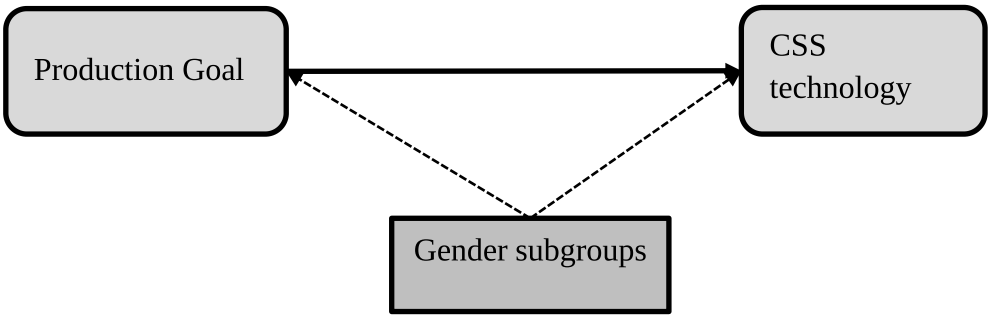

Figure 1: A conceptual framework of the study

Under MEC, a construct is linked to other constructs, and the more links running through a particular construct, the more central it is in the hierarchical value map (Kupilas et al., 2022). This is measured by a centrality index. This is the ratio of in-degrees plus out-degrees of a construct to the sum of all links in the hierarchical value map. The values are presented in an implications matrix (IM), and the CI calculation is represented in the equations that follow.

$$IM = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1i} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2i} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots & \cdots & \vdots \\ a_{j1} & a_{j2} & \cdots & a_{ji} & \cdots & a_{jn} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{ni} & \cdots & a_{nn} \end{bmatrix} \tag{3.1}$$

The calculation of the centrality index is shown in equations 3.2, 3.3, and 3.4, and the final centrality index is 3.5. Column S includes the sum of our constructs in the row, and column T includes the sum of our constructs from both relevant rows and columns.

$$S_j = \sum_{j=1}^{n} a_{ji} \tag{3.2}$$

$$T_j = S_j + \sum_{j=1}^{n} a_{jn} \tag{3.3}$$

$$\sum T = \sum_{j=1}^{n} T_j \tag{3.4}$$

Finally, the centrality index (CI) is given at 3.5

$$CI_j = \frac{T_j}{\sum T} \tag{3.5}$$

CI, as reported by LadderUX software made it possible to highlight goal priorities by gender subgroups.

Study area:

This study was part of a climate-smart agricultural collaborative research project supported by NORHED II. In Uganda, the participating institutions include Makerere University, Rural Enterprise Development Solutions, and the Norwegian University of Life. The data is from four sub-counties of the Greater Lira district, including Awei, Amugu, Omoro, and Alebtong Town Council.

