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Unknotting typologies in smallholder farmers investing in seed potato production in South-Western Uganda

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ABSTRACT

Smallholder farmer participation in seed production ensures seed security among farming communities. Interventions that promote farmer investment in seed production, however, enroll any willing farmer, yet smallholder farmers can be heterogeneously composed of receptive and new intervention-shy individuals. This study sought to identify homogenous typologies of seed potato producers investing in seed potato production in South-Western Uganda. Data collected from 213 farmers and 16 focus group discussions were analyzed using principal component and cluster analysis methods to construct farming typologies. Psychological capital and investment level were major variables in typology distilation. The results revealed 4 seed potato producer typologies including, typology 1 of 'middle-aged female seed multipliers of moderate psychological capital and low investment level', typology 2 of 'old-aged seed recyclers of high psychological capital but with the lowest investment level', typology 3 of for 'young male seed recyclers of moderate psychological capital but with high investment level' and typology 4 of 'young male seed multipliers of high psychological capital and the highest investment level'. Investing in seed potato production across the typologies was constrained by identical factors, including land shortage, limited access to markets, credit facilities and seed storage facilities. Seed interventionists are recommended to focus on typology 4, 3 and 1 producers. Future typology studies should include psychological factors to introduce practical variability nested in individual interpretations of seemly constant contexts.

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Introduction

Typologies, which are defined as organized systems of types, are commonly used analytic tools in social sciences to form as well as refine concepts, draw out underlying dimensions, create categories for classification and measurement and sort cases (Collier et al., 2012). In agriculture, typologies have been valuable, including in clustering farmers, soils, varieties and farming systems in a way that supports the alignment of interventions with specific cases (Martínez et al., 2022; Nikolov et al., 2022; Priegnitz et al., 2019; Villano et al., 2023).

To cluster farmers in similar groups, the resource base of the farmers has been used as the foundation for developing farmer typologies. Here smallholder farmers, who cultivate less than 2 hectares, are distinguished from their resource-rich medium-scale and/or

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large-scale counterparts who cultivate 2–6 hectares and above 6 hectares, respectively (Graeub et al., 2016). Studies show most (84%) of the world's 600 million farms are smallholders (Lowder et al., 2016). However, mixed evidence from reports suggests that smallholders contribute 70% (Wolfenson, 2013), 70–80% (FAO, 2014), 53% (Graeub et al., 2016) and 30–34% (Ricciardi et al., 2018) of the world's food supply which points to an identification crisis for who a smallholder is.

There has been debate whether the term smallholder farmer and family farmer, are interchangeable and, thus warrant clustering all family farms together (Graeub et al., 2016; Ritchies, 2021; Tindiwensi et al., 2020). Graeub et al. (2016) particularly described the smallholder as a family farmer who was either: well-endowed and well-integrated into markets, or had considerable assets and favourable conditions but lacked critical elements, and/or farmers who were land-poor, mostly occasioned by family subsistence/non-market activities and who require significant investment in social safety nets. Recent evidence suggests that family farms can be of any size, and not necessarily smallholders (Ritchies, 2021). Thus, what differentiates smallholder farmers and the constraints each group could face constitutes a key knowledge gap for global agricultural development and research agenda.

The above is particularly of concern for most developing countries, more so in sub-Saharan Africa where smallholder farmers constitute the most important backbone of food and agro-material production (Graeub et al., 2016; IFPRI, 2019; Lowder et al., 2016), but paradoxically constitute the largest fraction of the world's poorest and most hungry people (Hasell et al., 2022). As such, several development programmes in developing countries are tailored around smallholder farmers' economic transformation. The UN Sustainable Development Goals (SDGs), Goal 2, for example, focus on ending hunger and food insecurity through sustainable agriculture with particular attention on doubling agricultural productivity and incomes of small-scale food producers by 2030, (United Nations, 2015). Yet, despite progress in development policy, there is scant evidence to suggest that hunger is about to end where it exists (Hasell et al., 2022).

While smallholder farmers across continents, regions, nations or even within a country share the same attributes, clamping these farmers under a single group could be an over-simplified image (Guarína et al., 2020; Lowder et al., 2016; Opolot et al., 2018). This could impede efforts intended to support smallholder farmers at the policy and field levels (Graeub et al., 2016), because situations in which smallholder farmers' activities are nested do vary extensively. In addition, smallholder farmers are highly diverse in resource endowments and livelihood strategies (Tittonell et al., 2010). The seminal work of Munier et al. (1999) demonstrates that due to relevant variables, such as information asymmetry, and or the value assigned to the economic worthiness of the intervention due to variation in smallholder social, economic and psychological status can constrain or enhance a farmer's reasoning and response to actionable interventions. In sum, the staging of smallholder farmers' uniform group can mask relevant details and thus lead to poor targeting, design and oversights in the implementation fidelity of interventions (Graeub et al., 2016).

Potato, the crop used in the study context, is the world's fourth largest food crop in terms of production preceded by cereal crops, that is, maize, rice and wheat (FAOSTAT, 2019). Potato is thus the largest non-cereal food crop cultivated in the world. Uganda is an agricultural country with an average farm size of 0.97 ha (Food and Agriculture Organization of the United Nations, 2018). The country's agriculture is predominately smallholder (UBOS, 2020). Fifty percent (50%) of potato production is by smallholder farmers in the south-western (82,806 metric tonnes) and the eastern (80,377 metric tonnes) mountainous agro-ecological zone.

In the south-western region, potato is the flagged intervention for food security, income generation, poverty reduction and economic transformation strategies (Okoboi et al., 2014; UBOS, 2020). The crop's short maturation cycle yields a potential of up to 50 tons/ha, and easy cultural activities, make it an intervention of choice in the farming area with limited cultivatable space and profuse labour since potato was particlularly promoted for land -scarse families (Aliguma et al., 2007). The shortage of land in the area is due to high population growth coupled with land fragmentation (Whitney et al., 2018).

Despite potato production promotion in intervention areas such as South- Western Uganda, smallholder farmers' ability to meaningful gain from potatoes is poor and they have been losing ground. Uganda's national average potato production was 7 MT/ ha in 1999 –2007 and declined to below 5 MT/ ha in 2008 (Food and Agriculture Organization of

the United Nations (FAO), 2018; UBOS, 2020). The low yield of potatoes in Uganda is constrained by the low use of fertilizers, plant health enhancers and improved seeds. For example, Okoboi et al. (2014) found in their study conducted in 2008/09 that within the south-western region 18.1% of the farmers used fertilizers, 29.2% of the farmers used fungicides and 0.5% of the farmers used quality seed. The use of poor-quality seed is by far the most limiting factor in food production since it can cause 100% yield loss (Bertin et al., 2012). In addition, the quality of the seed interacts with and determines the utilization of other farming inputs, such as water, fertilizers and the optimization of the pedigree of the variety grown (Lukonge et al., 2015; Welu, 2015). Seed quality also determines the crops' ability to outvigour weeds and pests and to cope with aggressive climatic conditions. Thus, it can be argued that the supply of quality seed potato to farmers is the main constraint to potata production in Uganda and in most developing countries.

