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Contextual realities in sustainable intensification: why do smallholder maize commercializing farmers in Eastern Uganda use sustainable intensification practices

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Abstract

Sustainable intensification (SI) of agriculture is hyped for its likelihood to enhance food systems, and to reduce poverty. In Uganda, SI has for decades been included in government's agro-based intervention targeting smallholder farmers, although the uptake of SI practices remains limited. This study sought to utilize the experiences of farmers to construct an adoption profile of SI practices and to establish why farmers choose to or not to implement the promoted practices. Using descriptive design, data from 584 maize commercializing farmers of Eastern Uganda was subjected to one-way analysis of variance (ANOVA) and identified four distinct SI practice user profiles. The "non-adopters"; "sustainable farmers" (users of maize-legume intercrop and/or organic fertilizer); "intensifying farmers" (users of improved varieties and/or inorganic fertilizer); and the "sustainable intensifying farmers" (joint use of sustainable and intensification practices). Farmer socio-demographic attributes (age, sex, education, orientation to market and cultivated acreage) as well as the goals for using SI practices differed across the four profiles. Farmers in the SI profiles were middle-aged relatively better-resourced and educated male and female farmers producing mainly for market and aiming to improve yields ($F=4.16$, $p<.006$) and soil fertility ($F=13.72$, $p<.000$) through conforming to expectations of valued peers ($F=6.46$, $p<.003$). It is, thus concluded that the use of SI practices is a spatial game, limited by insufficient resourcing, gender inequities, inadequate strategies to supplement farmers' resources and differing farming goals. It is recommended that extension workers and policy makers should undertake well-targeted SI practices delivered using socially inclusive strategies and policies that promote equitable distribution of resources to men and women, respectively.

Keywords: Maize commercialization, maize-legume intercrop, Uptake of sustainable intensification practices, improved varieties, Uganda

Introduction

Global food security is increasingly becoming a challenge due to rapid population growth and changes in consumption patterns. The productivity and size of land on which food production is done have kept on reducing. Great mileage in food production has been attained especially in developed countries through intensification. However, considerable gaps remain in the developing world, where food production is by smallholder farmers, who use inefficient systems. If inefficiencies in smallholder production systems are corrected, a remarkable increase in food security can be achieved, safely.

The commonality among researchers and development practitioners is that through sustainable intensification (SI) it is possible to improve smallholder food systems in both developed and developing countries (Chaudhary *et al.* 2023) ^[10]. SI is the process of increasing agricultural yields without causing adverse effects to nature, social, and human well-being and without expanding cultivated land (Chaudhary *et al.* 2023) ^[10]. SI emphasizes the need to produce more food under good stewardship to the environment that supports production.

SI can be attained through use of multiple practices, which

are adapted /adopted by each farmer. Farmer-level SI practices have been evolving and cover the use of efficient inputs, practices, and/or technologies, mostly in an integrated way (Xie *et al.*, 2019). Some of SI practices include agronomics innovations such as legume-cereal intercrop, use of organic fertilizers, no-tillage farming, crop residue retention, soil and water conservation, crop rotation and integrated pest management. They also include the judicious or efficient use of resources, such as agro-chemicals, improved seed varieties and deficit irrigation (Jone-Garcia and Krisha, 2020; Kansiime *et al.*, 2022) ^[22, 24]. The cornerstone of SI is the need to increase in food production without expanding net acreage (Pretty and Bharucha, 2014; Buckwell *et al.*, 2014) ^[39, 8].

However, the story of SI seems to be oversimplified in literature because 'intensifying' in a 'sustainable' manner can offer challenges. Trade-offs are important considerations for each farm and increasing yields is not the one and only impetus. Because each farm is or can be uniquely resourced and deficit in others, farmers must adapt the SI measure(s) that best align with the needs of their agro-ecological zones (Buckwell *et al.*, 2014; Scherer *et al.*, 2018) ^[8]. Therefore, the direction of attaining sustainable

intensification can be dynamic, involving: 1) upgrading from the conventional systems via intensification; c2) de-intensifying; 3) amending demands over intensified lands via resting, and or; 4) reallocating particular cultivations to more suited agro-ecological zones (Scherer *et al.*, 2018).

In Uganda, considerations for agricultural SI practices have been part of most of the interventions targeting the food and income security of smallholder farmers (Bachmann *et al.*, 2017; Piemontese *et al.*, 2022) ^[37]. The main strategy pursued for most programs is to encourage smallholder farmers to increase the use of efficient inputs and practices. Piemontese *et al.* (2022) ^[37] estimate that an investment of US\$ 4.4 billion in Uganda's smallholder farmers' use of SI practice (e.g. use of mulches, intercropping, and integrated animal-crop systems) at scale can generate US\$ 4.7 billion annually. However, there have been explicit concerns in the literature that posit that as farmers desire higher yields, their conservational systems could end up transformed into intensification systems (Scherer *et al.*, 2018). This can be problematic if yields are increased at the cost of soil and water resources (Scherer *et al.*, 2018; Kim *et al.*, 2019) ^[25].

Several studies opine that the measures adaptable for environmental sustainability can be tangential for intensification objectives and vice versa (Byrnes, 1990; Hart *et al.*, 2004; Bronick and Lal, 2005; Garnett *et al.*, 2013) ^[9, 5, 15]. Needless to emphasize, sustainable intensification has in the past years been pursued through spatial separation between land considered for human development and that used to conserve nature, with the latter gazetted and protected by law (Mace, 2014) ^[27]. Such an approach presupposes that it can be possible for the micro-ecosystems nursing humans and the diverse interests of nature to exist without reasonable interdependence, which is a faulty assumption (Pretty and Bharucha, 2014) ^[39]. Human needs and those of nature, co-exist and must be concurrently tackled (Pilgrim and Pretty, 2010; Mace, 2014; Boehm *et al.*, 2014; Pretty and Bharucha, 2014) ^[39, 27, 3].