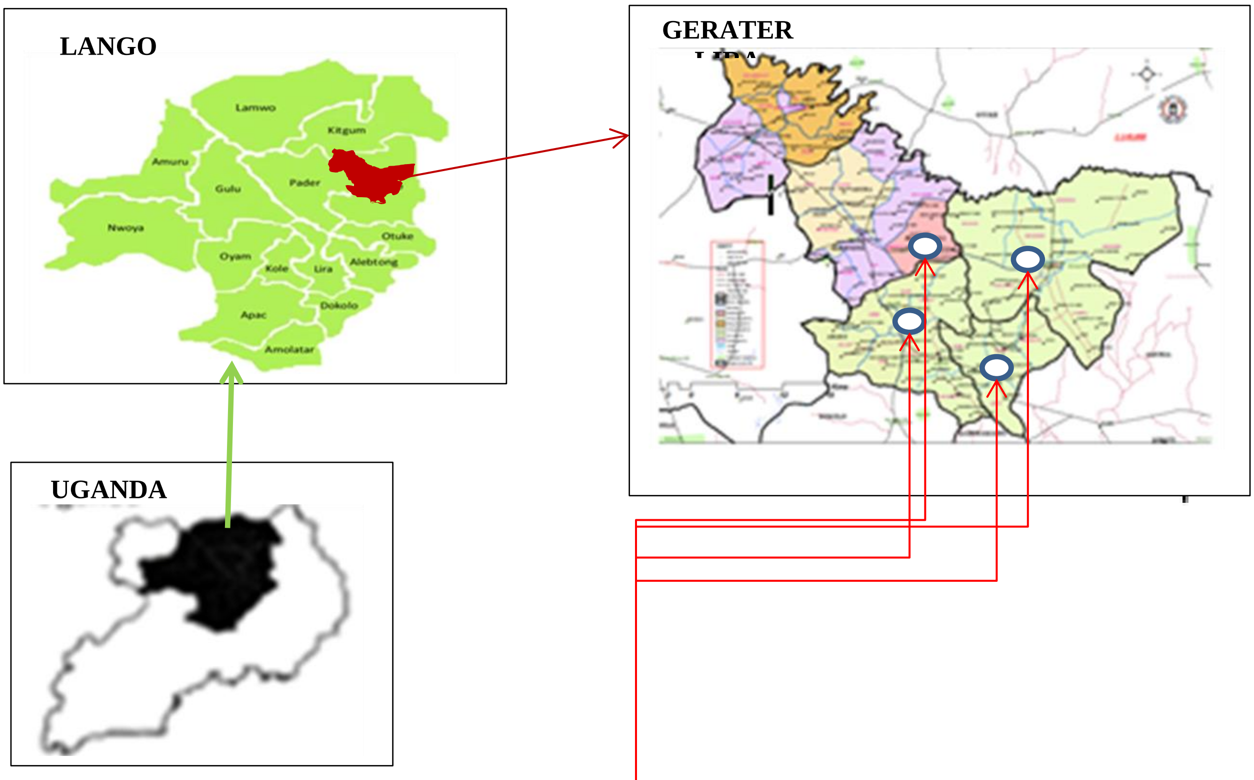

Figure 2: Map of the Study Area-Greater Lira

These sub-counties represent diverse socioeconomic conditions, institutional arrangements, and susceptibility to climate change in the region. Awei and Amugu have received direct CSA training under the project. Omoro is the most food-insecure sub-county, and Alebtong Cown council is the most urban in the district. The researchers believe that these sub-counties represent Greater Lira's diversity and context.

This region has one long rainy season, and the primary source of livelihood is smallholder farming (Kaweesa et al., 2018). Household food shortages are at 64.6%, compared to the national average of 47.3%. Climate-induced shocks such as floods and drought-invasive species are at 93.5%, compared to the national average of 74.2%. Productivity for major cereals (maize, rice, and sorghum) is 25% lower than the national average (UBOS, 2020).

Pigeon peas play a vital role for people in this region and are major contributors to CSA practices. The researchers thought they would paint a comparable picture of CSA practices based on locally available strategies. The districts were selected for being the highest producers of pigeon peas in the country (Kaweesa et al., 2018; Namuyiga et al., 2022). On top of other economies and cultures features noted by previous scholars (Namuyiga et al., 2022; Nkwonta et al., 2023), they could also could address soil fertility, food insecurity, and carbon sequestration.

Sampling procedure:

The study purposively recruited 20 farmers from 150 farmers who had taken part in CSA training, and 20 more were recruited based on cultivating pigeon peas as a main household crop. The selected pigeon pea farmers were expected to have rich experience in pigeon pea production amidst changing production goals. In addition, they were expected to face adverse climate change effects. In total, 40 farmers were recruited and interviewed in July, August, September and October 2022. 39 complete interviews were considered for the final analysis. They comprised 16 females and 23 males, of whom 53.8% were categorized as young farmers below 40 years. This sample size is sufficient because the major subgroups (male and female or young and old) exceeded 12, the number that Boddy (2016) recommends for in-depth interviews to achieve circulation. Moreover, the sample size generated sufficient ladders of 172 as compared to Ngigi et al.'s (2018) 125 and in a similar analysis, Atieno et al. (2023) used an equal sample size.

Data collection:

Empirical studies use in-depth interviews to elicit farmers' technologies and probe the respondents with a series of "Why is it important to you?" questions in the so called laddering interview (Atieno et al., 2023; Kilwinger et al., 2020; Kilwinger & van Dam, 2021; Ngigi et al., 2018). This technique is strong in data mining and elicitation of laddered responses that reveal numerous short-term and long-term benefits of a behavior (Kilwinger & van Dam, 2021; Reynolds & Phillips, 2017). The responses generate different levels of abstraction and when analyzed, they form hierarchical value maps (HVM). Here, we administered a semi-structured tool to elicit the contextual factors that determine climate change adaptive capacity and further asked the farmer to select the CSS technology they ever implemented on his or her farm. For each technology selected, the farmer was asked "why the technology was important?" We then probed the farmer for a response that pointed to soil-related goals. The adjustments to data collection, especially the laddering technique, were intended to capture soil-related benefits that are otherwise not a priority for farmers and are hardly recalled. Our actions were justified by (Reynolds & Phillips, 2017). They suggested that the laddering question could probe the direct benefit of an action or behavior. Pointing out that in laddering, a researcher can use preference differences or usage questions. Depending on the respondent's context and the direction in which the interview is conducted (Reynolds & Phillips, 2017).