The common way in Uganda of choosing seed tubers for the next season consists of selecting tubers from the bulk of the harvest of the ware potato (potato intended for consumption) (Mbowa & Mwesigye, 2016). Ware potato is known to lead to poor-quality seed potato and low yields (Kumar et al., 2022). Several students of seed distribution (e.g. Louwaars & De Boef, 2012; Maredia et al., 1999) posit that if smallholder farmers are supported to produce quality seeds, it is possible to increase their level of use of quality seeds. As such, several government and NGO agencies in Uganda have promoted smallholder farmers' investment in seed potato production arguing that locally produced seeds involve low transaction costs for the seed suppliers and ware potato farm which makes it a lucrative investment opportunity. For example, the return on investment in seed potato production in Uganda is three times the invested money (Mbowa & Mwesigye, 2016) compared to that in other countries such as Nepal that is estimated at two folds (Kumar et al., 2022).

Despite the well-argued case for farmers' investment in quality seed potato production and 10 years of promoting the intervention (2008–2018), only 10% of the farmers use quality seeds (UBOS, 2020). As noted earlier, interventions can fail because the design and implementation are poorly aligned with the intervention groups, leading to poor targeting. Potato farmers do not experiment with interventions that they deem misalign their goals (Ortiz et al., 2011). Mapping different smallholder farmer categories is a conduit for incorporating farmers' socio-economic situations into the uptake of agricultural technologies (e.g. Jayne et al., 2019). The use of typologies is considered the starting step of technology delivery (Berre et al., 2017) and in improving running programmes. The attempts have mainly been to characterize variation in adopter categories in terms of differences in the socio-economic characteristics of the farmers and access to support services such extension (Tadesse et al., 2019). Ownership of production assets closely estimates the financial capacity to invest (Tittonell et al., 2010) whereas support services offer valuable knowledge and information (Ortiz et al., 2013) that may be necessary in choice of investmnet enterprisese. However, the role of psychological factors in smallholder typologies, remains unclear although the socio-economic status can lead to different psychological constraints (Ndaula et al., 2021).

Moreover, typologies are not static but are subject to change because as farmers or nearby peers interact or experiment with the intervention, they accrue experiences that re-enforce individual farmer's cognitive environment (Ndaula et al., 2019; Ndaula et al., 2020). Under such conditions, the role of socio-economic factors in typology formation is expected to continually be deferred and or reframed into new interactive 'circuits' of practice (Sovacool & Hess, 2017). For an intervention like local seed potato production, some typologies could emerge as being well suited for buying and producing seed and others may even distance themselves from the interventions (Long, 2001; Mango, 2002). Thus, to enhance understanding of smallholder farmer investment in seed potato production, identification of homogeneous typologies is likely to be helpful. The next section highlights the conceptual framework and methodology used in the study, followed by the presentation and discussion of results. The conclusion and recommendations of the study are presented in the last section.

Conceptual framework

The development of typologies could better be pursued through the sorting of types depending on the way each aligns along a standard scheme of concepts. To that end, Jan Douwe van der Ploeg offers the farming styles theory (FST) (Howden et al., 1998;

Mesiti & Vanclay, 2006; Vanclay, 1997). From the FST perspective, different farmers have different stances about the most appropriate manner to farm to fulfil their own goals, which are based on their knowledge and experience. The utility of FST was deemed appropriate because the theory assumes the decisions of each farmer are guided by own view of what constitutes a good strategy.

The traditional FST uses structural characteristics of the farm such as landownership, size of land and the production system to classify farming households because members in the same neighbourhood should encounter the same ecological and institutional conditions and constraints (Ignorelli et al., 2016; Kuivanen et al., 2016; Michelle et al., 2015). Thomson (2001) extended FST and he incorporated variations due to cognitive stance (attitudes, beliefs and perceptions). This study extended Thomson' (2001) stance, by utilizing the concept of psychological capital from the Modified Sustainable Livelihood Framework (MSLF) by Chipfupa and Wale (2018) but within the assumptions of FST. The addition of of psychological capital in typology development in this study is bassed on the assumption that, under the same structural situations, people are not bound to display similar cognitive readiness to respond to an intervention. Psychological capital refers to one's state of mind at a given time in a given state of existence and context (Seligman, 2002). This implies that people's mindsets are subjects of time, space and occasions and as such the mind is a nest of forces that could constrain or enhance one's decision to pursue opportunities.

Figure 1 summarizes the conceptual framework. The estimation of psychological capital was deemed to match psychological factors because attention to the former was aimed at understanding the farmers' cognitive environment related to investment in seed potato production. Chaudhary (2013) outlines, anchoring (optimism), over-under reaction (resilience), over-confidence, loss aversion and herd behaviour (social influence) as the major psychological factors affecting financial decisions. Anchoring refers to the human tendency to attach or 'anchor' their thoughts to a past reference point even though its logic is weakly aligned with the task at hand. Over-under reaction is concerned with disproportionate reaction to opportunities, news or information leading to irrational optimism or unjustified pessimism. Overconfidence refers to people's tendency to underestimate the imprecision of their beliefs and to overestimate their ability. Herd behaviour is the tendency of an individual to follow the actions (rational or irrational) of a larger group. Loss aversion refers to the willingness of people to take more risks to avoid loss than to take similar risks to realize gains. Thus, in this study, the use of psychological factors was aimed at estimating farmers' predispositions regarding optimism, resilience, self-confidence, loss of aversion and social influence towards investing in seed potato production. It is assumed that farmers with supportive psychological factors, have a higher psychological capital to pursue 'opportunities in new interventions (Simons & Johanna, 2013; Luthans et al., 2015).

Previous studies (Bidogeza et al., 2009; Briggeman et al., 2007; Daloglue et al., 2014) demonstrate the importance of household-specific factors such as age, gender, marital status of the household head and household size in typology development, with their role varying across contexts. The use of economic and institutional factors is common (Ignorelli et al., 2016; Kuivanen et al., 2016; Michelle et al., 2015). Therefore, these factors are introduced in this study to evaluate the emerging types of smallholder seed potato investors. It is assumed that the incorporation of individual farmers' contexts could bring out an insightful understanding of seed potato production investments. Therefore, this study sought to identify homogenous typologies of seed potato producers in south-western Uganda among smallholder farmers in seed production intervention communities.