While emerging SI literature recognizes that the well-being of humans and their ecosystems co-exist and need to be pursued concurrently (Pretty and Bharucha, 2014) ^[39], research also points to a lack of uptake of SI practice, seen in low adoption rates and high dis-use rates (Brown *et al.* 2021; Chaudhary *et al.*, 2023) ^[10, 6]. From the perspective of sustainable intensification, the use or non-use or dis-use of any SI practice or a combination of such practices may not be the problem because the use of SI practices is expected to be situational and based on, spatial and experienced needs of each farm. Attributes of soil, which is the primary target for SI practices even on the same farm, and the socio-demographics of farmers can vary considerably calling for variations in the SI practices needed for adoption (Pretty and Bharucha, 2014) ^[39]. As such, socio-demographic inequalities (Ngoma, 2018; Brown *et al.*, 2017) ^[6], gender disparities in access to production resources ((Ndiritu *et al.*, 2014) ^[35] and difficulties in overcoming traditional systems and existing barriers, such as varying scale of production (Mendola, 2007; Rodenburg *et al.*, 2020; Brown *et al.*, 2021) ^[6] impact on the uptake of SI practices. In addition, such studies focus on production systems, especially profit, and yield analysis (Islam *et al.*, 2019; Piemontese *et al.* 2022) ^[37]. However, even though the uptake of SI measures cannot be understood without

considering the experiences of farmers (Chaudhary *et al.*, 2023) ^[10], farmers' lived experiences of implementing SI measures remain ignored. Insight from farmers' experiences is likely to enhance the reasons behind the use of SI practices. Therefore, this study sought to construct profiles of farmers using SI practices and the constraints these farmers encounter as they use SI practices.

Maize, the crop used in the study context, is the most abundantly produced cereal in the world, produced in every continent (FAOSTAT, 2020). The crop is the most grown cereal in sub-Saharan Africa (SSA) and more than 300 million Africans depend on maize as the main staple food crop. In Uganda, maize is grown across the country and is a direct livelihood source for 2 million households, 1,000 traders/merchants, and 600 millers who count on the crop for income. In the most recent agricultural statistics (2019) maize was produced by 69% of agricultural households and produced 2.8 million tonnes, with an annual yield of 1.6 MT/Ha (UBOS, 2020). Maize is one of the priority commodities in the Agriculture Sector Strategic Plan – ASSP (MAAIF, 2016). While the production of maize has shows a steady increase between 1999/2000 and 2018, the increase is due to expanded planting rather than productivity. For example, between 2018 and 2019 production of maize declined by 682 MT (20% of the 2018 production), which was attributable to the corresponding 24 percent less planting given that productivity for the two periods was the same at 1.7 t/ha (UBOS, 2020). Therefore, the productivity of maize is very low given that the average global productivity is 5.75 t/ha (FAOSTAT, 2020). In most parts of developing world, productivity of crop has been challenged due low rainfall and inadequate soil moisture that stress crop during growing seasons (Guzha *et al.*, 2018). Declining soil fertility and the use of poor water conservation practices has caused soil water stress and decline in maize yield (Kaizzi *et al.*, 2012) ^[23]. Uganda has been promoting sustainable intensification as an intervention with the potential to boost maize productivity for smallholder farmers. Therefore, understanding the uptake of SI practices among smallholder farmers will be insightful for national and regional economic development targeting improved livelihoods.

Analytical framework

The profiling of farmers could be pursued using the farming styles theory (FST) (Vanclay, 1998; Howden *et al.* 1998; Mesiti and Vanclay, 2006) ^[17, 30, 19]. FST proposes that individual farmers have specific understanding of what constitutes the best way to farm in order to fulfil own goals, which is shaped by their knowledge, situations and experience. FST uses contextual attributes to classify farms/farmers. Previous studies (such as Briggeman *et al.*, 2007; Daloglue *et al.*, 2014) ^[4, 12] have argued that farm/farmer socio-demographics (age, sex, marital status, primary source of income, purpose of farming, farming experience, education, and soil conditions) account for variations in the way farmers respond to interventions. In addition, for environmental-related interventions such as sustainable intensification, farmers could select a measure or fail to do so because of economic and ecological factors (Ignorelli *et al.*, 2016; Kuivanen, 2016) ^[20, 26]. For example, the goals of better-resourced farmers cultivating upland

areas can invite for the uptake of totally different SI practices from those adopted by their counterparts, poorly resourced or not, who farm on wetland fringes.

In addition, scholars of sustainable intensification identify 'sustainability = S' and 'intensification = I' as the two most important drivers of the outcomes of uptake of SI practices

(Brown *et al.* 2021; Pretty and Bharucha, 2014; Chaudhary *et al.*, 2023) ^[10, 6, 39]. Learning from Mary Douglas's (1978) four moralities framework, a graphical plot of S-I could offer a useful analytical framework for classifying and assessing variation in contextual factors among adopters of sustainable intensification practices, Figure 1.

