FARMING SYSTEM DESIGN FOR SUSTAINABLE AGRIFOOD SYSTEMS: THEORIES AND PRACTICES

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Co-design of socio-technical innovation bundles: lessons for sustainable intensification of smallholder farming systems in Malawi

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Introduction

Agriculture is vital to Malawi's economy, but it also contributes to negative environmental impacts, including the degradation of soil fertility. The urgent need for increasing farm productivity while minimizing environmental impacts calls for the transitioning to more sustainable smallholder farming systems (Burke et al., 2022). This transition requires the introduction of innovative agricultural practices and technologies - sustainable intensification (SI) options - such as multi-functional legume crops into cereal-dominated cropping systems. Current research on farming systems mainly focuses on the technical suitability of SI options, often overlooking the social and institutional contexts that influences smallholders' adoption decisions. This signifies the need to consider innovation bundling, coupling social and/or institutional innovations (e.g., financial services, markets) to technical innovations (Barrett et al., 2020). However, it is largely unknown which approaches can effectively support the design of socio-technical innovation bundles (STIBs). In Malawi, recent research initiatives, that integrate legumes into maize-dominated smallholder farming systems, seek information on the required socio-institutional bundle components to underpin promising technical innovations. The aim of this paper is, therefore, i) to explore which social and institutional innovations to bundle with the integration of legumes, and ii) to assess to what extent bundles need to be tailored to specific farm types.

Methods

We used mixed methods combining participatory research with the conjoint technique (Rao, 2010), typically applied for designing products and services, and cluster analysis. We first conducted focus group discussions that lasted, on average, one and half hours to understand perceived advantages, barriers to adoption, and farmers' needs, engaging farmers involved in trials for Mbili-Mbili strip cropping. Mbili-Mbili is a crop intensification practice in which two maize rows are alternated with two legume species in three rows, enabling efficient use of land to boost productivity while enhancing soil fertility through biological nitrogen fixation (Kihara et al., 2022). This makes Mbili-Mbili a suitable technical innovation. Based on these assessments we defined potential social or institutional innovations to be combined with the technical innovation. The social and institutional innovations are referred to as 'attributes', with each attribute having two or more fixed values, or 'levels' (Kuhfeld, 2003). Using a fractional factorial design (Kuhfeld, 2003), we combined attribute levels and generated 18 hypothetical STIBs. In a conjoint experiment involving 246 farmers, pictorial representations of the hypothetical STIBs were presented one after the other for preference rating. When selecting participants, we tried to consider differences in resources and gender. Cluster analysis was used to determine farmer segments based on their preference scores to the attribute levels.

Results

The qualitative assessments highlight the need for complementary services (institutional innovations) to enhance the integration of legumes into the smallholder system in Malawi. These included joint supply of seeds combining legume seeds with maize, stable and profitable markets, micro-financing, and climate advisory services. The aggregate results from the conjoint experiment (Table 1) show that, overall, microloan service influences farmers' preferences most strongly. Farmers attached positive and higher utility value (0.95) to a microloan service to be paid back after harvest compared to the other microloan services. The second most important attribute is seed bundle, with a relatively high positive utility for a full seed bundle. Crop insurance and provision of climate information are the other important institutional innovations to consider in the design of STIBs.

Bundle attributes and levels	Relative importance scores (%)	Utility Estimates	df	F statistic	Sig.	Partial Eta Squared
(1) Seed bundle	25		3	150,86	<,001	0,09
maize alone		-0,60				
+ soybean		0,21				
+ pigeon pea		-0,13				
+ soybean, pigeon pea		0,52				
(2) Premium price	5		1	8,68	0,003	0,002
5% on group sales		-0,04				
5% on quality		0,04				
(3) Flexible sourcing arrangement	5		1	5,69	0,017	0,001
buyer contract without early purchase		0,04				
buyer contract with early purchase		-0,04				
(4) Seed loan	9		2	2,51	0,081	0,001
paid back in cash		0,04				
paid back in seeds		0,00				
paid back in grains		-0,04				
(5) Microloan service for inorganic fertilizer (maize)	40		2	1678,89	0,000	0,432
no microloan		-1,12				
microloan paid in installments		0,17				
microloan paid once after harvest		0,95				
(6) Crop insurance	10		2	46,45	<,001	0,021
offered to farmers		0,06				
offered via seed supplier		0,14				
offered via loan supplier		-0,19				
(7) Climate information on anticipatory action	6		1	91,10	<,001	0,020
not included		-0,13				
included		0,13				

Table 1. Relative importance, utility estimates and effect sizes (partial eta) of socio-institutional bundle attributes and levels related to the technical innovation Mbili-Mbili (n=246).

