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Contribution of Pluralistic Agriculture Extension Service Provision to Smallholder Farmer Resilience

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Abstract

The paper examined the relationship between pluralistic agriculture extension systems and the socioeconomic resilience of smallholder farmers in northern Uganda. A categorical regression analysis was conducted on quantitative data that were randomly collected from 308 respondents. The pluralistic agriculture extension service accounted for a 40% and 32% change in social and economic resilience respectively. The main factors that had positive and significant effects on socioeconomic resilience were the management style of extension agents and participatory monitoring and evaluation of smallholder farmer extension activities that caused less than half a unit fold of increment in socioeconomic resilience. Although small, they form the ground for farmers' capacity to buffer, adapt to changes, and cope with stresses and disturbances. The F-values in the regression models are important in the prioritization of the significant factors during the design and implementation of extension models. The paper contributes to the ongoing discussion on the role the pluralistic agriculture extension system plays in enhancing farmer resilience and the use of quantitative methodological procedures in identifying the strength of the relationship between the factors.

Keywords: farmer field schools, governance, innovation, multistakeholder, network, social systems

1. Introduction

In many parts of Eastern Africa, smallholder farming consists primarily of a mixture of farms that are specialized, and also diversified (Kansiime et al. 2018). With the high dependence on rain-fed agriculture, these smallholder farming communities are known to be vulnerable to climate and weather variability (rainfall patterns, temperatures), declining soil fertility, increasing pest and disease outbreaks, legislation and policy changes, price fluctuations, and limited markets (Nettle et al. 2015). The ability of smallholder farming communities to manage the risks associated with changes is mainly affected by the poor design and implementation of agricultural extension approaches (Osumba et al. 2021; Bhowmik et al. 2021), and the inability to improve the capacity of extension agents, knowledge and skills to provide adequate social protection and social networks needed to build smallholder farmers' resilience. Thus, the majority of the smallholder farmers in East Africa are vulnerable to variations in regional climate and agricultural markets due to the fact that they generally have limited social protection and social networks, human capital, diversification of agricultural activities, risk management practices, access to knowledge, assets, and services (Manevska-Tasevska et al. 2021; Bhowmik et al. 2021).

The disruption of the global food supply chain and markets due to the Russia-Ukraine war in 2022 and the aftermath of the COVID-19 pandemic (Ben-Hassen & El Bilali, 2022; Glauber et al. 2023), with the increased impacts associated with climate change and rain-fed agriculture (Cohn et al. 2017), and the agricultural extension approaches on smallholder farmers (Hasan et al.2013; Wright et al. 2017), the need to design and promote agricultural extension approaches that can reduce vulnerabilities by lessening the exposure and sensitivity of smallholder farming communities to climatic and economic disturbances and stressors to build their robustness, adaptability, and transformability capacity is eminent (Bailey & Buck, 2016; Manevska-Tasevska et al. 2021). Many studies evaluated the impacts of agricultural extension systems on the resilience of farming systems

(Cradock-Henry, 2021; Faure et al. 2016; Meuwissen et al. 2019; Paas et al. 2021) resulting in frameworks for assessing farming systems' resilience. The qualitative agriculture extension systems studies indicate that aspects such as formal and technical knowledge, governance, polycentric management structures, social capital, human capital, physical capital, natural capital, and social capital are linked to farmer resilience (Bhowmik et al. 2021; Kliem, 2022; Meuwissen et al. 2019). Other qualitative studies also identified the agriculture extension factors that contribute to building farmer resilience (Hunt et al. 2011; Knook et al. 2023), however, the magnitude of the relationship is yet unknown. Studies on the effect of agricultural policies on resilience also revealed the influence of agricultural policies on farming systems' resilience (Buitenhuis et al. 2020; Thorsøe et al. 2020). All the studies have limited focus on the quantitative effect of pluralistic agriculture extension approaches on smallholder farmer resilience (Buitenhuis et al. 2020; Hasan et al. 2013; Thorsøe et al. 2020; Wright et al. 2017).

A theoretical lens was used to provide insight into not only the expected future real reform options but also the changes in the behavior, learning, and practices of policymakers, practitioners, researchers, and farmers (Cook et al. 2021; Sewell et al., 2017; Smets et al., 2012) in line with pluralistic agriculture extension systems and the social and economic resilience of smallholder farmers. A causality framework for resilience assessment based on a farming systems perspective (van der Lee et al. 2022) was used for this study. A farming system is considered a population of individual farm systems that are widely differing in resource bases, enterprise patterns, household livelihoods, and constraints (Giller, 2013). Resilience incorporates the skills, abilities, knowledge, and insight that accumulate over time as people struggle to surmount adversity and meet challenges (Garmezy, 1996). According to Obrist et al. (2010), social resilience is the capacity of actors to access capital in order to not only cope with and adjust to adverse conditions (reactive capacity) but also search for and create options (proactive capacity), and thus develop increased competence (positive outcomes) in dealing with a livelihood challenge. While Hallegatte (2014) and Rose (2004), define the economic resilience of farm households as the distribution of direct losses across the farm households, the existence of basic needs, and the ability to smooth the shock across time through savings, borrowing, insurance, and the ability to share risks across households through social protection. In general, resilience is used to describe individuals and communities that adapt to extraordinary circumstances by achieving positive and unexpected outcomes in the face of adversity as it is a dynamic response to a multiplex of biological, psychological, social, and other environmental influences (Fraser et al. 1999). It is characterized by successful functioning in the context of high risks and depends on a host of factors that interact with one another to determine how one responds to stressful experiences. Individual response to stress takes place in the context of interactions with other human beings, available resources, specific cultures and religions, organizations, communities, and societies (Southwick et al. 2014). This framework thus looks beyond future reforms, by also including how behavior, learning, and practices change.

Although the van der Lee et al. (2022) framework provides a very useful base for this study, it is based on general traditional, capacity, vulnerability, and agroecological lenses. It, therefore, does not quantify the different aspects of smallholder farmer resilience by lacking the identification of the specific social and economic factors influenced by the pluralistic agriculture extension system. Furthermore, the framework has been developed from a general farming system approach and has not been tested for pluralistic agriculture extension system outcomes. Therefore, this study addresses the lack of inclusion of a holistic set of quantified predictors and outcomes (e.g., pluralistic agriculture extension system factors and social and economic resilience factors) in the evaluation of socioeconomic resilience of smallholder farmers and the limited understanding of the contribution of pluralistic agriculture extension system to social and economic resilience separately. The objective of this study is to apply a pluralistic agriculture extension system lens to investigate the change generated in the social and economic resilience of smallholder farmers in northern Uganda, focused on identifying significant predictors that cause changes in social and economic resilience. The contribution of this study is threefold. First, theoretically, it adds value to the current literature by conducting an empirical test of the framework proposed by van der Lee et al. (2022) and expanding this framework by quantifying the predictors and the change they cause in social and economic resilience. Second, it addresses a gap by looking into the perception of smallholder farmers on the design and implementation of pluralistic agriculture extension systems, such as technical and managerial skills and quality of service provision to farmers. Third, it provides policymakers, researchers, and practitioners with greater knowledge of the change established due to the design and implementation of pluralistic agriculture extension systems, as well as the magnitude of the changes. The in-depth knowledge increases the understanding of the importance of relationships between pluralistic agriculture extension systems and building farmer resilience, and design of future pluralistic agriculture extension initiatives.