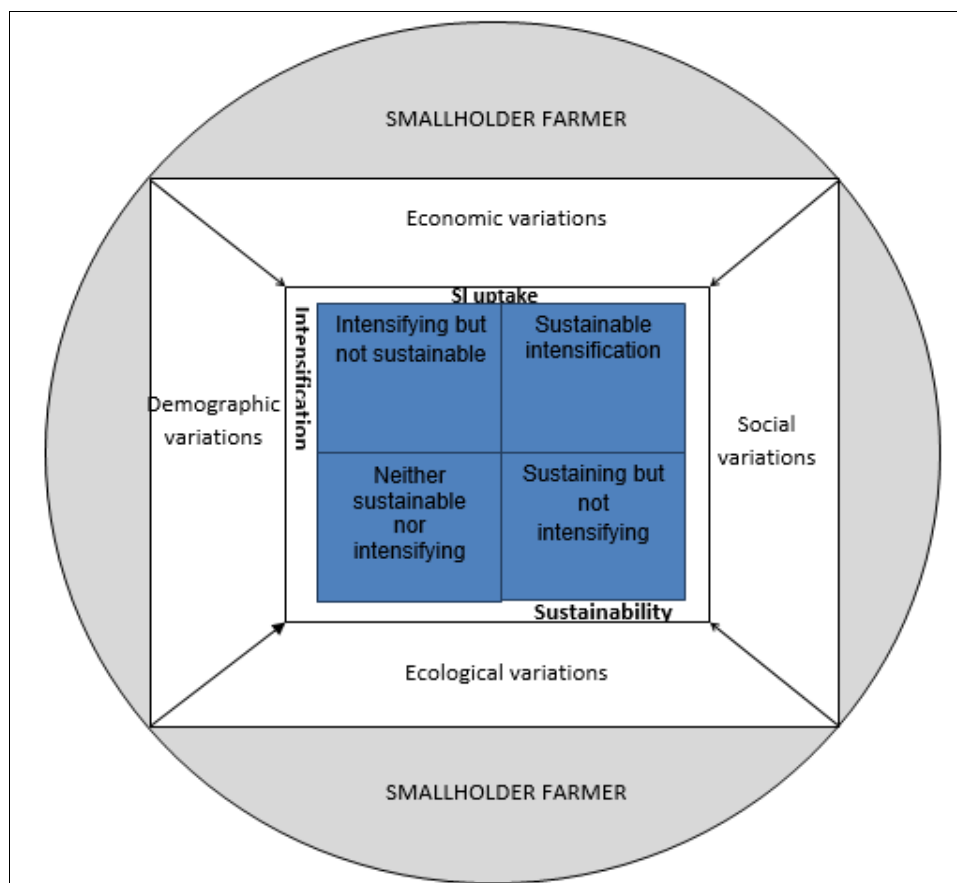


Fig 1: Conceptual model for the profile of users of SI practices

Sustainability taps into the extent to which SI practices are deemed appropriate for long-term ecological and social goals. SI measures with higher sustainability ratings are deemed to take care of the long-term farmers' interests and vice versa. Intensification focuses on the ability of the SI measure to improve yields and as such is focused on how well the measures meet the farmers' economic goal. Particularly, a plot of sustainability against intensification represents an opportunity for distinguishing the different practical groups using SI practices based on the related adoption motives and or constraints. In the end, the analytical scheme resolves into four basic typologies: farmers who are neither concerned with sustainability nor intensification, those intensifying but not concerned with sustainability, those sustaining but not concerned with intensification, and sustainable intensification-oriented farms. The resultant quadrants voice variations of farmers' situations (their socio-demographic, ecological, economic, and social contexts) in which SI measures are received, interpreted, and used (Chaudhary *et al.*, 2023) ^[10]. The study proposes that the uptake of SI practices is context-specific and rationally suited to the modalities constituting farmers' farming conditions. So, the analysis through the S-I approach aims to offer insights into farmers' decisions to

use sustainable intensification practices and the factors that condition their decisions.

Materials and Methods

Study area

The study was undertaken in Bulambuli, Namutumba and Mayuge, which are rural districts situated in Eastern Uganda, *Figure 2*. The districts were deemed appropriate sites based on evidence that they are among the highest producers of maize. The eastern region is highly infested by poverty and maize commercialization through the dissemination of SI practices are part of the poverty alleviation initiatives.

In addition, the three districts were situated in uniquely different ecological zones, that is, Bulambuli is a lowland area whereas Namutumba and Mayuge were highland areas to cater for variability in the uptake of SI practices based on agro-ecological differences. Major maize growing areas were targeted because they were most likely to exhibit the attributes under study (varied uptake of the SI practices). Deeper, for each district, two sub-counties were purposively selected for their highest maize production based on insights from district agricultural production officers. Finally, the targeted participants in this study were 600 smallholder

maize farmers (300 per district) selected using proportionate random sampling from lists of maize farmers obtained from district production officers. During actual data collection,

584 maize farmers representing a response rate of 97% of the targeted 600 were interviewed.