Table 1: Production goal construct codes, descriptions, and percentages (%) in the data

Code	Theme Description	% in the data
CSA-technologies		
Crop diversification	The managing of more than one crop enterprise on the farm, ie: Growing many crops on the same plot at the same time; Growing two crops each in a season on the same plot; and Growing crops that maintain the well-being of other crops and/or soil.	100

Code	Theme Description	% in the data
Residual retention	The reuse of farm wastes to manage soil. Ie, Application of decomposed/burned farm wastes to the soil in the plot. Spreading of farm/crop wastes the in plot Reapplication of decomposable farm wastes to the soil in the plot.	69
Fertilizer application	The application of inorganic fertilizer to the soil in the plot ie, Application of NPK to the soil in the plot Application of UREA to the soil in the plot. Application of any other inorganic fertilizer to the soil in the plot	62
Minimum tillage	The planting of crops with minimum soil disturbance ie, Clearing the plot and planting without tilling. Having made basins (holes) for present and future planting. Having made rip lines for present and future planning.	38
Immediate Goals		
Address dietary needs	The goal or reason was to have different food types as needed to make a good or complete meal. To have different food types for different meals/markets.	85
Spread production risk	The goal or reason was to have at least one crop to feed the family if other crops fail or to have at least one crop to sell if other crops cannot get to the market.	51
Retain soil moisture	The goal or reason was to keep the soil wet, to keep the soil humid, and to prevent the soil from getting dry.	62
Retain soil nutrients	The goal or reason was to prevent on-farm flooding, prevent soil runoff, or nutrient leaching.	54
Add soil nutrients	The goal or reason was to add organic matter, make soil have healthy crops, have crops with broad leaves, to have crops with a sizable stem.	41
Consequent Goal		
Maintain fertile soils	The goal or reason was to have a good or better or high or higher crop harvest in the following season, to have crops grow well; to keep soil dark, and to keep soil vegetative.	46
Produce for markets	The goal or reason was to produce crops that are of features (size or color content or quantity) that are demanded or preferred by the market.	56
Increase yield	The goal or reason was to have more volumes produced in the current season.	97
Improve own health	The goal or reason was to prevent or treat disease in a home. To have happy children, to have energetic members in a home.	56
End Goals/Personal Values		

Code	Theme Description	% in the data
Increase Income	The goal or reason was to gain monetary value (cash, assets...) or reduce farm expenditure.	100
Avail own food	The goal or reason was to have or increase food for home consumption.	90
Benevolent	The goal or reason was too different from increasing income or providing own food.	38

Source: Field data

Data analysis:

Laddering interviews were coded using mind maps with pre-stated themes. A mind map (figure 3) provides a visual representation of ideas and concepts, making it easier to visualize connections and relationships between different pieces of information. The researchers listened to the farmer and manually analyzed their responses on their mind map (Mammen & Mammen, 2018).