2. Theoretical Framework

Pluralistic agriculture extension theory has received significant attention already (Birner et al, 2009; Rivera &

Sulaiman, 2009; Christoplos, 2010; Leeuwis & Van de Ban, 2004; Sulaiman & Davis, 2012). Rivera & Sulaiman (2009) refer to pluralistic agriculture extension as a variety of systems and providers that have emerged for communicating and transmitting information and technology to farmers and other rural populations comprising public, private, and semi-public 'systems' that make up a multi-institutional, multi-sectoral 'pluralistic' system with the emphasis to help farmers organize themselves, and link them to markets. It also aims at transferring knowledge from researchers to farmers, advising farmers in their decision-making and educating farmers on how to make better decisions, enabling farmers to clarify their own goals and possibilities, and stimulating desirable agricultural developments (Anderson & Feder, 2007).

The coordinated management system built through a network of social relations is required for the multi-actor interactions within complex institutional and governance contexts if pluralistic agricultural extension systems are to enable smallholder farmers to develop the capacity to cope with and recover from shocks and stresses (Evans, 2011; Luthe et al. 2012). Network governance theory focuses on facilitating the coordination of public and private interests, actions, and resources through negotiated interaction among a plurality of political actors (Rhodes, 1997). The network of organizations and individuals involved in bringing new products, new processes, and new forms of organization into social and economic use requires networking, interactive learning, and negotiation among a heterogeneous set of actors (Hellin, 2012).

Rogers (2010; 1995) explains that innovation is communicated through specific channels over time among members of a social system that are linked via networks, and the 'diffusion of innovation' theory also known as 'Innovation Decision Process theory' argues that the potential adopters progress and pass through the five (5) stages from the awareness of knowledge, persuasion, decision, and implementation to confirmation. Innovation systems theory further argues that innovation results from interactions between diverse, self-organizing actors, and the complexity of their interaction makes the knowledge they produce highly unpredictable calling for the need for network facilitation (Klerkx et al. 2010). The theory of agricultural innovation systems emphasizes the critical role played by heterogeneous relationships that focuses on the practices as a result of farmer networks and the exchange of knowledge that takes place in densely tied and strongly organized interpersonal networks (Wood et al. 2014). Social network theory posits that social networks comprise a structure of individuals or organizations (nodes), which are linked together through various social relationships that vary in strength and familiarity with their influence on the trust and access of information for members in the network (Luethge et al. 2010).

The social networks in the diffusion of innovations theory promote social learning, linking knowledge with action, and enhancing collective action that fosters the capacity to buffer, adapt to, and shape change by providing resources needed to cope with external stresses and disturbances (Rockenbauch & Sakdapolrak, 2017). Agricultural innovation involves processes of social learning in the context of rural transformation, innovation, and learning play a critical role in creating resilient communities. Engagement in diverse fora of social learning influences pathways of system self-organization through the formation of patterns due to social interactions needed for the enhancement of resilience (de Paoli et al. 2017).

Wossen et al. (2013) argue that social networks and interactions shape social learning and adaptive changes, which help to reduce information asymmetry and transaction costs for technology adoption. It also relaxes the labor and financial constraints of farmers and improves their bargaining power. However, with scarce or inadequate information sources and imperfect markets and transaction costs, social networks facilitate the exchange of information, enable farmers to access inputs on schedule, and overcome credit constraints, thus helping farmers earn higher returns when marketing their products. This, in turn, can affect technology adoption as farmers learn from their networks about new technologies (Kassie et al. 2012). The diverse improvement of single capacities of individual members of the innovation network is merged into new and strong collective ones, which facilitate self-supportive and continuous capacity development; an opportunity to define member's interests, exchange knowledge and mobilize resources through the social learning, thus enabling farmers to collaborate and change their situations in a profound, strategic and meaningful manner (Wossen et al. 2013). The social network features of social memory, heterogeneity, redundancy, learning, adaptive capacity and trust, and characteristic density, reachability, betweenness, and centrality determine access to information and technology adoption rate (Bodin et al. 2006). Henly-Shepard et al. (2015) point out that social and geographical proximity, that is the strong and homophilous ties, for example, kinship ties, facilitate information diffusion, as ties to geographically distant actors increase the likelihood that farmers gain access to new information; and bridge and link ties between diverse actors from civil society, public extensions, and private sector, which provide farmers with access to external sources of information and experiences (Wossen et al. 2013).

Pluralistic agriculture extension and the advisory system is well positioned to coordinate multiple groups at various stages of shock and stress because of its linkages at local, sub-national, and national levels. Due to its potential

access to timely information, the system can identify relevant actors with whom to work to ensure that intervention strategies are harmonized, relevant, effective, and timely (Davis et al, 2014). By providing relevant information and knowledge regarding weather and climate change, market prices, regulatory structures, quality standards, and consumer demands, a pluralistic agriculture extension service enables smallholder farmers to make informed decisions on their farming activities. This can be achieved through education and training for smallholder farmers. In contexts of adversity, positive adjustment based on a learning process is an essential dimension of resilience that leads to increased competence in dealing with challenging livelihood conditions (de Paoli et al. 2017). The process of anticipating livelihood challenges, changing rules and regulations, creating new options, planning ahead, recognizing danger, mobilizing assets, organizing support, and developing new and flexible institutions and organizations enhance the capacities of individuals, groups, and organizations to deal with livelihood challenges more competently (Li, 2023; Lyon & Parkins, 2013). Both resilience and diffusion of innovations theories investigate how change is brought about in systems through the innovation and adaptation of social actors. Resilience is considered as human agency, social learning, and the skills and capacities of social actors to cope with and adapt to change facilitate transformation (Folke *et al*, 2010), which form the basis of our paper.

A particular issue emerging from both scholarly and practitioner domains relates to the network governance of agriculture extension systems, particularly in the context of pluralistic agriculture extension systems in which many different organizations, including the private and public sectors as well as not-for-profit groups, are involved (Klerkx et al. 2012; Klerkx et al. 2010; Southwick et al. 2014; Rockenbauch & Sakdapolrak, 2017; Wood et al. 2014). Assessment of the roles, effective performance, and democratic quality of governance networks play in facilitating interaction and coordination among heterogeneous actors and its relation to smallholder resilience will stimulate the diffusion of innovations, support smallholder farmers in improving their farming decisions, and help them achieve enhanced democratic participation in pluralistic agriculture extension public policy-making and implementation geared towards improving the design, implementation, and evaluation of extension models and approaches. More so, in some situations, the same registered farmer groups are always selected to work with different actors limiting communication of innovation to a few in the rural communities.