Materials and methods

Study area

The study was conducted in two purposively selected rural districts: Kabale[1] and Kanungu of Uganda, a country that lies between 1̊29′ South and 4̊12′ North of the Equator and between 29̊34′ East and 35̊00′ East of the Greenwich. Both districts are situated in South-western highlands, a region well suited and known for potato production, courtesy of the region's year-round mild temperatures, abundant rainfall and deep volcanic soils. This region offered a good context for the study because it has a history of producing a vast proportion of Uganda's potatoes, which is 88% national annual yield as of 2008/2009 at the capacity of 5.2 MT/ ha (UBOS, 2010), which has since declined to 64% at 3.0 MT/ha (UBOS, 2020). Of concern, in nearby regions of Rwanda with

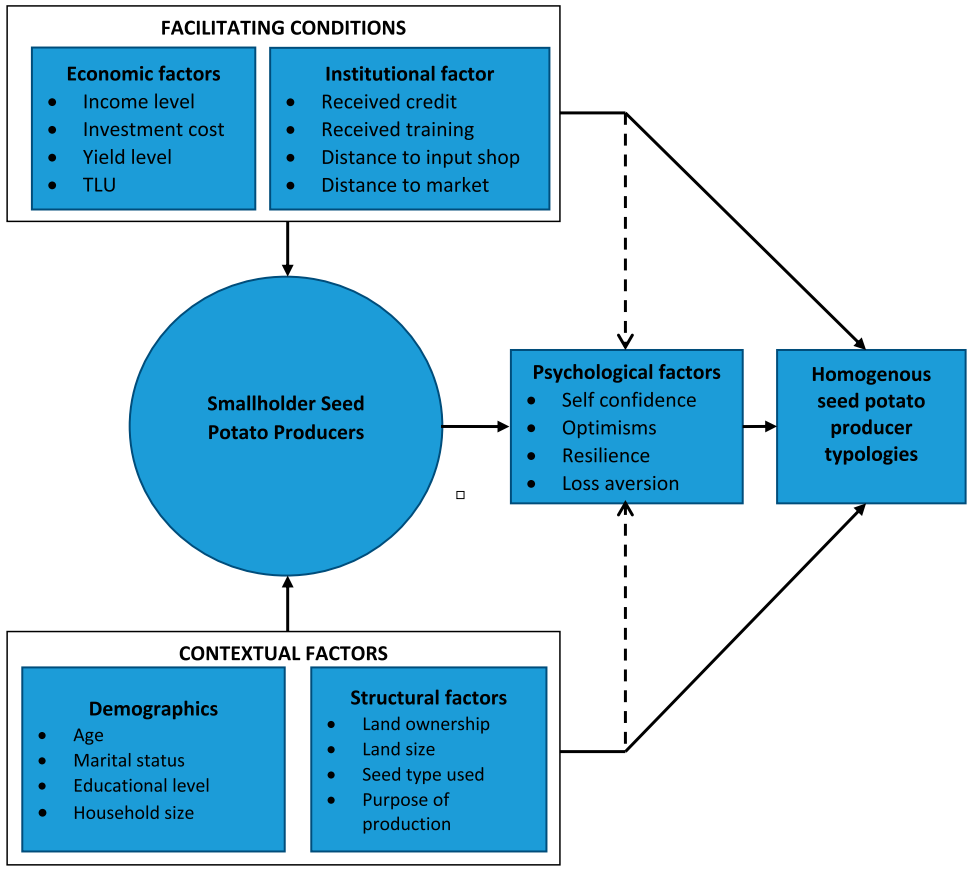

Figure 1. Conceptual model of variables defining smallholder seed potato producer typologies. Source: Adapted from Bidogeza et al. (2009), Chipfupa and Wale (2018), Goswami et al. (2014) and Imogen et al. (2009).

comparable agro-ecological status, the average potato yield is 14.2 MT/ha (Knoema, 2016).

In selecting Kabale and Kanungu, it was intended to include a district with the highest (Kabale = 52% of households in the district) and lowest (Kanungu = 7.3% of households) prevalence of smallholder potato production in the region (UBOS, 2016). Second, the selection aimed to include districts that had had extensive projects and NGO activities on seed potato production implemented over the last decade (Mbowa & Mwesigye, 2016). Particularly, with attention to the preceding criterion, study participants were enrolled from Muko and Kamuganuzi sub-counties for the case of Kabale district and from Rutenga subcounty for Kanungu district.

Study design, sample and tools

This study employed a mixed design conducted between November 2018 and February 2019, where a cross-sectional survey preceded the in-depth focus group discussions on a purposively selected smallholder potato seed producers. This design was most appropriate given that the intention was of developing typologies of farmers is situated within the farming system. Survey data were collected using a semi-structured interview schedule, administered by trained interviewers. Individual producers offered their own views on the structural, institutional, economic and psychological variables pertinent to seed potato production. Data included in the study were from 213 (86.6% response rate) seed potato producers using a sampling frame provided by UNSPPA (an umbrella body for seed producers) and farmer group chairpersons. These were then used to identify and characterize seed potato producers into four typologies.

In-depth scans for attributes of each typology were pursued by conducting qualitative strategies on a sub-sample of the survey sample. Sub-sample

participants were enrolled purposively based on the key attributes of each typology. Particularly, two focus group discussions (one per district) of 11 producers each were conducted for each identified typology. The aim was to elicit deeper insights from survey farmers in each typology regarding land size, access to institutions, household assets, adaptation to production risks and farmer knowledge and skills. Production constraints for each typology were also established and evaluated within the FGD sessions.

Measurement

Demographic characteristics included sex (male = 1, female = 0), age (in years), household size (number) and education (years completed in school). Structural variables covered land ownership (yes = 1, otherwise = 0), land size (acres) and seed type used (1 = basic, 0 = otherwise). Psychological factors (self-confidence, social influence, loss aversion, optimism and resilience) were assessed using a five-point scale (*1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree 5 = strongly agree)*. Interpretation of the psychological scale was based on means (*mean ≤ 2 was deemed to be low, values between 2 and 3 were equated to moderate and a value ≥ 3 was deemed high*). Institutional variables, included belongingness to a seed producer group, acquired credit, and having acquired training, all measured as a yes = 1 or no = 0 scale while credit magnitude was measured by the amount of credit received in Ugandan shilling. Institutional variables, included distance to input shop, distance to seed potato source and distance to market measured all in kilometres and economic factors, that is, selling price for seed potato and average invested money (measured in Ugandan shilling), yield (kilograms) and total livestock unit (TLU) measured numerically.

Data analysis

Analysis was done in three major steps of multivariate analysis. First, Principal Component Analysis (PCA) was performed to establish the data patterns and to identify variables that were likely to offer meaningful explanations for typology development. Within agricultural field, several studies in the typology development domain have adopted this approach (Bidogeza et al., 2009; Chipfupa & Wale, 2018; Goswami et al., 2014; Hammond et al., 2020; Matus et al., 2013; Musafiri et al., 2020; Tittonell et al., 2010). Given that the study deals with different scaled variables, standardization through scaling was done before the running of the PCA (Nainggolan et al., 2013). This ensured that all variables were on a common scale and had equal influence on the principal components. PCA diagnostics included in the analysis were the Kaiser–Meyer–Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity, with Eigen values set at 1. The KMO value ≥ 0.5 and Bartlett's value ≤ 0.05, for the extracted component signal that the components merit being used in typology development (Hair et al., 2010). Factor loadings ≥ 0.4 were considered adequate to qualify a variable under a component.

Second, two phases of Cluster Analysis (CA) that is, Agglomerative Hierarchical Clustering (AHC) and K-Means Clustering, were implemented to distil seed producers of homogenous characteristics. The AHC was used to determine the number of clusters which were subsequently subjected to K-Means clustering for further sorting. AHC uses Euclidian distance and the means to identify the differences in variance between clusters using PC scores through the nesting process (Field, 2013). The nesting process ran until it produced more reliable and stable clusters. Four distinct clusters with maximum homogeneity within were maintained. Third, a One-Way Analysis of Variance was performed to identify variables that accounted for variations between clusters, which was intended to benefit typology naming. FGD data were subject to content analysis using themes that aligned with survey data.