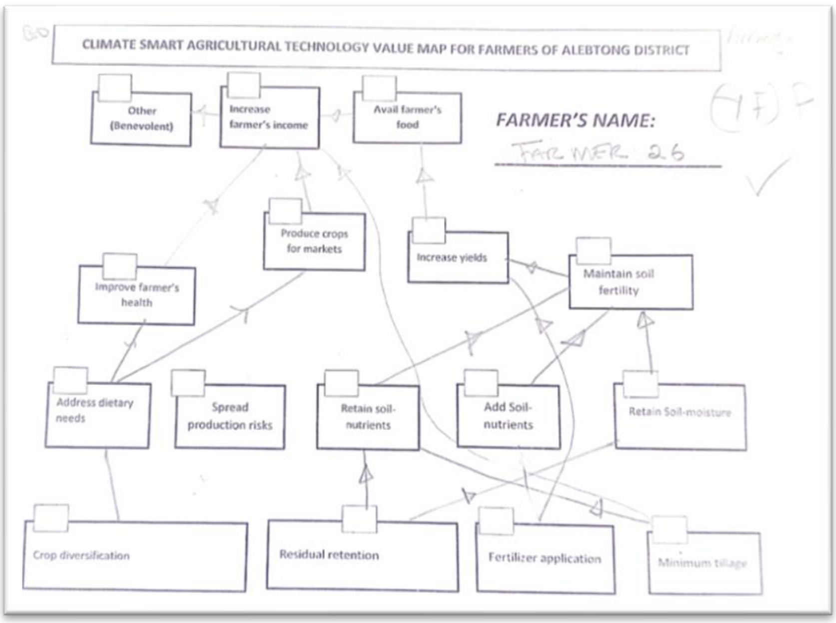

Figure 3: Mind-Map of farmer number 26

The mind maps were developed using themes in related literature that applied laddering interviews to analyze goal structures for similar CSS technology adoption (Atieno et al., 2023; Ngigi et al., 2018). The codes presented in Table 1 were validated by two coders as part of the research team. The team met every evening to compare the codes, and only codes agreed to by both parties were considered. For codes that generated disagreements, the team sought consensus and often reached agreement after reengaging the farmer for clarifications. 16 goal hierarchy constructs emerged from 39 farmer interviews. The constructs were grouped into CSS technology, immediate goals, consequent goals, and personal values (end goals). Then individual mind maps with complete constructs of the goal hierarchy of CSS technology →

immediate goals → consequent goals → personal values/end goal were entered into LadderUX-software (https://app.ladderux.org/luxapp/projects) for analysis. LadderUX reported a centrality index for each construct and the aggregated HVM for farmers. The 39 interviews with 16 constructs generated 172 ladders, 411 direct links, and 409 indirect links. This, according to the explanations given before (Reynolds & Phillips, 2017), was sufficient data to generate reliable conclusions under MEC.
We relied on the integrity of coders who are natives of Greater Lira and on their commitment to remaining true to the study. We further compared our results with existing literature and found that our goal hierarchy constructs are consistent with those of Atieno et al. (2023), Kilwinger et al. (2020), and Ngigi et al. (2018). To generate hierarchical value maps, trivial repossess needed to be eliminated. A cut-off point technique was used. While it is recommended to try different cut-off points and select the one that most effectively presents an HVM logical structure. The study used a cut-off point of 7, where at least 82% of the links remained.

Results:

Contextual factors of interviewed farmers:

Table 2 shows young male farmers were the most educated subgroup with 9.36 years of formal education. The least educated were old female farmers. Old male farmers reported the highest monthly income and the largest farm size. In contrast, young male farmers had the smallest farm size, and old female farmers reported the lowest monthly income. On average, old female farmers were the oldest subgroup with 56.4 years, and the youngest lot was young male farmers with 29.5 years.

Table 2: Summary statistics by gender subgroup of laddering interview participants

Variables	Old Female (N=9		Young Female (N=7		Old Male (N=9)		Young Male (N=14)	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Age (year)	56.44	5.46	31.86	5.76	54.44	7.81	29.50	6.24
Education (years)	6.33	1.32	6.86	3.72	8.78	3.99	9.36	3.08
Household size	6.11	1.62	5.57	1.62	8.56	1.94	4.71	1.82
Farm size (acres)	2.22	0.97	2.79	1.15	3.78	1.99	2.11	1.18
CSA experience (years)	2.89	1.54	2.57	2.15	4.22	5.07	2.43	2.62
Monthly income (‘0000’ UGX)	12.00	5.77	18.43	16.86	16.00	14.30	14.54	15.95

Note: old means a farmer was at least forty (40) years; young means a farmer was less than forty (40) years

Source: Field data

Female farmers interviewed exhibited less adaptive capacity than their male counterparts. This is demonstrated by their lower scores on key competence indicators of education, access to land, experience, and income.

Centrality indices for goal hierarchy constructs:

Table 3 presents the results of centrality index calculations of 39 laddering interviews regarding CSS technology ever practiced. These interviews were organized into four (4) categories that included crop diversification, residue retention, minimum tillage, and fertilizer application. Among these technologies, as indicated by the centrality index, crop diversification (CI = 0.09) was predominant. This means the farmers most linked crop rotation or cover crops to other constructs.

Table 3: Centrality Index (CI) for the 16 goal constructs.