Although much research has focused on the assessment of the performance of pluralistic agriculture extension approaches (Birner et al. 2009; Christoplos et al. 2003; Faure et al. 2016) and the role of pluralistic agriculture extension in meeting farmer needs (Adhiguru et al. 2009; Chowa et al. 2013; Gemo et al. 2013; Rivera & Alex, 2004;), the area related to social network governance of pluralistic agriculture extension systems on farmer resilience remains an area in which more research is called for (Milestad and Darnhofer, 2003). This is in the view of ongoing reform such as empowering farmers to become resilient through better quality pluralistic agriculture extension services, which has been debated over time (Álvarez-Mingote, et al. 2020; Ayre et al. 2015; Milestad et al. 2010; Fox, 2012; Glover, 2012; Singh and Burman, 2019; Uprety and Shivakoti, 2019).

Although network governance of pluralistic agriculture extension systems has been widely recognized as a process of building farmer resilience through improved communication and information flow between research, extension service providers, and farmers (Darnhofer and Strauss, 2015; Darnhofer, 2014; Vanclay and Leach, 2011), its impacts in both a positive sense as well as its unintended negative consequences in the form of failure to improve interaction and coordination among heterogeneous actors, and the lack of coherent policies to guide the interaction and coordination among actors are becoming visible, and have also been discussed in a broad body of literature (Dessein et al. 2016; Faure et al. 2016; Faure et al. 2012; Hunt et al. 2012, 2014; Klerkx et al. 2006; Labarthe and Laurent, 2013b; Laurent et al. 2006; Mikwamba et al. 2016; Nettle et al. 2017; Prager et al. 2016; Prager et al. 2017; Rivera and Alex 2004a; Rivera 2008 and Sutherland et al. 2013). These include the impacts of network governance on the coherence of policies to guide interaction and coordination among actors, particularly in Uganda; how interaction and coordination among heterogeneous actors of pluralistic agriculture extension systems relate to smallholder farmer resilience in response to positive and negative consequences of network governance in providing pluralistic agricultural extension services. These areas remain understudied, particularly related to comparing pluralistic agricultural extension approaches and smallholder farmer resilience in northern Uganda and in different contexts.

2.1 Pluralistic Agriculture Extension in Uganda

Pluralistic agriculture extension as a function of providing needed and demand-driven knowledge and skills to rural men, women, and youth in a non-formal, participatory manner by different service providers, improves smallholder farmers' quality of life (Gemo et al. 2013). By increasing technology transfer, farmers' organizations' support, facilitation of market linkages and natural resources management; pluralistic agriculture extension increases farmers' access to tangible and intangible resources, such as inputs and knowledge that are needed to both adequately prevent, anticipate, prepare for, cope with, and recover from shocks (Davis et al. 2014).

The Ugandan government and its development partners including local development agencies adopted National Agricultural Advisory Services (NAADs) and Farmer Field Schools (FFS) models that act as a coordinating body for multiple support organizations as well as providing more relevant services (Figure 1). They were intended to increase smallholder farmers' access to agricultural inputs, knowledge, and skills needed to improve their ability to cope and recover from production, marketing, economic, and political stresses and shocks. The introduction of NAADS and FFS was to involve the interaction between smallholder farmers, local government agents, private extension service providers, and policymakers, and establish social networks that empower farmers to demand and control agricultural advisory and information services and also improve the diffusion of innovation, ultimately resulting into increased adoption of agricultural technologies (Wood et al. 2014; Wossen et al. 2013). The farmer associations and public-private partnership provided evidence of useful social network structures to help promote social learning that could create and strengthen linkages, and coordination within the overall extension services, as well as, increase smallholder farmers' access to sustained knowledge, information, and communication (Nahdy, 2002). Through this, the smallholder farmers are thought to increase their output for the market; access inputs, outputs, and markets; access extension services, and advice about market and credit information; and connect to other farmers, and local, regional, and national institutions with anticipation to reduce costs, increase efficiency and productivity, and raise household incomes needed to build farmer resilience (Ariong et al. 2016).

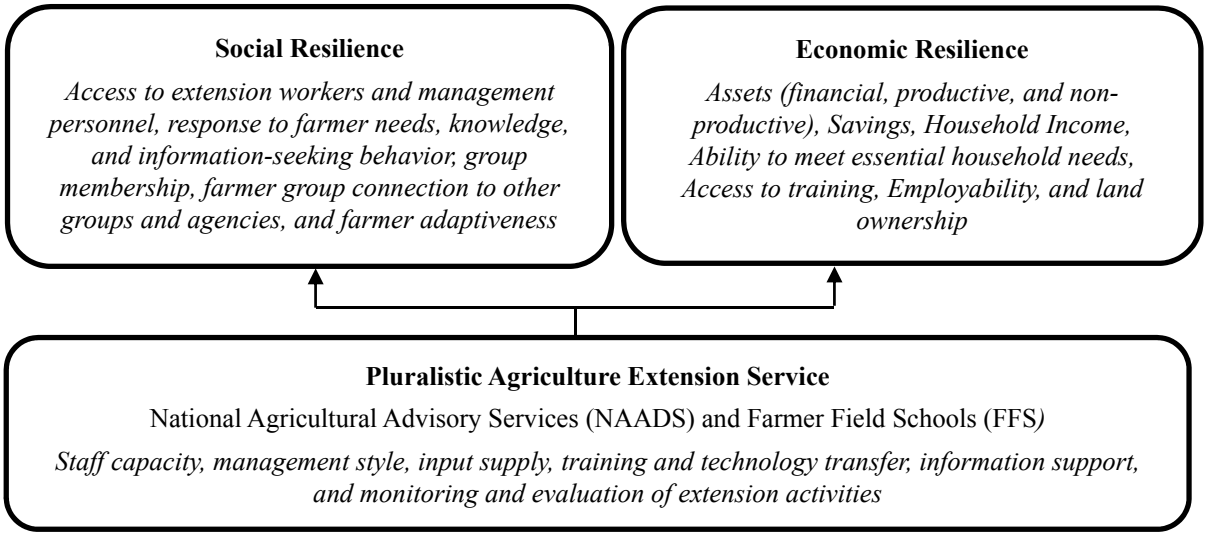

Figure 1. Pluralistic agriculture extension service and farmer resilience in Uganda

Both NAADS and FFS models were to encourage smallholder farmers to engage in both weak-tie relations with external agents and strong-tie relations with close associates that should result in broader access to information needed for innovation (Thuo et al. 2013). Weak ties facilitate the integration of new information into the social system, but, the presence of strong ties further supports technology diffusion processes by helping farmers develop a shared understanding about technology characteristics (Ten Kate et al. 2010). According to a mixed qualitative and quantitative study on information sources and constraints by Mubangizi et al. (2004), there is limited access to technical agricultural information; limited information sharing among private service providers and with public extension agents; inadequate quantity and quality of information; difficulty in translating information, and absence of standard procedures for ensuring the quality of information given to farmers due to inadequate financial resources and unavailable internet services in rural areas. These models promote the failure to strengthen the social relationships between smallholder farmer groups, private extension service providers, local government agents, and higher-level farmer organizations by reducing opportunities to exchange perspectives, explore new ideas and programs, appreciate differences of opinions, negotiate common goals, develop partnerships, propose changes to programs and become confident participants able to articulate needs and opinions of smallholder farmers (Ramírez, 2005). The quantification to which these factors interact and influence each other is not known yet.