Results and discussion

Description of PCA variables used in the identification and classification of typologies

Table 1 presents the status of the variables used in the principal component analysis. The summary of PCA loadings is offered in Table 2 and details of diagnostics are in Appendix B in the suplementary materials file. The KMO coefficient of value 0.7 (threshold ≥ 0.5) and a significant Bartlett's value ($p \leq 0.002$) for the nine extracted components gave a positive signal to proceed with the components in typology development. In addition, the explained variance of 64% indicated that the components accounted for a pragmatically significant proportion of the dataset. The explained variance, by components 1 through 9, was the largest for component

Table 1. Descriptive statistics of the variables used in principal component analysis and typology development.

Variable	Description and Units	Mean	Standard-deviation
Household characteristics			
Sex of household head	=1 if man, 0 otherwise	0.53	–
Age of household head	Number of years	43	31
Level of education	Number of years of schooling completed	6.25	4.07
Structural variables			
Land ownership	=1 ownership, 0 if otherwise	0.93	0.26
Land size	Size of land accessed for all farming (acres)	2.93	2.73
Seed type used	Seed type used = 1 if a farmer used basic seed, 0 otherwise	1.07	0.79
Land under seed	Amount of land demarcated for seed potato in acres	1.30	1.21
Psychological variables			
Self-confidence 'Strong belief in oneself that he or she has all that is required to produce seed	I am confident that I can produce seed potato better than others.	4.39	1.09
	I have specific skills and experience to produce seed potato.	4.41	1.14
	I have knowledge about the expected costs and benefits of producing seed potato.	3.96	0.83
	I have the power to influence the outcomes of my investment in seed potato production.	3.23	1.36
Social influence 'Influence from friends and peers and experts in regard to seed production	I produce seed potato because of my friends and family members.	3.22	1.31
	I value others' views about seed potato production.	4.09	0.65
	I make personal decisions and evaluations about my seed potato production activities.	2.11	1.23
	I seek the advice of experts such as extension officers and KaRZADI staff regarding anything about seed production.	4.35	0.61
Loss aversion 'Fear to make losses and take on risks in production'	I am so afraid of making losses in producing seed potato.	3.33	0.42
	I am much more concerned about expected losses than gains from seed potato production.	3.01	0.56
	I fear taking on more risks when it comes to producing seed potato.	3.21	1.88
	I compute the expected costs and returns of producing before I engage in production.	4.10	1.9
	I study the market and investment environment for seed production carefully before producing to avoid making losses.	4.52	1.41
Optimism 'Positivity about the future of seed production'	When it comes to producing seed potato, I cannot give up easily.	4.28	0.68
	I can produce even when I incur risks and losses.	3.73	1.02
	I am sure the future of producing seed potato is bright.	4.23	0.87
	I am very positive that seed potato production business will keep improving.	4.18	1.01
	I see seed potato production as a better source of income.	4.87	0.78
Resilience 'Ability to produce amidst risks and uncertainties'	I can easily adapt to shocks like floods.	2.96	0.88
	I have the skills to manage production risks.	2.43	0.47
	I have the resources to recover from risks and uncertainties related to seed potato production	3.01	0.98
	I have the ability to produce seed potato amidst risks and uncertainties.	2.15	1.36
	I cannot give up producing seed potato.	3.07	1.53
	I do not mind incurring losses in the short run so as to offset profit in the long run.	1.44	1.12
Institutional variables			
Belonging to a seed producer group	=1 membership to a seed producer group, 0 if otherwise	0.88	0.33
Acquired credit	=1 Accessed credit, 0 if otherwise	0.66	0.48
Amount of credit acquired in 2018	Amount of credit received in UGX	696,524 (180 USDs)	525,880 136 USDs
Received training in 2018	=1 if trained, 0 otherwise	0.85	0.37
Economic variables			
Average investment costs	Money invested in producing seeds in both planting seasons of 2018 in UGX.	2.131.903 (551 USDs)	1.804.734 466USDs
Yield amount	Amount of seed produced in Kgs in 2018	3144.58	2959.95
TLU Large	Number of cattle and donkeys	2.7	1.22
TLU- small	Number of goats and sheep	4.	2.3
TLU Poultry	Number of chickens, ducks, turkeys, etc.	8.0	3.2

Note 1 United States dollar (USD) = 3869 Ugandan Shillings (UGX) (Bank of Uganda USD exchange rate, April 2019).

Table 2. Factor loading of principal components for 23 study variables, Eigen values and per cent cumulative variance explained.

Variable	PC 1 'Economic'	PC 2 'Psychological'	PC 3 'Demographic'	PC 4 'Institutional'	PC 5 Institutional	PC 6 'Small Ruminants'	PC 7 'Large Ruminants'	PC 8 'Overconfidence'	PC 9 'Social'
Age	−0.2	−0.1	0.5	0.2	−0.1	−0.1	0.2	0.0	0.3
Sex	0.2	−0.1	−0.1	−0.3	0.1	0.0	−0.1	0.1	0.6
Marital status	−0.1	0.1	0.5	0.1	−0.1	0.2	0.0	0.1	0.0
Average income	0.2	0.0	−0.3	0.0	−0.1	−0.1	0.1	0.3	0.2
Land under seed	0.2	0.0	0.2	−0.3	−0.2	−0.1	0.1	0.2	0.2
Received training access	0.2	0.0	0.2	0.4	0.0	−0.3	0.0	0.2	0.1
Investment cost	0.3	0.0	−0.2	0.0	−0.3	−0.1	−0.2	0.2	−0.3
Costs of production	0.4	0.0	0.1	0.0	0.0	0.1	−0.1	−0.2	−0.1
Seed amount planted	0.4	0.0	0.1	0.0	−0.1	0.2	0.1	−0.2	0.0
Seed harvested	0.4	0.0	0.1	0.0	−0.1	0.3	0.1	0.3	0.0
Credit access	0.2	−0.1	0.0	0.2	0.4	−0.2	0.1	0.2	−0.1
Seed type used	0.0	0.1	−0.3	0.4	0.2	0.0	−0.1	−0.2	−0.1
Belonging to a seed producer group	0.2	−0.1	0.1	0.2	0.4	−0.2	0.1	0.0	0.0
TLU_small	0.0	0.1	0.1	0.0	0.5	0.4	−0.1	−0.2	0.2
TLU_large	0.0	0.0	−0.3	0.1	−0.1	0.2	0.6	0.0	0.1
TLU_poultry	0.0	0.1	−0.2	0.3	0.1	0.3	−0.1	0.3	0.2
Social influence	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Self-confidence	0.0	0.2	0.1	0.0	0.0	0.3	−0.4	0.4	−0.2
optimism	0.1	0.5	0.1	−0.2	0.1	−0.1	0.1	0.1	0.0
Loss aversion	0.0	0.5	0.1	−0.2	0.0	−0.1	0.1	−0.1	−0.1
Resilience	0.0	0.5	−0.1	0.1	0.0	0.0	0.1	−0.2	0.1
Own land	0.0	−0.1	0.1	−0.1	0.3	0.3	0.5	0.3	−0.4
Amount of credit acquired	−0.1	0.1	0.0	0.4	−0.3	0.3	0.1	0.1	0.1
Eigenvalues	3.26	2.67	1.70	1.45	1.30	1.21	1.14	1.06	0.97
Cumulative explained variance	0.14	0.26	1.33	0.39	0.45	0.50	0.55	0.60	0.64

1 (14%) and component 2 (13%), Following Deressa et al. (2001), the descending explained variance was appropriate given that the first component is always the linear index of all of the items that capture the most information common to the considered variables. Field (2013) posits that an extracted component is primarily a measure of the variable(s) with which it is most strongly correlated.