Construct code	Code no.	Centrality index (n=39)
CSS technologies		
Crop diversification	1	0.09*
Residual retention	2	0.05*
Fertilizer application	3	0.02*
Minimum tillage	4	0.02*
Immediate goals		
Address dietary needs	5	0.10
Spread production risk	6	0.05
Retain soil-moisture	7	0.06*
Retain soil-nutrients	8	0.05*
Add soil nutrients	9	0.04*
Consequence goals		
Maintain fertile soil	10	0.06*
Produce for markets	11	0.06
Increase yield	12	0.13*
Improve own health	13	0.05
End goals		
Increase own income	14	0.10*
Avail own food	15	0.08*
Benevolent	16	0.03
Total CI		1.00
		$\sum CI^* = 0.72$

Where "" denotes a predicted soil-related goal construct*

Source: Field data

There were nine (9) goals linked to CSS technology. These goals had different levels of abstraction and were thus further regrouped into immediate goals—those presented as immediate during the interviews. They included "address dietary needs," "spread production risk," "retain soil moisture," "retain soil nutrients," and "add soil nutrients." Among the immediate goals, as indicated by the centrality index, "address dietary needs" (CI 0.09) was predominant.

The other goal subgroup was the consequent goals, which are realized after the immediate goals. They include "maintain fertile soils," "produce for markets," "increase yield," and "improve own health." The dominant being "increase yield" (CI = 0.13).

Three (3) personal values or end goals emerged from the interviews. They included "increasing farm income", "avail own food", and "benevolent". Among end goals, "increase farm income," with a CI of 0.10, was predominant.

Goal Hierarchies:

Figure 4: presents the aggregate hierarchical value map (HVM) for 39 farmers interviewed. This gives a visual picture of the goal hierarchy of how farmers link personal values to the CSS technology of choice. The boldness of the line gives a strong visual link between the two constructs. The bolder the line, the stronger the link between the two constructs. As shown in HVM, farmers linked strongly "increase yield" to "increase farm income" compared to other links. The choice of CSS technology is thus closely related to a farmer's objective of "increasing yield" and end objectives of "increasing farm income" and "avail own food."

The other dominant goal was to "address dietary needs" linked to "produce for markets" with the end goal of "increasing farm income." "Address dietary needs" was also linked to "avail own food" and linked to "improve own health".

Finally, the researchers moved the nodes and regrouped them to highlight the predicted soil-related goals discussed before. Accordingly, these formed 72% of the total production goal constructs for CSS technology. This is supported by the sum of centrality index values (CI*) for soil-related goal constructs in Table 3.