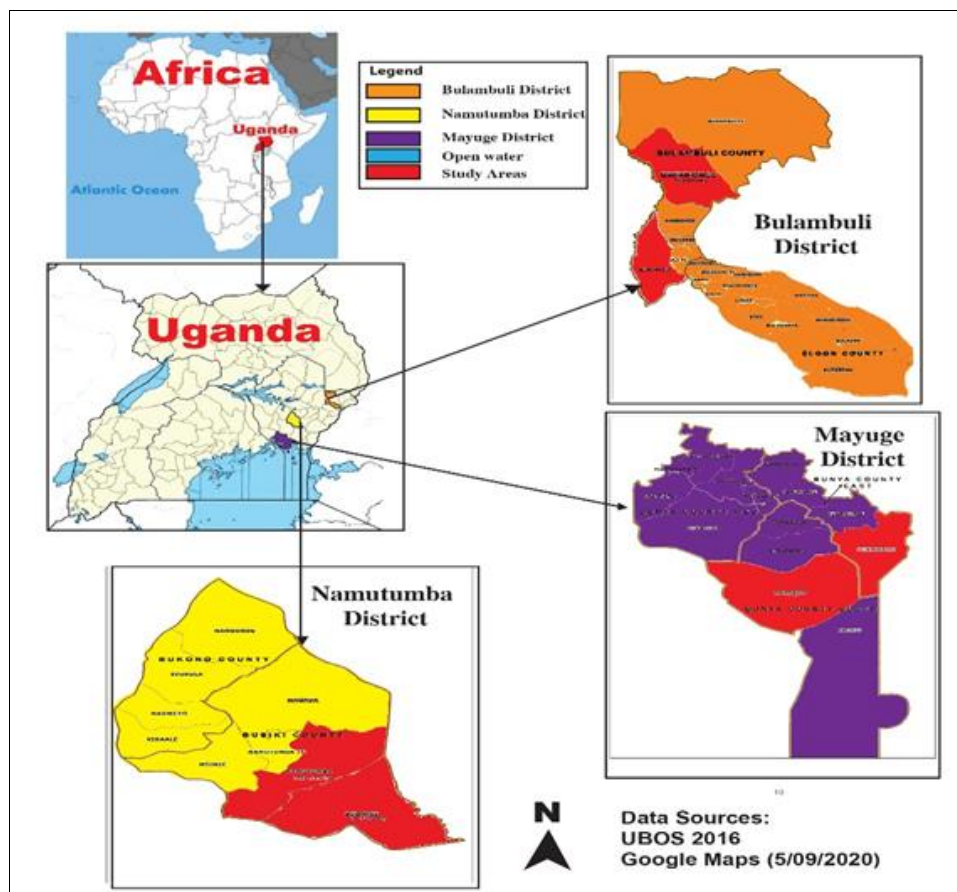


Fig 2: Map of Uganda showing study districts

Data collection

This study used the descriptive method where the aim is to describe the attributes of the event that is being studied. It focuses more on the “what” of the research subject rather than the “why” (Manjunatha, 2019) [28]. Both quantitative survey and in-depth interviews with sub-samples of the survey respondents were used. The survey was administered to smallholder maize farmers in Bukhalu and Bwikhonge sub-counties (Bulambuli district), Bulange and Namutumba (Namutumba) and Malongo and Bukabooli (Mayuge district). This helped gather in-depth information on the respondents’ demographics and their economic, social, and ecological goals. Demographics included attributes of the farmers, that is, age, gender, education, and farming experience, and the attributes of their farm, including land size, and soil type. The adopted SI practices were also covered, particularly by asking farmers to indicate on a five-point scale (Never = 1, Seldom = 2, Sometimes = 3, Often = 4, and Almost always =5), their use of each of the SI practices (inorganic fertilizers, organic fertilizers, improved varieties, and maize-legume intercrop) over the previous three growing seasons, that is the first season of 2019 and the two seasons of 2018. In addition, information was obtained on the criteria farmers consider (economic, ecological, social) when deciding about using SI practices. A five-point semantic differential scale (Never = 1, Seldom = 2, Sometimes = 3, Often = 4, and Almost always =5) was

used to gather information on the criteria. Sample questions, included, when making decisions about my farm: 1) I am concerned about improving the fertility of the soils in my plot (ecological impact); c2) I am concerned about maximizing my crop yields (economic impact) and; 3) I am concerned whether likely minded farmers are using the measure I choose to use on my farm (social impacts). Four items were included to collect information on ecological and on economic goals and three items on social goals. The instrument was piloted for appropriateness and clarity of question in Nabbaale sub-county, which is situated in Mukono district. Mukono was deemed appropriate because it was over 146 Km from the nearest study district and thus no possibility of contamination of the main study sample could occur. The survey was conducted between July and August 2019, which coincided with the start of the growing season. This was done to avoid the possibility of having farmers rely on decayed memory when responding to questions related to decision-making. Data cleaning and coding were performed to ensure the quality of data used in the analysis.

The four focus group discussions (FGDs), were conducted as follow-ups for each typology (non-sustainable intensification, sustainable, intensifying, and sustainable intensification farms) to understand the motive for farmers’ adoption or non-adoption of SI practices. Each FGD involved 10 farmers and was guided by open-ended

questions regarding the history of the land, yield trends, the perspective of land tenure laws, and how this affected the decision to use SI practices.

Data analysis

The data analysis was done in three steps using the Statistical Package for Social Scientists (SPSS) version 16. First, descriptive statistics (frequencies and means) were generated for social demographics and the uptake of sustainable intensification types. The second step established the conditioning factors of the individual categorical classes using a set of similar variables through comparing the mean scores of the variables using one-way ANOVA. At this stage, attention was assigned to the significance of the difference in the mean score of conditioning variables. Third, the post hoc test was conducted using one-way ANOVA aimed at locating the typologies that had means that significantly differed (Field, 2009) [14]. In addition, thematic content analysis of FGD information was used to identify constraints that were driving farmers' decisions under each typology.

Results and discussion

Sample characteristics

Results show that about 51% of the sample respondents were males, Table 1. Eighty-six per cent of these respondents were married. The majority of the respondents (98%) reported farming as their primary occupation and eighty-one percent of these farmers had maize as the most important crop in the cropping system. National reports cite eastern Uganda as a major maize producing hub (UBOS, 2020). Majority of the farmers sold above 50% of produced maize, which aligns with the fact that the sample was purposively of commercial maize farmers. Most farmers

were aged, 41 years, Table 2, which suggests that most of the respondents were middle aged adults according to the classification of Horng *et al.* (2001). Horng and his colleagues particularly classify people of age 30 to 39 year as young adults, then middle-aged adults for those between 40 and 59 and old-aged adults when one is sixty years of age and above. Most farmer had not completed primary education (mean <7 years) and had 14-years of experience in cultivating maize for income. On average maize was being produced on 2 acres of which the farmers owned 20% (0.4 acres) and the other used under temporary hire terms.

Table 1: Distribution of sample characteristics of maize farmers using SI measures

Characteristics	Response	%
Sex	Female =1	49.1
	Male = 2	50.9
Marital status	Married =1	86.1
	Widowed=2	7.0
	Divorced=3	3.4
	Single=4	3.4
Primary occupation	Farming (crop and livestock) = 1	97.8
	Formal employment =2	0.5
	Business =3	1.7
Most important crop	Maize = 1	81.2
	Cotton = 2	4.1
	Rice = 3	3.1
	Beans = 5	2.2
	Ground nuts = 6	2.2
	Others = 7	6.2
Proportion of sold maize for income	About or equal to $\frac{1}{4}$ =1	15.8
	About or equal to $\frac{1}{2}$ =2	35.8
	About or equal to $\frac{3}{4}$ =3	19.7
	About or equal to 1 = 4	28.8

Table 2: Socio-demographic characteristics of maize farmers using SI measures.

Variable (n =584)	Mean	Std. Deviation	Minimum	Maximum
Respondent's age (years)	41.065	13.546	17.00	97.00
Respondent's Education (years)	6.110	3.531	.00	16.00
Experience in growing maize for income (years)	14.126	9.596	1.00	49.00
Maize production (acres)	2.081	1.693	0.25	25.0
Land owned by farming (acres)	0.414	0.997	0.00	6.00

Profile of use of SI practices

The majority of the farmers fell under the sustaining (45%) typology, followed by those under intensification (25%) and sustainable intensification (19%), Table 3. Only 11% of the

farmers fell under the typology of Non-intensifying and Non-sustaining, suggesting that 89% of the farmers were implementing some part of SI measures.