Accordingly, Component 1 (PC1) represents economic factors because it is related strongly to input costs, seed amount used and the amount of seed yield. Component 2 (PC2) loaded strongly with social influence, optimism, loss aversion and resilience, thus it was labelled psychological factors. Using the same rule, Table 2, component 3 (PC3) through PC8 were labelled demographics (age and marital status), institutional1 (training, seed type used and access to credit), institutional 2 (credit accessed, belonging to a farmer group), small ruminants (goats and sheep), large ruminants (big ruminants and ownership of land) and over-confidence. Component (PC9) strongly correlated but negatively and positively with the ownership of land and sex of the household head, respectively which pointed to gender disparity in land ownership. Thus, component 9 was labelled as a social factor. Overall, economic, demographic, psychological and institutional factors merited being used in the creation typologies of smallholder seed potato producers. Previous studies (see, Chipfupa & Wale, 2018; Martínez et al., 2022; Priegnitz et al., 2019) have also found economic, demographic and institutional factors to be important variables in farmer typology construction.

Typology identification and classification

Figure 2 summarizes the distinct clusters on the Dendrogram. The clusters implied that smallholder seed potato producers in South-western Uganda were of four homogenous typologies. Tables 3 and 4 summarize the characteristics of the typologies. Broadly, the first type accounted for 23% of the sample, the second 20%, the third 22% and 35% belonged to the fourth type.

Tables 3 and 4 summarize the major variables that were relevant in typology construction. The significant mean difference of producers' age and education ($p \leq 0.01$) in the demographics domain indicated that means scores of sex, age and education were dissimilar across the sample and could be relevant in typology development. The relevance of sex could be inclined to the fact that potato production is male-dominated because more males than females have access to information by attending training, meetings and other sources (Aheisibwe et al., 2015). Age comes with experience and industrial knowledge (Sovacool & Hess, 2017). Horng et al. (2001) classification of age into young adults (30–39), middle-aged adults (40–59) and old-aged adults ($\geq$ 60) was adopted during typology development.

In the domain of economic variables, it was the mean of producers' income, input cost, investment cost, yield and total livestock units ($p \leq 0.05$) that differed. Marshall and Nelson (2018) found that social economic factors defined the farmer clusters in Southern Africa. Seed amount, seed type and producer type ($p \leq 0.05$) were the structural factors with probable descriptive relevance in typology differentiation. Institutional factors of relevance were belongingness to a group, amount of credit received, number of training sessions attended, registration as seed producer and distance to seed source ($p \leq 0.05$) while psychological capital utility was likely from overconfidence and loss aversion ($p \leq 0.01$) and optimism and resilience ($p \leq 0.10$). Chipfupa and Wale (2018) also found the utility of confidence, hope and optimism important in farmer typology description of KwaZulu-Natal Province of South Africa.

Typology 1: middle-aged female seed multipliers of moderate psychological capital and low investment level

Typology 1 was dominantly female producers (about 60%). Producers in this typology had the highest exposure to seed production training (four times on average in the two season of 2018). Investment in seed potato production was estimated at USD 501 in both seasons of 2018 and producers' distance to input-output markets for this typology was under 10 km. Particularly, producers' distance to quality seed source is 9.5 km, to the input shops 8.4 km and the output market is 5.4 km. All members in this typology belonged to a farmer group. These groups are associated with benefits that include group marketing and easy access to extension services. The producers also exhibited moderate psychological capital (*mean score = 2.874*). The high score on social influence and loss aversion meant that the decisions of producers in typology 1 were associated with peer perceptions and actions and low willingness to risks. Ndaula et al. (2021) also posit that in observing each other's actions, socially

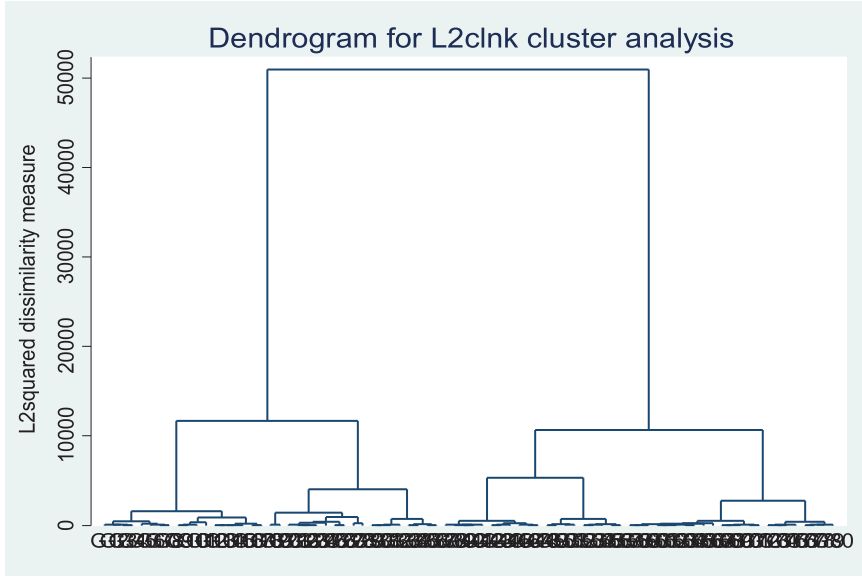

Figure 2. Dendrogram for typology identification.

Table 3. Distribution of household, economic and structural characteristics by typology and *P*-value of one-way analysis of variance.

	Typology I 'Middle-aged female seed multipliers of moderate psychological capital and low investment levell' $n = 48$	Typology 2 'Old-aged seed recyclers of high psychological capital but with the lowest investment level' $n = 43$	Typology 3 'Young male seed recyclers of moderate psychological capital but with high investment level $n = 47$	Typology 4 'Young male seed multipliers of high psychological capital and the highest investment level' $n = 75$	
Variable		Means			*P*-Value
Household characteristics					
Gender	0.4	0.5	0.6	0.6	0.186
Age	49	63	35	33	0.000
Educational level	5	5	8	9	0.002
Household size	7	5	4	5	0.221
Economic characteristics					
Average income	600,000	200,000	800,000	1,200,000	0.001
Costs of inputs	742,496				0.008
investment costs	1,940,017 (501 USD)	1,153,109 (298USD)	2,190,767 (566USD)	2,737,814 (708 USD)	0.000
Yield amount	3682	1869	3568	3868	0.001
TLU- Large	1	4	3	6	0.121
TLU- small	9	6	8	12	0.009
TLU Poultry	10	5	13	20	0.04
Yield amount	3682	1869	2448	3868	0.01
Structural characteristics					
Land ownership	0.47	0.88	0.51	0.92	0.35
Land size	2.94	3.22	2.40	3.89	0.472
Land demarcated for seed potato	1.48	0.81	1.38	2.35	0.0925
Seed amount planted	695	402	599	846.	0.002
Seed type used	1.2	0.03	0.14	1.2	0.035
Seed producer type	0.31	0.11	0.19	0.4	0.001

Table 4. Distribution of institutional and psychological characteristics by type and *P*-value of one-way analysis of variance.