To bring the aspects of social network impacts of NAADS and FFS on smallholder farmer resilience to light, there are mixed influences varying from no change in the proportion of households adopting new enterprises over time across the different groups (Benin et al. 2011), inadequate evidence of increased use of improved technologies, crop yield, and sales by households (Okoboi et al. 2013), and increased access to extension services and credit, social relations, income levels and food security status (Mfitumukiza et al. 2017), and strengthening the human

resource skills and institutional capacity of farmers that will potentially improve natural resource management, agricultural productivity, and marketing (Benin et al. 2008). Farmer's trust and perception of NAADS and FFS approaches are low and these have affected the effectiveness of the extension approaches (Turyahikayo & Kamagara, 2016). Additional shreds of evidence also show a combination of farmer empowerment through experiential learning in NAADS and FFS groups and changes in the opportunity structure through a transformation of local government staff, establishment of a sub-county farmer forum, and emergence of private service provider, which has been successful in reducing rural poverty in terms of improving employment, food security and investment in agriculture (Friis-Hansen, 2005). The models gave us the basis for assessing the magnitude of influence of some of the factors and how they promote farmers' socioeconomic resilience.

3. Methodology

3.1 Study Area

The study was conducted in northern Uganda's selected four (4) Peace Recovery and Development Plan (PRDP) districts of Amuria, Katakwi, Kitgum, and Lira. The four districts are among the fifty-five (55) PRDP local governments ((list of PRDP districts in Uganda)) in the northern region of the country. PRDP was developed to improve community participation and ownership of services; sustainability of services; promote economic recovery in Northern Uganda and revamp the quality of life of the beneficiary communities (Golooba-Mutebi and Hickey, 2010). This is to bridge the gap between the North and the rest of the Country. Agriculture is the predominant economic activity in the PRDP districts that are characterized by crop and livestock farming (Birner et al. 2010; Dalipagic & Elepu, 2014). According to Uganda's statistical abstract (2013), the estimated total production of metric tons of main crops was 6,314,042, and the total number of livestock was 38,169,674. PRDP local governments derive their investment priorities through bottom-up consultative planning, per the harmonized participatory planning guidelines and the regular annual planning processes from November to June. Local governments here are able to choose and allocate across eight key sectors including Education, Health, Water, Works, Environment, Lands, Production, and Local Government in line with their local priorities. The existing inter-organizational networks in PRDP districts provided the connection needed to generate superior collaborative capital for the provision of agricultural extension services to the communities. The more connected organizations can be leveraged for faster communication and resource flow to boost the delivery of agricultural extension services as this supports effective decision-making for agricultural development under NAADS and FIS (Ssengooba et al. 2017).

3.2 Study Design

The research employed a descriptive cross-sectional quantitative study that was carried out during the months from March to June 2020. A survey using a questionnaire was done that enabled the collection of categorical and numerical data. The data included the perception of smallholder farmers on pluralistic agriculture extension service provision and economic and social resilience. A relationship was established between the factors using categorical regression analysis. Before data collection, approval of the protocol of the study tool was done by the National and Institutional Ethical Board to ensure adherence to ethical standards. The researchers also sort permission from the Local Government Levels, and participants consented to take part in the study. The questionnaire was pre-tested on smallholder farmers who were non-study respondents and later revised to include local terms as understood by the community.

3.3 Population Sampling

A multistage sampling technique was applied in four phases involving: (1) random sampling of four (4) district local governments that implemented the Peace Recovery and Development Plan (PRDP); (2) a random sample of lower local governments (sub-counties) in the selected district; (3) four (4) random samples of smallholder farmer groups nested within the selected sub-counties were obtained; and (4) six (6) adult smallholder farmer group members were randomly selected based on their participation in NAADS and FFS programs. In each of the selected sub-counties, a list of registered smallholder farmer groups (mixed group only) was obtained from the office of the Community Development Officer.

3.4 Survey Instrument

The survey used a structured questionnaire with many questions that captured the indicators of the perception of smallholder farmers about pluralistic agriculture extension service provision, which were considered to be predictors of socioeconomic resilience. Faure et al. (2016) identified good pluralistic agriculture extension service provision measures to include governance structures, funding mechanisms, capacities of service providers and skills of advisors, and methods and approaches to provide advice - In this study, the measures of perception of

smallholder farmers for the pluralistic agriculture extension service provision were staff capacity, the management style of extension agents, information support, training and technology transfer, input supply, and monitoring and evaluation of extension activities of smallholder farmers which were evaluated using ordinal measures. The social and economic resilience variables were developed according to Copeland et al. (2020) and Briguglio (2016). The Resilience Index Measurement and Analysis (RIMA) was adopted from Mondal et al. (2023) and operationalized as a smallholder farmers' resilience capacity that also included access to basic services, assets, social safety nets, and adaptive capacity. The social resilience measures were access to extension workers and management personnel, response to farmers' needs, knowledge and information-seeking behavior, membership in groups, farmer group connection to other groups and agencies, and adaptiveness. Both pluralistic agriculture extension and social resilience had ordinal responses. The economic resilience measures had mixed data types of nominal, ordinal, and numeric, which were measured as access to agricultural training, employability, household net worth, ability to meet essential household needs, and asset ownership. All ordinal responses were 5-point Likert-type scale with 1 corresponding to strongly agree and 5, to strongly disagree, the nominal responses were yes and no, and the numeric responses were numbers.