Table 3: Profile of user of sustainable intensification measures

SI typology	% (n=584)	Farmers using SI practice per typology					
		Inorganic fertilizer	Improved varieties	Organic fertilizers	Maize-legume intercrop	Other (Mulching)	Other (Zero tillage)
Non-intensifying and Non-sustaining	11%	0	0	0	0	0	0
Intensifying	25%	77	146	0	0	0	0
Sustaining	45%	0	0	29	263	0	0
Sustainable intensification	19%	51	112	43	84	13	20

Consideration informing farmer use of SI practices

Broadly, the mean scores above the threshold of 3, suggest that as sampled farmers made decisions about SI practice use, there most concern was on yield, soil fertility, water retention, approvals by peer farmers, local availability and

increasing of soil volume. Under ecological, consideration for improving soil fertility (mean = 4.2), water retention (3.6) and enhancing soil volume (3.1) were highly prioritized, Table 4. Highest consideration under economical, was on crop yield (4.6) and local availability

(3.3) whereas under social only peer approval was given wider consideration. This implies that overall, farmers assigned importance to whether available SI practices can deliver ecological, economic, and social benefits once accepted. This is agreement with Ignorelli *et al.* (2016) [20] and Kuivanen (2016) [26] that farmers can fail to select a SI practice because the practice of inadequately addressed their economic and ecological goals. This is an important finding, particularly because it points to the need for promoters of SI practices to ensure that the SI practices being promoted are well-aligned with the social, economic, and ecological interests of targeted farmers. But the findings contradict Dahlin and Rusinamhodzi (2019) [11] who suggests that the use of SI practices is primary and other factors are just complementary.

Profile of use of SI practices and reason for their variation

This study hypothesized that socio-demographic factors as well as the social, ecological, and economic goals of different farmers can account for variation in uptake of SI practices. The finding presented in Table 3, revealed that some of the sampled farmers used sustainable, or intensification, or sustainable intensification practices alone

whereas a few did not use the practices at all. Tables 5 and 6 show the results of a one-way ANOVA that offers mean comparisons of descriptive variables across the four SI practice use profiles.

Table 4: Ecological, economic, and social goals

Objective	Mean	Std. Deviation	Minimum	Maximum
Ecological impact				
Erosion control	2.6	0.65	1	6
Improve soil fertility	4.2	1.42	1	6
Water retention	3.6	1.25	1	6
Enhance soil volume	3.1	0.22	1	6
Economic impact				
Enhances crop yield	4.6	1.08	1	6
Locally available	3.3	0.86	1	6
Minimize labour	2.2	0.69	1	6
Minimize recurring cost	2.6	0.46	1	6
Social impacts				
Minimize pest and disease risk	2.1	1.46	1	6
Used or approved by peers	3.6	1.36	1	6
Avoid disputes with neighbours	2.3	0.38	1	6

Table 5: Mean differences

				The mean score of variables						
Beliefs	Profile 1 (n=64)	SD	Profile 2 (n=146)	SD	Profile 3 (n=263)	SD	Profile 4 (n=111)	SD	F-value	P-value
Socio-demographics										
Sex	1.25	0.22	1.85	0.30	1.50	0.49	1.52	0.50	13.7	0.000
Age	48.6	12.10	38.37	6.38	32.43	9.72	41.06	13.55	5.84	0.016
Marital status	1.39	0.84	1.20	1.20	1.10	0.64	1.40	0.76	0.85	0.357
Occupation	1.03	0.27	1.06	0.22	1.02	0.27	1.05	0.27	1.89	0.169
Sold proportion of maize	1.08	0.96	3.4	1.04	1.60	1.06	2.62	1.08	14.85	0.000
Education	2.6	1.6	10.11	3.53	6.22	3.26	9.20	3.33	8.27	0.004
Experience in maize production	22.06	12.33	8.47	4.02	6.13	4.59	18.24	8.84	6.05	0.018
Maize production acreage	0.71	0.98	3.02	1.26	1.35	0.78	3.19	1.42	11.84	0.007
Ecological goals										
Erosion control	2.62	0.95	2.56	1.17	2.68	1.14	2.72	0.82	1.93	0.067
Improve soil fertility	2.28	1.69	4.68	0.62	3.88	0.42	4.72	0.24	13.72	0.000
Water retention	3.46	0.98	3.58	1.06	3.62	1.16	3.58	1.39	0.775	0.336
Enhance soil volume	2.12	0.89	2.01	0.96	3.6	0.22	2.84	0.62	7.53	0.001
Economic goals										
Enhances crop yield	4.10	0.96	4.8	0.24	4.23	0.96	4.25	0.88	4.16	0.006
Locally available	3.60	1.32	2.29	0.68	3.80	0.94	2.98	0.83	12.73	0.000
Minimize labour	2.21	0.96	2.26	1.12	2.32	0.98	2.26	0.68	0.54	0.638
Minimize recurring cost	2.66	0.89	1.98	1.02	3.20	0.68	2.89	0.98	4.80	0.007
Social goals										
Minimize pest and disease risk	1.62	1.02	3.02	1.12	2.88	0.96	1.90	0.62	9.64	0.000
Used or approved by peers	4.25	0.96	2.31	0.46	3.85	0.92	3.54	0.64	6.46	0.003
Avoid disputes with neighbours	2.38	0.86	2.68	0.96	2.93	1.04	2.48	0.88	1.64	0.956

* $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$ Profile 1 = Non-intensifying and Non-sustaining; profile 2 = Intensifying; profile 3 = Sustaining and; profile 4 = Sustainable intensification.