Variable	Typology 1 'Middle-aged female seed multipliers of moderate psychological capital and low investment level' $n = 48$	Typology 2 'Old-aged seed recyclers of high psychological capital but with the lowest investment level' $n = 43$	Typology 3 'Young male seed recyclers with moderate psychological capital and high investmnet level' $n = 47$	Typology 4 'Young male seed multipliers of high psychological capital and the highest investment level' $n = 75$	*P*-value
	Means				
Institutional factors					
Belonging to a	1	0.8	0.7	0.9	0.001
seed producer group	886,667 (229USD)	196,279 (51USD)	0.0	1,127,467 (291USD)	0.045
Amount of credit accessed					
Received training	0.6	0.7	0.7	0.6	0.797
Number of times trained	5	3	2	3	0.000
Registration	0.52	0.28	0.63	0.76	0.000
Distance to seed source	10	18.5	10	11	0.009
Distance to input shop	8.4	4	7	9	0.597
Distance to the market	5	5	8	9	0.122
Psychological factors					
Overconfidence	2.6	3.72	3.01	4.85	0.017
Social influence	3.3	3.6	2.4	3.4	0.41
Loss aversion	3.56	3.38	2.53	2.65	0.008
Optimism	2.3	2.76	2.84	2.88	0.053
Resilience	2.61	3.8	3.0	4.3	0.081

oriented persons aim to fulfil two goals related to optimizing decision-making outcomes: (1) making effective actions and (2) building and maintaining social relationships. Looking up to peers' actions and approvals is one important way to effective action when situations are novel, ambiguous or uncertain (Mackie et al., 2015), and helps individuals to keep away from opposing what is socially deemed right by their peers (Jolanda et al., 2002). Given that the typology was mostly female, limited extra-household mobility of women and their extensive multitasking within their household routines could have constrained them from pursuing risky ventures (Doss, 2001; Vigneri & Vargas, 2011). Optimism for producers in this typology was low whereas their confidence and resilience to invest in seed production were moderate. The prevalence of moderate self-confidence is surprising because this typology had received extensive training in the seed potato production enterprise (Table 4). This finding, together with the moderate resilience and inability to take risks, could be pointing to the prevalence of mental inertia, where female producers' confidence is constrained by a history of denial to access production assets. This could not be farfetched, given typology 1, had 1.58 acress allocated to seed pottao production.

Also, most of the producers in the typology had taken up the use of quality declared seed potato (basic seed) in their seed production system and had the second highest seed potato harvest (3682 kgs), led by producers in typology 4. The low education of the producers of this typology could also constrain their capacity to gain from training. This typology closely aligns with Bidogeza et al. (2009) classification cluster 1 of farmers in Utamara, Rwanda among post-genocide communities that constituted mainly by female household heads, with low levels of education, low economic status and low self-esteem.

Typology 2: old-aged seed recyclers of high psychological capital but with the lowest investment level

Typology 2 was predominantly of the old-aged adult producers (average = 63 years) with an equal number of female and male seed potato producers. These typically recycled seed potato and had the lowest income (average = 200,000 UGX/month). At 1870 kg of seed potato yields, typology 2 had the lowest yield, which was because it had the least

investments in seed and at USD 51 their access to credit facilities was also low. It is also possible that structural barriers were responsible for the low yield. This could have been the case because this typology had the longest mean distance to the nearest quality seed source. The long distance to seed source increases the cost of purchase of good quality seed from the research station KaZARDI or trained seed producers (Martínez et al., 2022; Priegnitz et al., 2019). Similarly, this typology had the lowest registration rate at 28% and the lowest level of education with an average of 2 completed years in school, which may limit their adoption of seed potato production technologies and innovations, hence, resulting into the low seed yields.

It is also probable that the low incomes constrained and or were an outcome of these producers' inability to invest in seed deliberately. Old age can be a proxy for experience, which frames the judgement of what constitutes good practice (Sovacool & Hess, 2017). So, typology 2 producers could have preferred to stick to the tradition of seed recycling, which, in turn, could have constricted their yields and incomes. Surprising, though, typology 2 producers were confident and resilient, which demonstrated high levels of mental stability in making decisions. Even the lowest level of education attainment that characterized producers of this typology did not reduce their confidence and resilience levels. This suggests that farmers' experiences contribute to the persistence of seed recycling. Also, given that these producers are involved in both seed and ware potato production, they could have deliberately rationalized their production to favour ware potato production. For example, they were second in land access but they had the least allocated land to seed production. The typology attributes are similar to those of type 1 farmers in South Africa (Chipfupa & Wale, 2018) and in Ethiopia (Mutyasira, 2020).

Typology 3: young male seed recyclers of moderate psychological capital but with the high investment level

Typology 3 was preponderantly young male adult producers of an average age of 35 years who recycled seed. Most of the producers reported the least membership to farmer groups. The limited membership to farmer groups may limit their easy access to services, including public extension, marketing and financial services. These producers' investment in the seed potato business was reasonably high although they had not accessed credit. It is probable that typology 3 producers had no access to credit due to having opted to work independently. This is a near argument because typology 3 producers had the shortest distance to input, which instead translates into the lowest use of basic seed. Their high investment in seed potato production could be due to the fact that these producers' risk aversion was the lowest and they had low predispositions of pegging their own decisions to the perceptions and actions of peers regarding seed production. This means that producers of typology 3 were self-motivated and saw seed production as a greater opportunity than any other typology. Moreover, typology 3 producers were largly self-confident and resilient which is due to their high education attainment (an average of 8 years in school). Further, while this typology was the 2nd highest investor, the investment did not translate into high yields since the typology had the 2nd lowest yields. This implies that producing local seed potato gives lower returns than producing basic seed potato. Comparably, typology 1 invested a lower amount than typology 3 but got higher yields and returns on investment than typology 3 becasue of its concentration on basic seed potato producion and use of good agronomic practices. Thus, while psychological capital, education attainment and structural factors could be necessary for smallholder producers to invest in seed potato production, they are not sufficient. It is also necessary for the producers to own production assets such as money to facilitate investing in recommended seed potato producton practices that translate into higher returns on investment.