3.5 Data Collection

In order to determine and assess the relationship existing between pluralistic agricultural extension service provision and socioeconomic resilience, a structured questionnaire consisting of 79 questions was prepared and administered to 323 smallholder farmer group members in the local languages of Luo and Ateso by trained and experienced research assistants from Luo (61%) and Ateker (38.5%) ethnic groups living in rural districts of Lira (42.4%), Amuria (26.2%), Katakwi (12.3%) and Kitgum (19.1%) in northern Uganda. Of the 323 smallholder farmer group members, 50.5% were males and 49.5% were females. The majority (75.4%) were aged between 20 and 50 years and had lived in the villages for 31 years. To ensure reduced biases, the questionnaire included opening statements on the aim and content of the research, the roles of the respondents, the benefits that would accrue from the research process, the right to opt out of the data collection, independence of the data and the confidential handling of responses. To ensure data quality was maintained during the data collection process, the questions in the questionnaire were worded in such a way that they were easily understood by interviewees and sought information that responded to the needs of the study. The questionnaire was also translated into the local languages. Prior to the fieldwork, permission was sought at the lower local government level. The study was also approved by the Institutional Review Board (IRB) of Mbarara University of Science and Technology (MUST) and the National Council of Science and Technology of the Republic of Uganda.

3.6 Data Processing and Analysis

Of the total 323 surveyed smallholder farmer group members, 319 completed responses were received and 11 responses were excluded due to incomplete feedback, missing data, and mistakes in the recording, thus resulting in 308 responses considered to be a valid sample set. The reduction in the number of data sets was done by Categorical Principal Component Analysis (CATPCA). The optimal scaling transformation during data reduction was nominal and ordinal to obtain numeric variables (Linting et al. 2007; Linting & van der Kooij, 2012; Meulman et al. 2004). Kaiser-Meyer-Olkin (KMO) and Bartelett Test (BTS) of sphericity measure of sampling adequacy and appropriateness of CATPCA were 0.94, 0.73, and 0.58, 11279, 254, and 235 above the minimum expected significant value of 0.5 (Field survey, 2020). The suitability of questionnaire items for factor analysis tests was assessed using the Variance Accounted For (VAF) of values ≥ 35%, and Principal Component Coefficients or loadings of ≥ 0.5 (Brown, 2009 and Stevens, 2012). The number of factors selected for the regression analysis was defined by the factors that had substantial amounts of common variance and component loadings using CATPCA. The second-degree optimal scaling with two interior knot transformations was done to control the smoothness of the data since they were mixed (Linting et al. 2007; Linting & van der Kooij, 2012; Meulman et al. 2004). The variables with no significant loading on the factor were deleted, and the factors were labeled based on the higher loading variables because of the greater influence than those with low loading (Hair et al., 2010). The questionnaire had a total of eighty-seven (87) questions, of which 35 were for pluralistic agriculture extension service provision, 21 for social resilience, and 31 for economic resilience. Of these, only fifty-eight (58) questions were selected by factor analysis - 31, 16, and 11 for pluralistic agriculture extension service provision, social resilience, and economic resilience respectively. The VAF and principal component coefficient values reduced the question further to only seventeen (17) components (42% selection) that consisted of 6, 5, and 6 under pluralistic agriculture extension service provision, social resilience, and economic resilience respectively (Tables 1 and 2). These measures under the different categories were transformed to form the main factors whose scores were obtained and later used in the CATREG analysis.

Table 1. The selected pluralistic agriculture extension service provision items

Factors	Statements
Staff capacity	The ability of extension agents to provide extension services
	The capability of extension agents to identify farmer needs and requirements
	Having the right knowledge to help farmers improve farming activity performances
	The usefulness of extension agent's facilities to achieve agricultural development goals
	Adequacy of facilities to extension agents to enable them to perform well
	Delivery of extension service promotes farmer acceptance and adoption
Management style	The behavior of extension agents promotes a good relationship between extension agents and farmers for improved technology adoption
	Coordination of farmer activities tailored toward the realization of farming outcomes
	Extension activities are organized to motivate farmers to adopt new technologies and meet farmer's daily needs
	The behavior of extension agents promotes the effectiveness and efficiency of resources allocation and use during the planning and budgeting process
	Communication of farming activities is aimed at enabling farmers to appreciate extension service provision
	Feedback on farmer's activities is aimed at enabling farmers to appreciate extension service provision
Information support	Information provided to farmers promotes farmer learning
	Timely and relevant information was provided to farmers prior to the planning and budgeting process
	The type of information provided is tailored to increasing farmer's productivity
	Methods of information provision increase farmers' access to extension service
	Information and Communication Technologies used are affordable and sustainable
Input supply	Adequate quantity of agricultural inputs provided to farmers
	Agricultural inputs provided are of the right quality and available all the time
	Agricultural inputs are provided at the right time to farmers
	Agricultural inputs are replaced when do not meet the farmer's target
	Agricultural inputs provided meet the needs and requirements of farmers in a particular community
Training and technology transfer	Training and demonstration meet farmer's technology needs and requirements
	Timing of training enables effective farmer learning
	Timing of demonstrations enables effective farmer learning
	Training methods are affordable to farmers
	Demonstration methods are affordable to farmers
	Technologies promoted are readily accepted by farmers
	Technologies promoted are sustainable for farmers
Monitoring and evaluation of extension activities	Extension officers follow up on farmer's activities to enable them to meet their goals
	Involvement of farmers during follow-up of farmer's activities to encourage learning from each other
	Feedback provided on farmer activity follow-up to farmers and other stakeholders for future improvement
	Decision on future extension activities in the sub-county is informed by farmer activity follow-up report

Table 2. Selected socio-economic resilience items

Factors	Statements
Social Resilience	Access to government extension workers
	Access to NGO extension workers
Access to extension workers and management personnel	Access to government management personnel
	Access to NGO management personnel
	Frequency of interaction with extension workers
	Frequency of interaction with management personnel
Response to farmer's needs	Extension worker's support to solve farming problems
	Management personnel support solving farming problems
Knowledge and information-seeking behavior	Individual farmers search for new knowledge
	The farmer group search for new knowledge
	Individual farmers search for new information
	The farmer group search for new information
	Participation in on-farm trails and demonstration
	Access to on-farm trials and demonstration
Group Membership	Number of farmer groups a farmer belongs to
Farmer group connection to other groups and agencies	Access to other development partners
	Access to community volunteers to link and connect
	Access to government staff to link and connect
	Access to NGO staff to link and connect
Farmer adaptiveness	Recognition of the need to sustain own production
	Acceptance of the need to sustain own production
Economic resilience	The alternative source of household income
Alternative household income	Type of income-generating activities (IGAs)
	Persons employed in IGAs
Total household income	Average monthly net income from IGAs
	Average annual net income from crop enterprise
	Average annual net income from livestock enterprise
Saving	Frequency of saving
	Place of saving
	Amount of savings in Uganda shillings
Financial asset	Amount in cash at hand in Uganda shillings
	Amount in credit in Uganda shillings
	Amount in debt in Uganda shillings
Ability to meet essential household needs	Able to harvest and buy food all year
	Able to pay school fees
	Able to pay medical bills
	Able to pay for social functions
Access to agricultural training	Attending agribusiness training
	Attending financial management training
	Attending credit access training
	Attending improved agricultural technology training

Employability	Able to get employment in agriculture
Land ownership	Size of land in acres
Productive assets	Number of cows
	Number of goats/sheep/pigs
	Number of chicken/turkey/ducks
Non-productive assets	Number of radios, motorcycles, bicycles, mobile phones and mattresses
	Type of house

4. Results

The majority of the smallholder farmers agreed with the study statements except for input supply and farmers' group connection to agencies and other groups that showed relatively strong disagreement compared to those in agreement (Table 3). However, 7.4% and 21% were in disagreement and strong disagreement with pluralistic agriculture extension service provision, and socioeconomic resilience. On average, a few (16.7%) of the smallholder farmers were not sure of what to say about the pluralistic agriculture extension service provision and socioeconomic measures of the study. However, almost a third (24.5%, 29%) were not sure about pluralistic agriculture extension service provision and economic resilience respectively, and only less than 5% about social resilience.