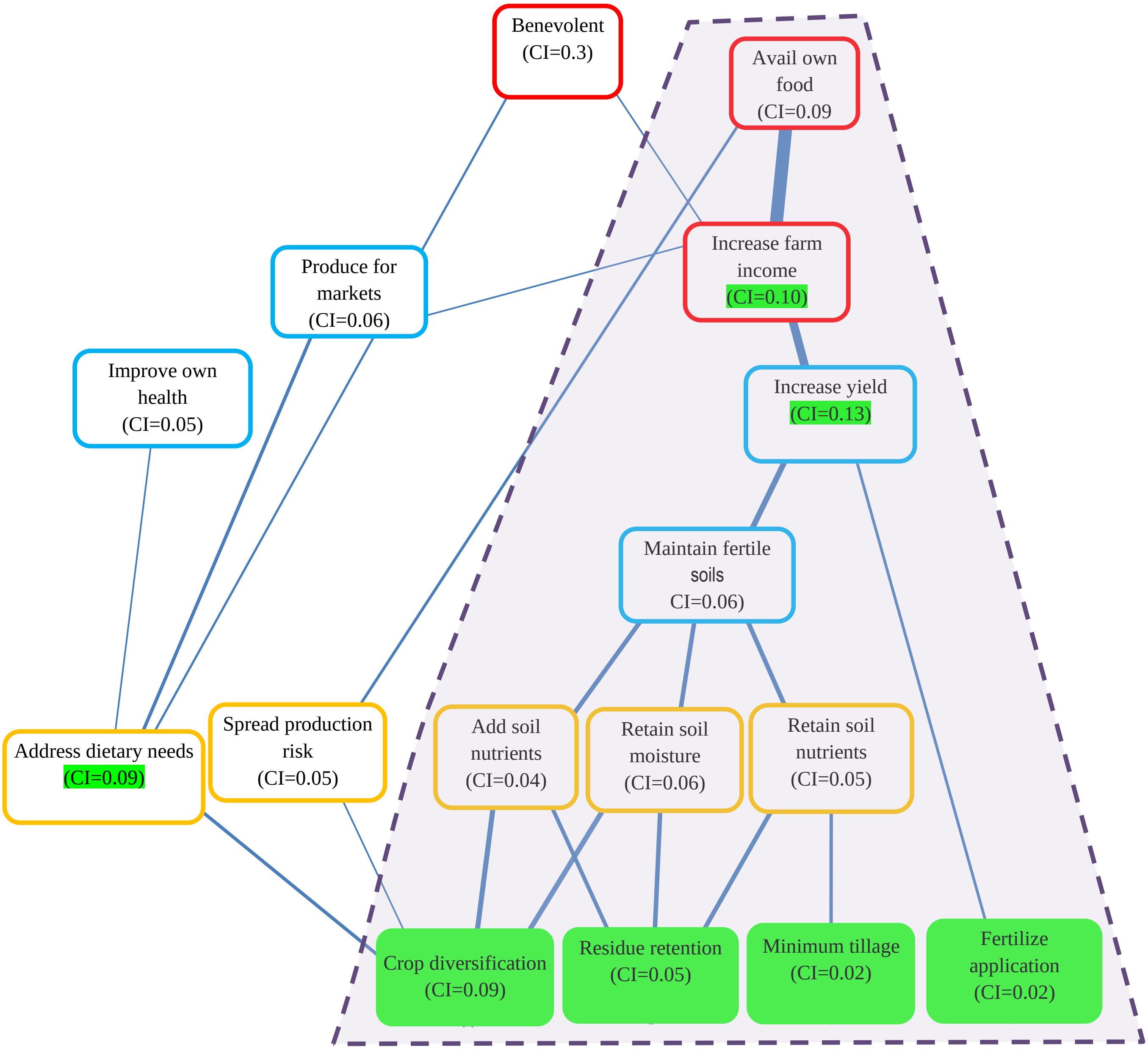

Figure 4: Aggregate HVM n=39) Cut-off point = 7
KEY:
Personal values Consequent goals Immediate goals CSA-technology Predicted soil-related goals

Centrality Index by Gender Subgroups:

Table 4.3 presents the centrality index of gender subgroups. Accordingly, the constructs present different centrality indices, indicating differences in goal or value preference between gender subgroups.

Table 4: Centrality Index by Gender Subgroups

Construct	Aggregate (n=39)	Old Female (N=9)	Young Female (N=7)	Old Male (N=9)	Young Male (N=14)
End goals					
Increase own income	***0.10***	***0.08***	***0.10***	***0.12***	***0.12***
Avail own food	0.08	**0.09**	0.08	0.07	0.08
Others	0.03	0.02	0.02	0.01	**0.05**
Consequence goals					
Maintain fertile soil	0.06	**0.09**	0.07	0.05	0.05
Produce for markets	0.06	0.05	0.07	0.03	**0.09**
Increase yield	***0.13***	***0.12***	***0.13***	***0.15***	***0.14***
Improve own health	0.05	**0.07**	0.03	0.05	0.04
Immediate goals					
Address dietary needs	***0.10***	***0.11***	***0.11***	***0.06***	***0.10***
Spread production risk	0.05	0.02	0.04	**0.08**	0.07
Retain soil-moisture	0.06	**0.11**	0.03	0.08	0.04
Retain soil-nutrients	0.05	0.02	**0.08**	0.07	0.04
Add soil nutrients	0.04	**0.08**	0.05	0.03	0.02
CSS technologies					
Crop diversification	***0.09***	***0.09***	***0.09***	***0.09***	***0.09***
Residual retention	*0.05*	***0.06***	*0.04*	***0.06***	*0.04*
Fertilizer application	*0.02*	*0.01*	*0.03*	*0.03*	*0.03*
Minimum tillage	*0.02*	*0.01*	*0.03*	*0.03*	*0.02*
Total CI	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*

Note: old means a farmer was at least forty (40) years; young means a farmer was less than forty (40) years

Source: Field data

By selecting a subgroup that linked the node (goal construct) the most, the researchers identified goals that inspired particular subgroups. Our results indicate that according to the aggregate HVM, old female farmers were inspired by goals such as producing their food (CI = 0.09), and improving their health (0.07). Female farmers, both old and young, tended to be motivated by improving soil fertility (CI = 0.09; CI = 0.11; CI = 0.08). Young male farmers were distinctively inspired by "benevolent" (CI = 0.05) and producing for markets (CI = 0.09). It was further established that old male farmers were also motivated by spreading production risks (CI = 0.08). Old farmers were more likely to reuse farm wastes (CI = 0.06) while fertilizer application and minimum tillage were least affected by subgroups (CI = 0.03 and CI = 0.01).