Typology 4: young male seed multipliers of high psychological capital and the highest investment level

Typology 4 producers were the youngest (average age of 33 years) and they were mostly male. These producers were seed multipliers with the largest investments in seed production (UGX 2,737,814 equivalent to USD 708) and accessed credit amout of UGX 1,127,467, an equivalent of USD 291. Seed yield for typology 4 was the highest at 3868 kg because farmers in this typology were innovative as they largely used basic seed, applied fertilizer and pestcides in their production. The typology also exhibited a high psychological capital. Particularly, producers had a high level of self-confidence, optimistic about the potential of seed potato production and were positive towards taking on risks. The producers in

Table 5. Seed production constraints per typology and implications for improvement.

	% case response per typology type			
Seed production constraints	Type 1: Middle-aged female seed multipliers of moderate psychological capital and low investment level (23%)	Type 2: 'Old-aged seed recyclers of high psychological capital but with the lowest investment level (20%)	Type 3: 'Young male seed recyclers of moderate psychological capital but with high investment level' (22%)	Type 4: 'Young male seed multipliers of high psychological capital and the highest investment level' (35%)
Limited access to land	93.0	76.4	84.7	87.5
Insufficient capital and credit	89.6	83.7	91.3	85.1
Limited access to market and marketing information	92.0	90.7	89.1	85.1
Pests and diseases	52.0	81.4	89.0	40.0
Lack of storage facilities	75.0	81.5	73.9	81.6
Climate change effects (flooding and drought)	83.5	76.5	84.3	79.7
Fake and counterfeit agro-inputs	75.3	80.0	62.0	55.0
Limited access to good-quality seed potato	43.0	34.5	56.5	43.25
Limited knowledge of quality seed production practices and innovations	52.0	65.12	52.0	56.76
Implications for targeting interventions for seed potato production improvement	Type 1: 'Middle aged female multipliers' (23%)	Type 2: Old aged seed recyclers' (20%)	Type 3: 'Young male seed recyclers' (22%)	Type 4: 'Young male seed multipliers' (35%)
Promote increased access to market and market information	XXX	X	X	XX
Support household access to land and promote crop intensification	XXX	X	X	XX
Promote household training on low-input technologies and increase extension visits	X	XX	XX	X
Support access to production credit	XX	X	XXX	XX
Promote increased access to quality seed source	X	XX	XXX	X
Support the construction of low-cost stores	XX	X X	X	XXX
Promote stabilization of seed potato price	XX	XXX	XX	XXX

Note: X – low priority intervention, XX – moderate priority intervention, XXX – high priority intervention.

typology 4 had access to institutions, large social networks and owned productive assets. These could have offered a holistic space in which producers were able to invest in seed potato production. Typology 4 shares attributes with cluster 3 offered in Bidogeza et al. (2009), which was characteristically constituted by young men (≈31 years old) with higher education gains. Attributes of typology 4 also resemble Mutyasira's (2020) cluster of resource-rich commercially oriented households in Ethiopia and the male-dominated business farmers of Eastern Cape, Gezina clustered by Denison et al. (2015).

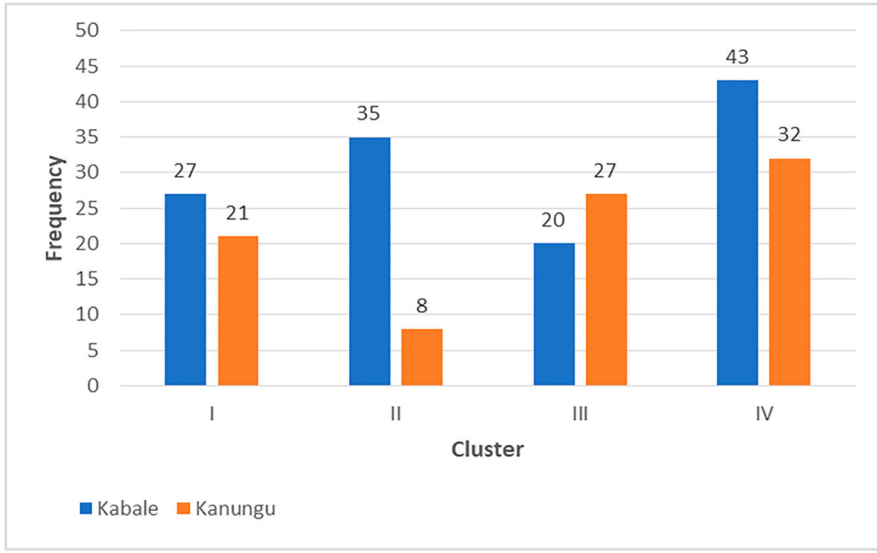

Figure 3. Seed potato producer typologies distribution by district. Source: Study data (2019).

Distribution of the farmer typologies by district

There was heterogeneity in farmer typologies in the study areas (The Pearson Chi-square value generated as part of the results in Figure 3 is significant at 1%). Kanungu is dominated by typology 3 while Kabale is dominated typology 4. The findings suggest that Kabale is relatively more progressive and doing better in seed potato production than Kanungu. This is because Kabale has the most seed multiplier base among Middle-aged female seed multipliers and the Young male seed multipliers. These are specialized and largely use recommended seed potato production practices such as basic seed, positive selection, fertilizer and pest use which practices result into better seed yields, better returns and competitive prices. The presence of research station KaZARDI and more supporting NGOS in Kabale than Kanungu who are handy in providing farmers with advisory services and inputs such as good quality seed, fertilizers and pesticides also explain the better performance and progress in seed potato production in Kabale relative to Kanungu.

Constraints nested in seed potato producers' typologies

Table 5 summarizes the production constraints. Most constraints were cross-cutting and a few were associated with specific typologies:

Crosscutting constraints in seed producer typologies

Overall, across the four typologies, shortage of land, insufficient ownership or access to financial assets, limited access to markets and market information, lack of storage facilities, fake and counterfeit agro-inputs and climate change-constrained investment in seed potato production. Given that the constraints are institutional, structural and geographical by description and that the four typologies were drawn from the same agro-ecological zone, then producers in each typology would be expected to face these constraints (Ignorelli et al., 2016; Kuivanen et al., 2016).

Land shortage in the Kigezi sub-region is extensive due to high land fragmentation practices that have an association with high population growth of the region (Giller et al., 2011). Also, of late, due to the diversification or substitution of income sources, tea and potato production compete for space in this region. Such constraints could reduce possibilities for scaling up and or experimental investment in seed potato (Bidogeza et al., 2009). This is because viable seed potato production requires the use of virgin land which is scarce in Kabale, hence, limiting both the production and productivity of seed potato. This was affirmed by a male seed producer FGD

> Seed potato production requires fresh virgin land or land that has been followed for at least 2 years, which is scarce

> here. (FGD in Kabale under Typology 2 held in January 2019)

The quality of land to be used in seed production is very important for seed potato quality (Doss, 2001).

In addition, the mountainous landscape also makes access to services, such as finance, markets and market information and inputs, difficult for producers in the study area. Moreover, establishing demand and marketing of seeds of vegetative nature is naturally difficult. Male participants with a FGD under typology 4 in Kabale, expressing the challenge of marketing noted:

> We are not organised, we lack regulation and different farmers use different scales such as tins, basins, sacks of 100kg, and sacks of 50kg to measure seed potato, which makes marketing difficult. (FGD in Kabale under Typology 4 held in January 2019).