The calculated monthly saving of the smallholder farmers was 266,151 ± 336,905 Uganda shillings with a maximum of 2,500,001 shillings. The average productive and non-productive assets per farmer were 4.58 ± 4.13 and 2.11 ± 1.40 with a range of 1 - 30 and 1 - 10 respectively.

Table 3. Frequencies of the components of the pluralistic agriculture extension service provision, and social and economic resilience (n=308). Source: Field survey data

Items	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**Strongly disagree**
Pluralistic agriculture extension service provision					
Information support	15	207	24	18	44
Staff capacity	27	197	27	29	28
Training and technology transfer	7	156	23	33	89
Input supply	-	39	10	82	177
The management style of extension agents	12	203	32	19	42
Monitoring and evaluation extension activities	20	136	31	38	83
Social resilience					
Access to extension agents and management personnel	24	235	1	24	24
Response to farmer needs	25	190	4	14	75
Knowledge and Information seeking behavior	44	171	3	12	68
Farmer group connection to agencies and other groups	6	128	6	36	132
Farmer adaptiveness	53	198	1	5	51
Membership in more than one group	51	204	2	-	51
Economic resilience					
Access to agricultural training	45	152	31	18	61
Ability to meet essential household needs	72	168	20	26	22
Employability	80	118	36	5	67

4.1 Regression Models

The models were developed for pluralistic agriculture extension service provision's influence on social and economic resilience.

Change in smallholder farmer social resilience

The regression gave the value of the multiple determination coefficient (R^2) as 0.396, for pluralistic agriculture extension service provision influence on smallholder farmer social resilience, which implies that almost 40% of the variance in social resilience is explained by pluralistic agriculture extension service provision, the p-value together indicate the fit of the model. The F-statistic value of 12.75 is the level of a critical point of change in smallholder farmers' social resilience. The relationship of the pluralistic agriculture extension service provision with social resilience showed significant value for monitoring and evaluations of extension services, and management styles of the extension agents with the critical contribution in the model occurring at 3.072 and 2.766 respectively (Table 4). These F-values indicate a lower management style effect compared to monitoring and evaluations of extension services.

Table 4. Relationship of pluralistic agriculture extension service provision with social resilience

	Standardized Coefficients				
		Bootstrap (1000)			
Items	Beta	Estimate of Std. Error	df	F	Sig.
Input Supply	.085	.077	1	1.215	.271
Training and technology transfer	.092	.079	3	1.376	.250
Information support	-.157	.156	4	1.013	.401
Staff capacity	.327	.195	1	2.807	.095
Monitoring and evaluation of extension activities	.214	.122	2	3.072	.048
Management style	.243	.146	4	2.766	.028

The model indicates that the removal of the variables 'monitoring and evaluation of extension activities' and 'management style of extension agents' from the relationship, weakens the prediction of social resilience. On the contrary, if the rest of the factors are removed, the model's predicting ability shows only a minimal decrease in variance. If added together, the relative significance of the independent variables of the 'management style' and the 'monitoring and evaluation of extension activities' variables account for 76% of the overall influence of the independent variables.

To examine how the six variables appear to play a role in the social resilience of smallholder farmers, transformed plots have been produced (Figure 2). In order to effectively explain the influence of the pluralistic agriculture extension service provisions variable on the social resilience variable, it is essential to refer to the quantified values of the variables through transformation plots. The original category values and obtained category quantifications are shown on the x-axis, and y-axis respectively. Thus, the higher the quantification received by the original category, the greater the contribution of this category in the interpretation of the dependent variable (social resilience of smallholder farmers).

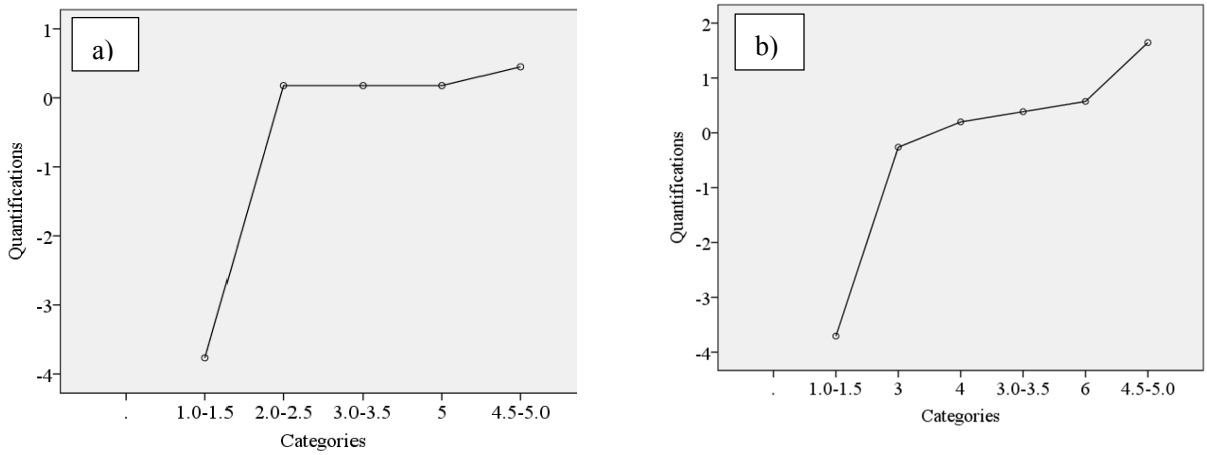

Figure 2. Transformation plots for a) management style and b) monitoring and evaluation of extension activities

From the 'management style of extension agents' transformation plot and in combination with the positive coefficient, it is obvious that the transition from the behavior of extension agents that do not promote good farmer relationships, effective and efficient resources allocation, and use, motivate farmers, coordinate and communicate farmer's activities to the improved behavior of extension agents that promote good farmer relationship, effective and efficient resources allocation and use, motivate farmers, coordinate and communicate farmer's activities management style levels is related to an improved smallholder farmer social resilience. More importantly, the 'monitoring and evaluation of extension activities' variable transformation plot, in combination with the positive sign of the coefficient, shows that the transition from a non-participatory to a participatory and regular feedback level of monitoring and evaluation of extension activities is related to an improved smallholder farmer social resilience.