Discussion:

Gender issues:

The age structure reported here contradicts Ngigi et al.(2018) findings that reported male farmers engaged in CSA being older than female farmers. The unusual age gap between women and men in Greater Lira could be because the area was affected by civil wars until 2007 and paralyzed livelihoods. Since men tend to lose lives in wars than women both as fighters and captives (Micheletti et al., 2018; Plümper & Neumayer, 2006), this might have reduced the number of elderly men who were young during the civil war.

We, however, found persistent vulnerability among women, as indicated by their lower scores on income, education, and access to land as reported in other studies (Kaweesa et al., 2018; Ngigi et al., 2018; UBOS, 2020). Thus, as evidenced by adaptive research interpretations and similar findings, female farmers in the Greater Lira are more vulnerable to climate change than their male counterparts. Therefore efforts to empower women in the wake of climate change need to be emphasized.

CSS technology:

The study reports that farmers manage different crops, reuse farm waste, practice minimum tillage, and add fertilizers to achieve their end goals. This signals technology commitment among the sample and contradicts earlier assertions that reported low adoption of CSS technologies (Kaweesa et al., 2018; UBOS, 2020). This is likely because our sample was not random. We selected farmers who were introduced to CSS technologies and those who mainly grow pigeon peas. Thus most of them were expected to be practicing CSA more than the average farmer in the region. Nevertheless, the centrality index figures for minimum tillage and fertilizer application (CI=0.02) reaffirm the low adoption especially of fertilizers in the region as reported before (UBOS, 2020). Farmers need money to buy fertilizers if they are to apply them and the fact that most of them are low-income, they hardly can afford fertilizers. To improve the situation, it might require that they intensify residual retention and make their farmyard, compost, and biochar.

Production Goal:

These results highlight the multidimensionality of production goals for CSS technology as espoused by the hierarchy goal theory (Jeong et al., 2021; Locke & Latham, 2006, 2019), means-end framework (Kilwinger & van Dam, 2021; Reynolds & Phillips, 2017) and in other empirical studies (Atieno et al., 2023; Kilwinger et al., 2020; Ngigi et al., 2018). It contrasts with earlier findings that place income and household food as the most critical end goals of production (Atieno et al., 2023), which would place those constructs at lower abstraction levels. Indeed, there might have been other goals beyond income and food that we would capture. However, because we were duty-bound to analyze soil-related goals within a production season, we felt comfortable having food and income as farmer production goals. Our comfort is further supported by earlier studies that reported income and food as the main farmer production goals in the region (Isubikalu et al., 1999; Kaweesa et al., 2018; Kaweesa et al., 2020).

Nevertheless, our results agree with previous research that indicated male farmers were more commercial-oriented and money-minded (Ikendi et al., 2023). The explanation for this could be that male farmers in the study area are the breadwinners for their homes; they are expected to pay school fees, medical bills and buy necessities, including clothes for their wives and children (Akpo et al., 2020). In this context, they look for money, and indeed, they earned almost double what female farmers earned.

In contrast, the finding that women are more concerned about food can also be corroborated with findings by Akpo et al. (2020) that reported female farmers tend to worry more about household food availability. The explanation for this could be that females in Greater Lira prepare food at home. Children look up to their mothers for food, and females report higher incidents of household food shortages (UBOS, 2020). Another explanation is that female farmers have limited income sources because they are less educated. This means they have fewer chances to earn a living, making them to exchange food for income.

Goal hierarchies:

Goal hierarchies refer to farmers' mental structure. We set our objective to explore the relationship between these subdimensions (Chen, 2013; Reynolds & Phillips, 2017). Our results reaffirm our soil-related goals. We recognize that most farmers mention non-soil-related goals, but our deeper probe with why questions revealed the significance of soil-related goal hierarchies, which are estimated at 72% of the total linkages in the framework. Using a series of why questions, we generated ladders of what inspires farmers' choice of technologies. This debunks earlier assertions that ecological goals are hardly elicited because farmers easily recall economic and social benefits (Gosling et al., 2020).

Immediate goals:

Farmers mentioned "retain soil moisture," "retain soil nutrients," and "add soil nutrients" as some of the immediate reasons for adopting CSA technology. Indeed, managing soil moisture and soil nutrients is a well-established goal among farmers in the literature literature (Jones et al., 2023; Thierfelder et al., 2018; Tibasiima et al., 2023). We sought to establish the extent to which these are deliberate goals for CSS technology being pursued in the wake of climate change's adverse effects in the area of study. It is consistent with Ngigi et al.'s (2018) and Atieno et al,'s (2023) findings that farmers use CSS technology to manage soil moisture and nutrients.