Given that the seed potato production business is unregulated by the government, farmers acquire seed from friends, neighbours, saved harvest or as gifts, which reduces the potential demand and market for seed, leaving the seed producer demotivated (Hirpa, 2013).

It also forms the basis for an urgent necessity for storage facilities to accommodate seed potato marketing or delivery delays. Particularly, a male key informant interviewed in January 2019 exemplified the challenge when he noted: 'most of our seed potato producers lack access to the diffused light stores for seed potato'. In addition, across the FGDs for each typology, farmers noted that the constructed communal storage facilities by NGOs were distant from producers and using them involved a high transaction cost to individual farmers. Seed storage is vital in the seed potato business because poor storage impacts the quality of the seed potato (Aheisibwe et al., 2015).

Climate change is also a gravitated new constraints for seed potato producers. In their study using remote sensing, Luliro et al. (2022), demonstrated that 30.8% of the areas in Kigezi highland regions were under agriculture of which 72% was under Irish potato. However, climate changes have left only 2% of the 72% area as being suitable for potato production and 5.34% completely unsuitable and the other proportion has either become moderately or marginally suitable for potato production including seed potato production (Luliro et al., 2022).

Typology nested constraints among seed potato producers

Pests and diseases were constraints of major concern for only the seed recyclers (typology 2 and 3). This could have been because farmers in these typologies recycled seed potato, which could have degenerated the quality of the seed (Navarrete et al., 2022). Recycled seed exposes producers to a high incidence of systemic diseases, including the potato's devastating bacterial wilt and early blights. Surprisingly, typology 3 producers differed from those in typology 2, when they scored access to quality seed as a major constraint. This could suggest that the state of recycling seed for typology 3 is probably conditioned by a lack of capacity to pay for quality seed. On the other hand, for typology 2, recycling was probably deliberate. In fact, at a 35% rating level, typology 2 considered the constraint of access to quality seed, the least. Thus, typology 2 producers could have deliberately distanced themselves from quality seed (Long, 2001; Mango, 2002), which could be due to limited knowledge of quality seed production practices and innovations (65%). Moreover, typology 2 consisted of old-aged adult producers (≈65 years old), which could mean that their decision-making frame was stable and based on knowledge and experiences or lack of same (Sovacool & Hess, 2017). The limited knowledge on cultural practices of a crop intervention lower its uptake (Mbowa & Mwesigye, 2016; Onu, 2006). On the other hand, typology 1 and 4 who are seed multipliers were more constrained by limited acess to market and market information. Specifically typology 1 made of female seed multipliers were challenged by limited acess to market information, long marketing chains, low price and low negotiation power as revealed by the feamale farmers in Kanungu: "we are always cheated by middle men because we lack capacity to transport our seed to distant markets such as Rwanda. We sell our seed at the farm gate immediately after harvesting because we lack stores, and we aslo don't have information on where good market are and this leads to very low price sales." Despite the high membership to producer groups in typology 1, farmers had not tapped into the benefits of group marketing. Besides, the moderate psychologcal captal in typology 1 would be a limiting factor to their active involvement in the market since farmers in this typology were less self confident, optimstic and higly loss and risk averse. This finding is in agrement with the

findings of Chipufa and Wale (2018) where low markket participation of farmers in typlogy 1 and 2 was linked to their low psychological capital interms of low hope and low confidence. Similarly, given that producers in typology 4 are largely commercial and business-oriented, they are likely to be demotivated to produce more seed potato because of limited acess to market measured by the demand of seed potato from the community. Seed marketing for vegatatively propagated crops is not regulated by the government of Uganda, therefore, the willingness to pay for seedpotato is low as households acquire seedpotato from informal sources including from friends, neighbours, saved harvests and from gifts (Gildemarcher et al., 2009; Hirpa et al., 2013; Namuga et al., 2017).

Conclusion and recommendations

This study concludes that seed potato producers are of heterogeneous structure although the constraints that condition their investment decisions were similar. The findings showed that seed potato producers' typologies distilled into 4 different types based on seed producer type (recycler or multiplier), age, sex, level of investment and psychological capital. These included: Typology 1 of 'middle-aged female adult seed multipliers of moderate psychological capital and low investment level', typology 2 of 'old-aged adult seed recyclers of high psychological capital but with the lowest investment level, typology 3 for 'young male adult seed recyclers of moderate psychological capital but with the high investment level' and typology 4 that included 'young male seed multipliers of high psychological capital and the highest investment level'. Particularly, the cognitive environment (psychological capital) of producers in typologies 3 and 4 was supportive to seed potato investment although type 3 producers mainly recycled seed potato and their motivation were individualistic. Similarly, although typology 1 was of seed multipliers, meaning that they used quality seed, their cognitive environment was non-supportive whereas producers under typology 2 distanced themselves from investing in basic seed potato.

Accordingly, the above findings point to the need to incorporate psychological variables in smallholder farmers' typologies, a finding that bears practical and theoretical importance. On the practical side, promoters of seed potato intervention need to focus on typology 4, 3 and 1. High-impact interventions are likely to be those, which support the installation of producer-level storage facilities on farmland and, the tailored extension of financial services, training and marketing services to producers to meet each typology's needs. Given that the land size is structurally small in the study area, increasing seed production is likely to be feasible through intensification strategies such as the promotion and use of improved seeds, fertilizers and pesticides. Policy-makers need to pay specific attention to setting standards and regulatory systems in the seed potato trade. Typology 1 could require special programmes that support the cognitive state of the female farmers, such as documents that guarantee ownership of land to appreciate seed potato production. Relatedly, given that the study found that the marjority of seed producers were male except for typlogy 1 that was domitated by female producers that faced gender specific constraints around acess to market and land, there is need to develop gender responsive strategies to support female farmers' profitable engagement in seed potato production. More specifically, there is a need for a detailed study on what is constraining female farmers from actively participating in seed potato production.

Theoretically, this study offers insights to researchers that cognitive concepts from social psychological theories, such as the theory of planned behaviour and health belief model could offer a more relevant differentiator of smallholder farmers in the understanding of smallholder typologies. Smallholder farmers are nested in the same or related structural, institutional, economic and geographical contexts. Smallholder farmers could be expected, however, to have informative variations for typology formation that are founded on their cognitive differences.

Finally, while typologies developed revealed a general picture of seed potato producer's heterogeneity and homogeneity, we cannot claim that we were able to capture all the differerences and similarities that exist among seed potato producers since these are not only complex, contextual and dynamic, but also varry in space and time. This means that the seed potato producer typologies developed may not be generalised to a larger context, but since the study areas of Kabale and Knaungu are largely representative of south western Uganda, the findings can be generalizable to the whole of South western Uganda and other areas in Uganda that share similar characteristics with the

study area. However, the methodolgy used in this study is generalizable any where around the world subject to its validation. In addition, given that this study identified the homogenous typologies, future research on typologies among smallholder seed potato producers could also use more robust analysis tools such as latent class analysis (LCA). This is particularly because LCA classifies groups under the assumption that the number of classes is known before analysis (Barnes et al., 2022).

Note

1. The study was conducted in the former Kabale district before it was divided into two other districts of Rubanda and Rukiga districts.

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