Change in smallholder farmer economic resilience

The smallholder farmers participating in the pluralistic agriculture extension approach were interviewed to determine the factors that influence their economic resilience. The ordinal and nominal scores were used as the numerical values of the dependent variable 'economic resilience' for each respondent in the CATREG model. The model gave a multiple determination coefficient (R^2) of 0.32, which contributed to a significant variance (32%) of the economic resilience (F =15.851, df = 9, p = 0.00), implying the model predicts the changes adequately. The F-value in the modal reveals the level at which there is a significant change in economic resilience, which corresponds to the critical level of 5.498 and 10.672 for monitoring and evaluation of extension activities, and management style of extension agents respectively (Table 5). The F-values indicate that the significant effect of monitoring and evaluation of extension activities on economic resilience occurred before that of the management style of extension agents.

Table 5. Relationship of pluralistic agricultural extension service provision with economic resilience

	Standardized Coefficients				
		Bootstrap (1000)			
Items	Beta	Estimate of Std. Error	df	F	Sig.
Input Supply	-.012	.112	1	.012	.913
Training and technology transfer	.069	.121	1	.324	.570
Information support	.092	.169	1	.297	.586
Staff capacity	-.046	.165	1	.076	.783
Monitoring and evaluation of extension activities	.224	.096	3	5.498	.001
Management style	.352	.108	2	10.672	.000

Removal of the management style of extension agents and monitoring and evaluation of extension activities from the model weakens its prediction of smallholder farmers' economic resilience. On the contrary, if we remove the variables 'staff capacity', training and technology transfer', 'input supply', and information support, the model's predicting ability shows only a minimal decrease in the variance. The relative significance of the independent variables (management style, and monitoring and evaluation of extension activities), if added together, account for 100% of the overall change in economic resilience. In order to effectively explain the effect of the pluralistic agriculture extension service provision on economic resilience, it is essential to refer to the quantified values of the variables through transformation plots (Figure 3).

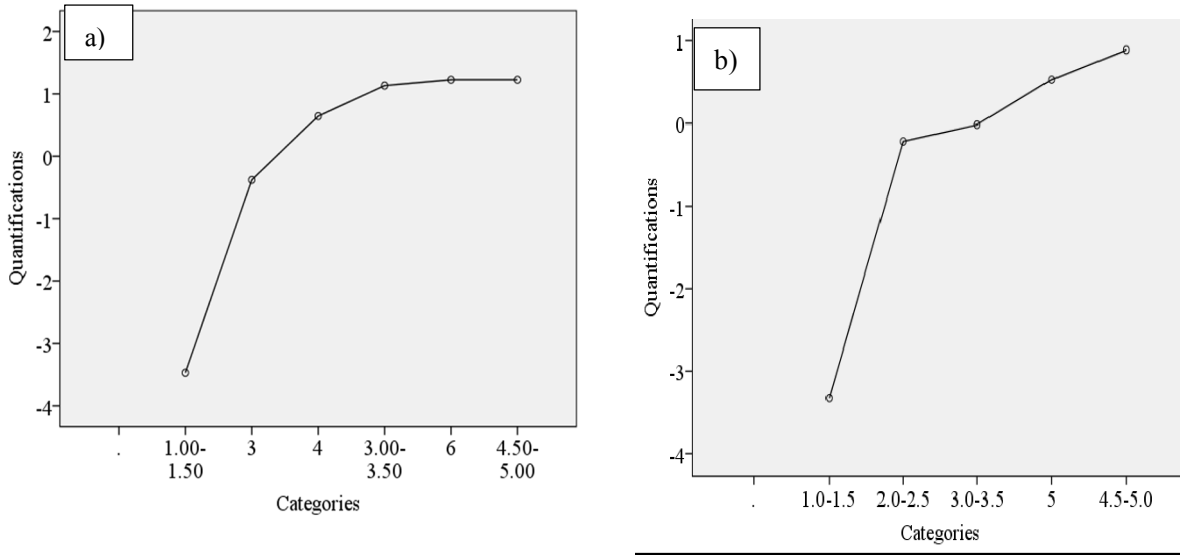

Figure 3. Transformation plots for a) management style and b) monitoring and evaluation of extension activities

From the 'management style of extension agents' variable transformation plot and in combination with the positive sign of the coefficient, it becomes obvious that the transition from the behavior of extension agents that do not promote good farmer relationships, effective and efficient resource allocation, and use, motivate farmers, coordinate and communicate farmer's activities to the improved behavior of extension agents that promote good farmer relationship, effective and efficient resources allocation and use, motivate farmers, coordinate and communicate farmer's activities management style levels is related to an improved smallholder farmer economic resilience. Similarly, the 'monitoring and evaluation of extension activities' variable transformation plot, in combination with the positive sign of the coefficient, shows that the transition from a non-participatory to a participatory and regular feedback level of monitoring and evaluation of extension activities is related to the improved economic resilience of smallholder farmers. In contrast, the 'input supply' variable transformation plot, in combination with the negative sign of the coefficient, shows that the transition from non-replacement of inputs that do not meet farmer's targets, needs, and requirements of farmers to a replacement of inputs that meet the target, needs, and requirements of farmers levels of input supply is negatively related to smallholder economic resilience. Similarly, the 'staff capacity' variable transformation plot, in combination with the negative sign of the coefficient, shows that the transition from an inadequate ability, capability, knowledge, and useful facilities of extension agents to an adequate ability, capability, knowledge, and extension agent's levels of staff capacity to plan is related to a lower smallholder farmer economic resilience.

5. Discussion

These analyses reveal several important insights about the relationship between individual pluralistic agriculture extension services, and social and economic resilience. The relationships between pluralistic agriculture extension service provision and social resilience and economic resilience are consistent with that of smallholder farmer resilience in Sub-Saharan Africa (Dixon & Stringer, 2015). It should be noted that not all independent variables were significant in the models. The major finding of this study was that smallholder farmers' social resilience and economic resilience can be significantly predicted by the management style of extension agents, and monitoring and evaluation of extension activities. In any agricultural development planning practice, this translates to improved access to extension workers and management personnel, response to farmers' needs, knowledge and

information-seeking behavior of smallholder farmers, farmer group connection to other groups and agencies, and farmer adaptiveness. However, the positive and significant predictors could explain the 39.6% of the social resilience and the 32.4% of the economic resilience of smallholder farmers. The gaps in change are explained by other factors that were not included as variables in this study. However, pluralistic agriculture extension and the advisory system should coordinate multiple groups at various stages of shock and stress because of their linkages. In addition, the potential access to timely information enables the pluralistic agriculture extension and advisory systems to identify relevant actors with whom to work to ensure that intervention strategies are harmonized to become relevant, effective, and timely (Davis et al, 2014).