Generally, Table 5 shows that under socio-demographics variables there is significant means differences for age ($F=5.84$, $p<.001$), sex ($F=13.7$, $p<.000$), proportion of maize sold ($F=14.85$, $p<.000$), education ($F=8.27$, $p<.004$), experience ($F=6.05$, $p<.001$) and production acreage ($F=11.84$, $p<.007$). This means that age, sex, education, sold proportion of produced maize, experience in marketing maize, and cultivated acreage were crucial contributors to farmers' response towards sustainable intensification

practices. Extended deeper, it can be interpreted that the use of SI practices partly rested on the adopters' age, sex, education, level of involvement in commercial maize production, experience, and ownership of productive assets. For ecological considerations, it was improved fertility ($F=13.72$, $p<.000$) and enhancement of soil volumes ($F=7.53$, $p<.001$) that differed significantly whereas for economic, it was yield ($F=4.16$, $p<.006$), local availability ($F=12.73$, $p<.000$) and recurring costs ($F=4.80$, $p<.007$).

Among social conditions minimization of pests and disease ($F=9.64$, $p<.000$) and approval of peers ($F=6.46$, $p<.003$), differed. A post hoc test was performed for means that significantly differed, *Table 6*. Variables whose means

across the profiles were below the threshold value 3, were excluded, *Table 5*. This was because significant mean differences hold no practical relevance if the criteria are not considered among SI practice users across the four profiles.

Table 6: Mean differences

Variable	Inter-profile Mean difference and significance					
	Profile 1—>2	Profile 2—>3	Profile 3—>4	Profile 1—>3	Profile 1—>4	Profile 2—>4
Socio-demographics						
Sex	0.6***	-0.35*	0.02	0.25*	0.27*	-0.33*
Age	-10.23**	-5.94**	8.63**	-16.17***	-7.54**	2.69
Sold proportion of maize	2.32**	-1.8**	1.02*	0.52	1.54**	0.78
Education	7.51***	-3.89	2.98	3.62	6.6***	-0.91
Experience in maize production	-13.59**	-2.34*	12.11**	-15.93**	-3.82**	9.77**
Maize production acreage	2.31***	-1.67*	1.84**	0.64	2.48**	0.17
Ecological goals						
Improve soil fertility	2.4***	-0.8*	0.84*	1.6**	2.44***	0.04
Enhance soil volume	-0.11	1.59**	-0.76**	1.48**	0.72**	0.83*
Economic goals						
Enhances crop yield	0.7**	-0.57**	0.02	0.13	0.15	-0.55**
Locally available	-1.31**	1.51**	-0.82*	0.2	-0.62*	0.69*
Minimize recurring cost	-0.68*	1.22**	-0.31	0.54*	0.23	0.91**
Social goals						
Minimize pest and disease risk	1.4**	-0.14	-0.98*	1.26**	0.28	-1.12**
Used or approved by peers	-1.94***	1.54***	-0.31	-0.4	-0.71*	1.23***

* $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$ Profile 1 = Non-intensifying and Non-sustaining; profile 2 = Intensifying; profile 3 = Sustaining and; profile 4 = Sustainable intensification.

Table 7: Attributes of the Profile of users of SI practices

Beliefs	The mean score of variables			
	Profile 1 (n=64)	Profile 2 (n=146)	Profile 3 (n=263)	Profile 4 (n=111)
Socio-demographics				
Sex	Female	Male	Female and Male	Female and Male
Age ¹	Middle-aged adults	Young adult	Young adult	Middle-aged adults
Proportion of Maize Sold	About 25%	Above 75%	Less than 50%	Above 50%
Education	Primary dropout	Secondary dropout	Primary dropout	Completed Primary
Experience in maize production	Above two decades	About one decade	Half a decade	About 2 decades
Maize production acreage	Very smallholding	Relative large holding	Medium holding	Relative large holding
Ecological goals²				
Improve soil fertility	Not considered	Considered	Considered	Considered
Enhance soil volume	Not considered	Not considered	Considered	Not considered
Economic goals				
Enhances crop yield	Considered	Considered	Considered	Considered
Locally available	Considered	Not considered	Considered	Not considered
Minimize recurring cost	Not considered	Not considered	Considered	Not considered
Social goals				
Minimize pest and disease risk	Not considered	Considered	Not considered	Not considered
Used or approved by peers	Considered	Not considered	Considered	Considered

¹Horng *et al.* (2001) classification of age into young adults (30 – 39), middle-aged adults (40 – 59), and old-aged adults (≥ 60) was adopted during typology development.

²(Never = 1, Seldom = 2, Sometimes = not considered; (Often = 4 and Almost always) = considered

SI user profile 1: Non-users of sustainable intensification practices

This profile of non-SI users was predominantly made up of female middle-aged farmers of minimal education attainment who produced maize for subsistence purpose. “To us women, offering meals to the household is given first priority in planting. We have to provide daily meals to our children and husbands”, Female FGD interview in Bugoto, August 2019. Beuchelt and Badstue (2013)^[2] posit male and female farmer have different farming preferences and priorities, which tend to affect their choices of technologies.

In addition, these farmers had extant experience of over two decades in maize production. Experience demonstrates higher predispositions and judgment of what constitutes good practice. This is well aligned with the Farming Systems Theory which suggests that farmers differ in their individual stance on the most appropriate manner to farm is, based on their knowledge and experience, which constricts adoptions (Nabasumba *et al.*, 2023; Mesiti and Vanclay, 2006; Vanclay, 1998)^[33, 30, 17]. For farmers in profile (the non-users of SI practices) when making decisions about SI practice, these farmers mostly considered yield

enhancement, which they aimed to attain using locally available materials used/ or recommended by peer farmers. The fact that taking up fertilizers was never an option for these farmers, can suggest that these subsistence maize farmers accepted any yield and they are not under pressure to utilize yield-boosting innovations such as SI practices if peers do not approve. Ndaula *et al.* (2021)^[34] found farmers conformity to peers' advice to be driven by the need to maintain social relations and to avoid taking wrong decisions especially under conditions of incomplete access to information. This implies that the use of SI practices for farmers in this profile was based on economic and social considerations. The group constituted the most resource poor farmers and their land holding used for maize production was the smallest at the 0.71 acreage. As such, the decision to invest in none locally accessible inputs needed to implement SI practice is secondary, as exemplified by the farmers in relation to fertilizer use:

"Buying fertilizers comes after paying fees for our children. Our men no longer pay fees for their children. Not even medical care. You may plan to buy fertilizers for your garden but when the child is sent home from school or falls sick, money is diverted to take care of men's forgotten responsibilities", a Female FDG interview in Igerera in August 2019.