Farmers were subdivided based on their preferences for attribute levels (Figure 1). Cluster 1, representing 26% of the sample, showed strongest preference for the full seed bundle. Cluster 2 (representing 30%) preferred the microloan service, regardless of the repayment schedule, while Cluster 3 (representing 36%) favored loans with repayment after the harvest. Cluster 4, the smallest in size (8%), was the only cluster with a positive preference for maize seed alone.

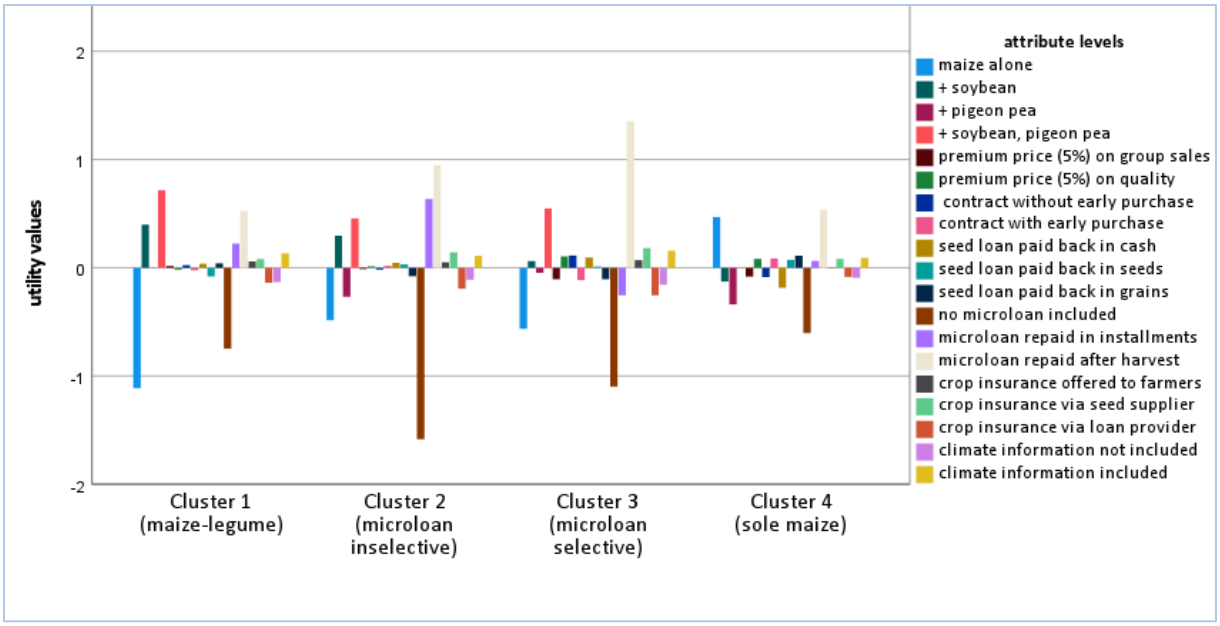

Figure 1. Farmer segments based on attribute-level utility values.

Discussion and Perspectives

The strong preference for microloan services suggests that farmers face financial constraints in adopting technical innovations, highlighting the need for bundling such services (Barrett et al., 2020). Farmers' interest in a full seed bundle reflects their willingness to adopt mixed maize-legume farming, if supportive seed market systems are in place. These findings indicate that smallholder adoption of diversified farming systems can be enhanced through the integration of institutional innovations, guided by the effective design of STIBs. However, the design of STIBs need to consider the heterogeneity in farmer preferences.

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