The strong positive relationship between the management style of extension agents and the monitoring and evaluation of extension activities is valid, and we can only suggest a preliminary explanation. It is possible that a pluralistic agriculture extension service model that promotes improved behavior of extension agents to develop good farmer and extension agent relationships, results in effective and efficient resource allocation and use, motivates farmers, and coordinates and communicates farmer's activities, favors farmers to farmer learning as well as knowledge sharing with extension agents, and increase innovation levels that play a major role in improving farm management needed to build resilience (Leitgeb et al. 2011). This is because increased social learning leads to increased problem ownership, enhances the knowledge base with regard to livelihood impacts and production adaptation options, improves the ability to see connections and interdependencies, and finally, strengthens relationships and social cohesion (Phuong et al. 2018). Smallholder farmer resilience is increased by access to multiple sources of agricultural knowledge and support for collective initiatives, co-learning, and co-innovation processes for local capacity building (Knickel et al. 2018). Koopmans et al. (2018) argue effective communication, coordination, and information enable smallholder farmers to develop social connectedness for resource exchange, cohesion, response, and recovery. In addition, a pluralistic agriculture extension service model that promotes participatory monitoring and evaluation of extension activities and provides regular feedback to smallholder farmers improves their capacity to discuss and understand threats and opportunities and prioritizes individual and collective actions aimed at improving overall resilience (Choptiany et al. 2017). According to Cinner et al. (2009) inadequate feedback on extension activity monitoring and evaluation to smallholder farmers reduces their adaptive capacity.

The information support, input supply, and staff capacity do not significantly explain the variances in smallholder farmers' social resilience and economic resilience. The negative beta values show a) the type of information provided is not tailored to increase productivity, b) the method of information delivery used does not increase farmer access to extension service, c) the information provided is not timely and relevant, d) inputs supplied do not meet farmer's target and are not replaced, e) inputs provided do not meet the needs and requirements of farmers, f) extension agents do not have the capacity to identify farmer needs and requirements, g) extension agents do not have the right knowledge to help farmers improve their performances, h) extension agents do not have facilities that are useful to achieve agricultural development goals, and i) their extension delivery system does not encourage farmer acceptance and adoption of new innovations. The untimely and irrelevant information reduces the ability of smallholder farmers to make the correct decision on their farming activities (Singh et al. 2018). Davis et al. (2014) argues that a lack of information about weather, inputs, farm management practices, or market prices increases smallholder farmers' exposure to risks and uncertainty leading to reduced production and income. Therefore, a smallholder farmer who receives quality, up-to-date information and has the ability to use it may be able to lessen the effects of these risks (Meera et al. 2012). Coomes et al. (2019) argue that the use of no-tillage systems conserves not only soil and water but also labor invested as farmers use the freed-up time to manage waste better or conserve water elsewhere on the No-tillage systems, conserve not only soil and water but also labor invested, as farmers use the freed-up time to manage waste better or conserve water elsewhere on farm, and lower input costs indirectly and directly increase smallholder farmer's resilience to economic and environmental shocks. Similarly, an extension agent with decreasing abilities or resources cannot enable smallholder farmers to understand the risks uncertainties, and management options, making smallholder farmers unable to make better choices to manage risks (Hunt et al. 2012).

Although the management style of extension agents, monitoring and evaluation of extension activities, input supply, information support, and staff capacity are recognized as fundamental factors that influence pluralistic agriculture extension service on smallholder farmer innovation and technology adoption needed to build their socio-economic resilience, many of the studies are qualitative in nature (Ashkenazy et al. 2018; Anderson, 2015; Cabell and Oelofse, 2012; Darnhofer, 2010; Darnhofer, 2014; Davis et al. 2014a; Davis et al. 2014b; Darnhofer and Strauss, 2015; Glover, 2012; Hunt et al. 2011; Knickel et al. 2018; Li et al. 2016; Moller et al. 2008; Milestad and Darnhofer, 2003; Milestad et al. 2010, July; Phuong et al. 2018; Šūmane et al. 2018; Vroegindewey and Hodbod, 2018 and

Waddington et al. 2014). This study determines the magnitude and the significant influence of these factors on the social resilience and economic resilience of smallholder farmers.

The F- values of the independent factors are critical points that caused significant changes in socioeconomic resilience. In terms of monetary values, more is required in monitoring and evaluation of extension activities compared to management style to impact social resilience while the reverse is true for economic resilience where management style takes precedence. This should be the basis of prioritization in the local planning and budgeting processing and the implementation of pluralistic agriculture extension services.

The advantage of this finding is that the regression models used input data that had no errors. Data preparation before analysis removed missing values by not including such questionnaires, and the imbalance in data distribution was properly checked using statistical tests. More so, there was a deliberate choice of a coding system that allowed for comparisons, and the smoothing of data by transformation was meaningful in the hypotheses testing. The employment of PCA identified the independent factors since regression models are usually susceptible to collinear problems. Therefore, the validity and ruggedness of the regression models in this study are accurate and can potentially apply to any design and implementation of pluralistic agriculture extension services. Overall, the importance of the findings can guide and inform decisions regarding how to improve the performance of pluralistic agriculture extension service provision for smallholder farmers to increase their competence in dealing with challenging livelihood conditions.

6. Conclusions

The paper provides some interesting and important findings and suggests some possible recommendations for the future design and implementation of resilient-based agriculture extension service systems. The empirical results show the strong increasing need to integrate the management style of extension agents and monitoring and evaluation of extension activities into pluralistic agriculture extension service provision have a significant and positive influence on social resilience and economic resilience of smallholder farmers. The results indicated that smallholder farmers' social resilience and economic resilience are increasing when: a) the management style of extension agents promotes a good relationship between smallholder farmers and extension agents, b) communicates, coordinates, and provides feedback on activities of smallholder farmers, c) organizes extension activities to motivate smallholder farmers to adopt new technologies and meet smallholder farmer's daily needs and promotes effective and efficient allocation and use of resources during local government planning and budgeting process. In addition, if extension agents i) follow up on smallholder farmer's activities, ii) involve smallholder farmers during the follow-up of farmer's activities, iii) provide feedback on farmer activity follow-up to farmers and other stakeholders for future improvement and iv) the decision on future extension activities are informed by farmer activity follow-up report, the end result is 30-40% flexibility in social and economic variance. This implies improving coordination of farmer activities through a two-way communication approach, collaboration between smallholder farmers and extension agents, and emphasizing participatory monitoring and evaluation of smallholder farmer extension activities will directly link farm decision-making with the practices needed to increase smallholder farmer resilience. For the practitioners, policymakers, and researchers of agriculture extension service systems, this means redesigning the current pluralistic agriculture extension service approach to improve the behavior of extension agents toward farmers, coordinating of farmer extension activities, and strengthening the feedback mechanisms used during planning and implementation of extension activities at the local level.

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