Consequent goals:

When asked why managing soil moisture and nutrients was important, farmers revealed that this would lead to higher yields. Others thought it would help maintain fertile soils. In earlier studies, some farmers used yields as a measure of soil fertility (Bajgai & Sangchyoswat, 2018; Buthelezi-Dube et al., 2020). Others observe the color of the soil and vegetative cover, among other indicators, to tell if the soil is fertile. As part of our study, the objective was to determine the motivation for CSS technology. We defined the goal of "maintaining fertile soil" as a deliberate effort to preserve soil capacity to support the same or more plants in the following season. Our finding is that farmers are less motivated by maintaining fertile soils than by increasing immediate yields.

A key point is that farmers aiming at increasing yield often do so without regard for soil health effects. This is supported by the high centrality index value of "increase yield," where up to 97% is linked or mentioned this as a consequent goal. In contrast, "maintain fertile soil" scored a low centrality index, with only 46% mentioning it as a consequent goal. This suggests that farmers tend to boost yields with less regard for maintaining fertile soils or the environment. Our sample reaffirms earlier observations by Pagnani et al. (2021) that female farmers care more about soil fertility than male farmers. This further highlights the need to engage female farmers in soil fertility improvement efforts in Greater Lira.

End goals:

As discussed, the study adopted end-of-season farming goals. "Increasing farm income" and "availing own food" emerged as end goals that inspired farmers to implement the CSS technology under study.

Conclusions and implications:

In this study, the authors attempted to validate farmers' production goals for CSS technologies. 39 farmers who had previously been introduced to CSS technology were engaged in laddering interviews. Using the Means-End Chain framework, the authors present soil-related goal constructs alongside other functional goals linked to CSS technologies. The authors further calculated the centrality index to estimate the strength linkage for each construct. They also produced a hierarchical value map to visualize the mental structure of goal constructs linked to CSS technologies.

The authors have derived the goal hierarchy by validating the goals and goal structure behind farmers' choice of CSS technology. The goals are divided into two broad categories: non-soil-related and soil-related goals. Soil-related goals account for 72% of the total linkages in our framework; they include managing soil moisture and soil nutrients to maintain fertile soils and improving yields to meet farmer food and income goals. It is worth noting that 62% of the interviewed farmers used inorganic fertilizers and linked this mainly to increasing yields. There is a need to sensitize farmers about the long-term effects inorganic fertilizers might have on future soil fertility. This is to avert the looming danger posed by the higher desire to increase immediate yield (CI=0.13) than the maintain fertile soils (CI=0.06)

Farmers' choice of CSS technologies, especially crop diversification, was also linked to non-soil-related goals. A number of these goals were linked to "produce for markets" to increase farm income, improve health, and provide food for the family. Farmers also reported benevolent as an end goal. These non-soil-related goals and personal values are key determinants of technology commitment. However, the need to focus on farmers' perspectives regarding soil-related goals inspiring CSS technology has been long overdue, especially in light of climate change's adverse effects. Nonetheless, as farmers venture into maintaining fertile soil, it is imperative to enhance their incomes to drive down the need for immediate increases in yields. This is detrimental to long-term soil fertility.

In general, farmers' choice of CSS technology is linked to "increased farm income," and old female farmers' choice of CSS technology is linked to producing own food. Again, the centrality index helped identify gender subgroup-preferred goals. This fits CSS technology in the context of farmers, as it has already been reported that these subgroups have differences in access to land, level of education, income earned, age, and experience. It also needs to be noted that female farmers are more inclined to care for soil moisture and soil nutrients than male farmers. Male farmers prefer to produce for markets than female farmers. The implication is that proponents of CSS technology may need to target gender subgroups to achieve better results with CSS technology.

Our work extends MEC use beyond identifying factors influencing CSS technology choice by gender subgroups. It uses the centrality index to isolate soil-related goal hierarchies that inform farmers' production goals for CSS technology. Constructs that appeal to soil-related benefits; also highlight gendered tendencies predicated on the context of the interviewed farmers. While our findings are novel regarding farmer goal hierarchies and production goals in the context of CSS technology in Greater Lira, we will benefit from future studies that test the proposed constructs using larger samples for more generalizable conclusions. Future studies could also consider mixed methods to apply multiple tools for triangulations and further reduce coder and individual researcher bias.

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