"The government gave away our traditional land to the Arab investor with no meaningful compensation. We now do not have enough land to grow a variety of crops except on the small land left. Our husbands are now working as casual labourers on sugar and avocado plantations but with little pay", Female FGD interview in Bugoto, August 2019.

SI user profile 2: intensifying farmers

Users of SI practices in this profile were predominantly male, young adults with the highest education attainment and mainly producing maize intended for the market. This is consistent with studies that suggest that men control the income sources of the family. Particularly in this study farmers are not: "As a man, I must be in control of all incomes either from maize sales or otherwise sources", Male FGD interview in Simu, August 2019). With about 10 years of maize production, farmers in this profile are considered experienced and cultivated maize on relatively large areas of about 3 acres. This corroborated literature that suggests that smallholder farming is an engendered business. Men are cited to have more access to resources, ownership of land and claim on benefits from farming than their female counterparts (Mnimbo, 2018; Wekesah *et al.*, 2019)^[32]. These male farmers aimed to maximize yield, improve soil fertility, and minimize pests and diseases when making decisions about SI practice. 'Fertilizers when combined with the new maize seeds, the yield is always wonderful in both the wet and dry season', male FGD in Bukatabira, August 2019. This implies that farmers in this profile considered ecological, economic, and social goals.

SI user profile 3: sustaining farmers

The profile had balanced sex composition between the female and male farmers and most of them young adults. Although these farmers had attended several classes of primary education, they had not completed the seven-year level. These farmers had half decade of experience, which

indicated that they were still learning about the maize production trade. This could explain why across the four profiles, this sustaining group had lengthy criteria for using SI practices. For example, these farmers' considerations for using SI practice were guided by their focus on improving soil fertility and increasing the volume of soil under ecological goals, and economic goals they aimed to maximize yield using locally available resources and aimed to avoid using measures with high recurring costs. In addition, these farmers valued peer referrals, meaning that they equally valued the recommendations of peers and or preferred the SI measures that they thought peers use, which corroborates the findings of Ndaula *et al.* (2021)^[34]. Taken jointly, farmers of this profile also value ecological, economic, and social goals in their decisions to use SI practices. Intercropping maize with legumes is considered part of the farming system for these farmers, particularly because the land is never adequate, yet farmers have to produce for food and income. Women by nature prefer to cultivate a variety of crops, mostly for food. This was corroborated in the FGD: "Intercropping maize with legumes is preferred by women because they want to plant every crop that can be served for a meal", Male FGD in Bukatabira, August 2019. The observation was confirmed in women FGD: "We have for years been intercropped maize-legumes due to limited land and the desire to grow foods and sauce a", female FGD in Bugoto August 2019. These farmers, however, did not grow improved varieties, which they said was caused by poor germination of both first and recycled seed, as exemplified by female FGD: "Some seeds we bought last year did not germinate. Also, when one recycles improved seeds, the yields are very poor. So, we decided to use local seeds", Female FGD in Buwenkanda August, 2019.

SI user profile 4: sustainable intensification farmers

Equal number of female and male farmers constituted this profile, an attribute shared with farmers in profile 3 of farmers mainly used sustainability measures. Also, likely profile two. Farmers in the fourth profile were dominantly middle-aged adults, who had completed primary education. These farmers had two decades of producing maize that they mostly targeted to produce both for the market and own consumption. This means that these farmers were experienced. Age, experience, and education jointly or individually, directly correlate with higher knowledge or understanding of the relevance of developmental interventions such as the uptake of SI measures. If subjects under study have a lengthy history of using an intervention, old age can be a proxy for experience, which as a result can shape one's judgment of what constitutes good practice. Similarly, more years in school signal acquired knowledge, which one could ordinarily have acquired through experience and maturity. These findings are consistent with the view that formal education enhances the use of technologies that require or enable workers to perform higher-order tasks (Reddell and Song, 2017). Therefore, farmers in profile 4 can use sustainable intensification practices, partly because of higher knowledge on the relevance of SI practices one owns. In addition, farmers' push to use SI practices was mostly oriented toward attaining improved yields and soil fertility under

arrangements that do not differ from peers' expectations. This means that these farmers equally valued the recommended measures and/or the measures they thought peers were using. Conformance to peer approval or perceived actions is common among socially nested individuals. Ndaula *et al.* (2021) [34] have revealed in their study on orange sweet potato acceptances that farmers tend to observe each other's actions, mainly to ensure the decisions they make are effective actions, and that they will help them to build and or maintain their social relationships.

Conclusion and recommendations

This study sought to utilize the experiences of farmers to construct an adoption profile of sustainable intensification (SI) practices and to establish why some farmers could be using SI practices while others are not. This study concludes that maize farmers take up or distance themselves from SI practices based on socio-demographic attributes and the ecological, economic, and social goals each farmer wants to

achieve. Four groups of users of SI practices exist, that is "non-adopters"; "sustainable farmers" (use maize-legume intercrop and or organic fertilizer); "intensifying farmers" (use of improved varieties and or inorganic fertilizer); and the "sustainable intensifying farmers" (joint use of sustainable and intensification practices), *Figure 3*. Broadly across the profiles with exception of intensification, farmers tended to use SI practices following the peer approvals. This means that targeting the most influential members and rewarding their progress when they implement SI practice is likely to increase the uptake of SI practices. When it comes to the specific profiles, the non-users of SI practices were female, middle-aged, subsistence maize producers who aimed to improve their maize yield using locally available peer-approved practices. This group was also resource-poor. This led to the recommendation that equitable access to productive resources, especially land would support the female farmers who are likely to fall into this group to adopt appropriate sustainable intensification measures.

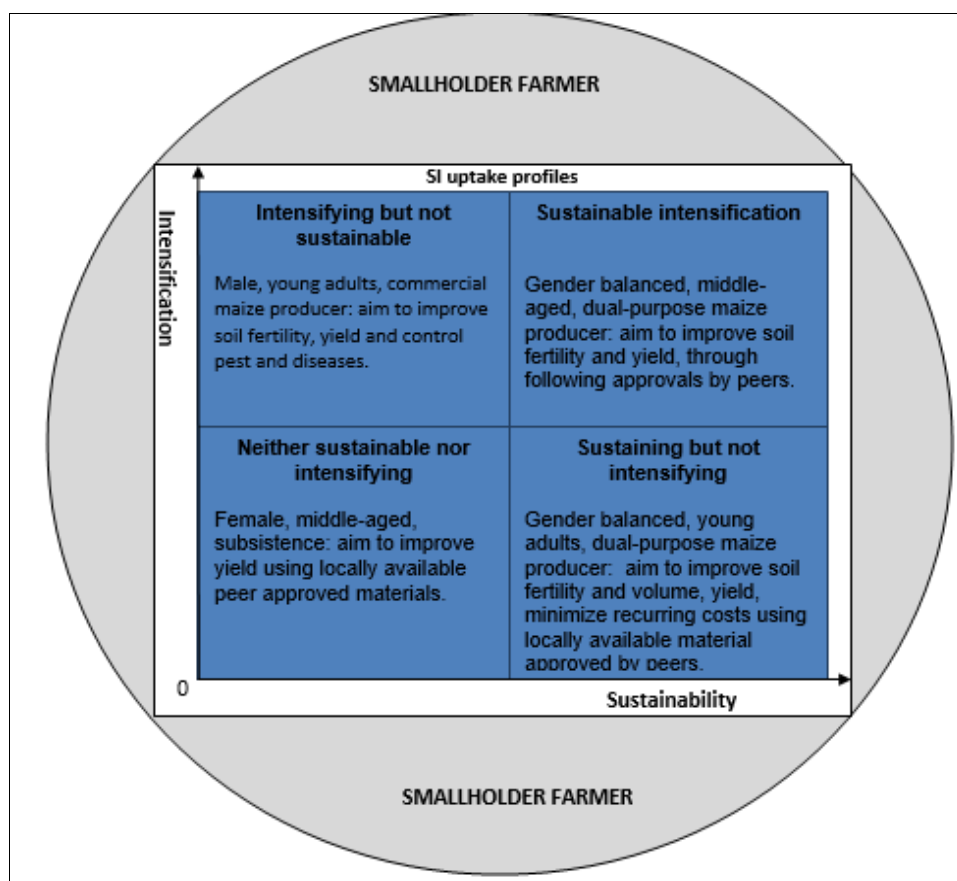


Fig 3: Profile of users of sustainable intensification practices

The intensification profiles were constituted of male, young adult, and commercial maize producers. These aimed to improve soil fertility and yields and control pests and diseases. This group requires tailored training incorporate sustainable practices such as maize-legume intercrop in order to minimize the extensive use of fertilizer. The profile of farmers who used sustainable practices had an equal number of young adult male and female farmers who produced maize both for the market and their own consumption. Their use of SI practice was aimed at improving soil fertility and yield, soil volume, and

minimizing recurring costs through using locally available practices approved by peers. Lastly, the sustainable intensification profile was gender-balanced and constituted of middle-aged farmers who produced maize for the market and their consumption. Their use of SI practices was conditioned by their aim to improve soil fertility and yield in a way that they deemed to be non-contradictory to the expectations/ approval of peers.

Accordingly, the findings of this study lead to the recommendation that when interventions such as SI are introduced in farming communities, it is important to period

change variations in adoption among the target groups to design tailored follow-up or relevant back-stop packages for adopters. This is important because each profile can be treated as a segment of single adoption journey that face differing bottlenecks. For example, the fact that the profiles with sustainable and sustainable intensification farmers were gender-balanced, indicates a likelihood that equitable engagement of women and men can improve the uptake of SI practices. In addition, those who did not adopt were subsistence women and those who adopted intensification practice were commercial male farmers, which suggests that the use of SI practices can be an engendered process, probably due to inequities in access to production resources and men's dominated control over incomes. As such, future researches should offer insights into how the gendered ownership of production resources and distribution of incomes from commercialized food crops like maize can affect the use of SI practices. Male dominated commercialized food crops can increasingly and gradually weaken women's capacity to feed their families because women would resort to using farming practices that exhaust land resource. Thus, making women unable to adequately supply food with the household. Similarly, the overuse of intensification practices by men, especially where food crops are being commercialized can expose future generations to similar risks, because overuse of intensification inputs such as fertilizers degrades land and water resources. Thus, policies that address gender inequities in resource distribution and those that create awareness on the relevance of SI practices among male and female farmers can help to create a balance in farming outcomes.

Theoretically, this study is insightful to researchers regarding the need to sustain the use of farming systems theory when delivering SI practices. Particularly, it emphasizes the relevance of valuing the contexts and holistic goals farmers put into consideration to adapt, adopt, or distance themselves from interventions. Such a revelation can obligate scholars to consider multiple theories, sometimes in combination to comprehensively obtain relevant predictors for the use of SI practices.

Conclusion

The study concludes that farmers' adoption of sustainable intensification (SI) practices is driven by socio-demographic attributes and their goals. Four farmer profiles were identified: non-adopters, sustainable farmers, intensifying farmers, and sustainable intensifying farmers. Peer approval played a significant role in SI adoption, particularly for sustainable farmers. Male farmers were more likely to adopt intensification practices, while female farmers focused on subsistence farming. Gender inequality, particularly in resource access, impacted SI adoption. Targeted interventions, including equitable resource distribution and gender-sensitive policies, are recommended to enhance SI uptake. Future research should explore the gendered dynamics in farming and resource control to inform policy development.

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