AGRICULTURAL KNOWLEDGE NETWORKS AND THEIR IMPLICATIONS ON FOOD ACCESSIBILITY FOR SMALLHOLDER FARMERS

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ABSTRACT

To explore and understand the knowledge systems of smallholder farmers, there is a need to investigate questions about *what* and *how* knowledge is delivered by networks to these farmers. Therefore, this study answers the following questions: What are the knowledge networks available for smallholder farmers, and how do they access them? Moreover, in the agriculture sector, information is considered an important decision-making tool for farmers when improving their livelihoods and accessing food security. Therefore, the study also aimed to answer a question: What are the implications of available knowledge systems on the food security status of active smallholder farmers? An effective information system within, along with supportive and continuous knowledge networks outside, agricultural communities is crucial for addressing the needs of marginalised farmers. To answer the research questions, purposive sampling was used to select a sample of 219 active smallholder farmers operating in the Appelsbosch and Bergville areas of the province of KwaZulu-Natal, South Africa. The study followed both a qualitative and quantitative approach. The overall results of the study demonstrated that agricultural knowledge flows through various channels, including farmers' local networks, the private sector, non-governmental organisations (NGOs) and research institutions. Furthermore, the participation level of farmers in local knowledge systems indicated a significant impact on farmers' food security status. Farmers in the study highlighted that the technical knowledge received during training and demonstrations helped them to improve their skills in conducting and performing field activities that improved their crop production. Therefore, the KwaZulu-Natal Department of Agriculture and Rural Development (DARD), as well as various NGOs, needs to have continuous access to updated information in order to promote transformative initiatives and integrated knowledge platforms that empower farmers in resilient food production.

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INTRODUCTION

The daily social interaction amongst farmers and other collaborations available to farmers provide many opportunities for farmers to learn from one another. Simpson and De Loë (2017) note that both informal gatherings and formal socio-cultural events tend to be the main platforms used for interaction between farmers. These interactions eventually lead to agricultural learning opportunities (Simpson & De Loë 2017). Furthermore, according to Tamako and Thamaga-Chitja (2017), rural communities across the province of KwaZulu-Natal comprise active smallholder farmers who form self-organised agricultural networks with both formal and informal actors (Tamako & Thamaga-Chitja 2017).

Smallholder farmers actively share and source agricultural knowledge through interpersonal communication during social gatherings; farmers' groups, meetings with village leaders, input suppliers, extension officers and non-governmental organisation (NGO) representatives; and agricultural exhibitions, (Kunda et al. 2018; Lwoga et al. 2013). Furthermore, Zeweld et al. (2017) emphasise that farmers play an important role in disseminating agricultural knowledge, since they are best able to see how it translates to practice. Farmers also gain new knowledge through various practices that can be shared through farmer social networks (Zeweld et al. 2017). These interactions amongst smallholder farmers build knowledge networks with multiple heterogeneous communities of knowledge.

The building of agricultural knowledge networks, which takes place both within and outside of farmers' communities has been discussed in the available literature (Kunda et al. 2018; Rangarajan & Chitja 2020). However, the effectiveness and the impact of these networks on farmers' access to food security have not been fully explored. Thus, the research objective of the study reported in this article was not only to describe the knowledge systems available in the selected study areas and the way the farmers in these areas were associated with these networks but also to examine the relationship between them and the farmers' access to food security. Food security is said to exist "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2015)." As the definition of food security has evolved, it has become apparent that availability, access, utilisation and stability of access are key components (FAO, 2015). The study specifically asked fundamental questions, such as what knowledge do networks deliver to the farmers in question, and how is it delivered? Moreover, the study asked the following question: What are the implications of available knowledge systems on the food security status of active smallholder farmers?

It should be noted that South African knowledge systems generally tend to include a combination of various government departments, local farmers' associations and cooperatives (Rankoana 2017). However, agricultural knowledge systems (AKS) are slightly different in that they are organised in complex networks of agricultural departments/universities and farmers. According to studies by authors, such as Macdonald (2012), Madukwe (2016) and Lwoga et al. (2013), farmers operate in multi-actor, overlapping, formal and informal knowledge networks, especially in South Africa rural communities. According to Pienaar and Traub (2015), farmers obtain knowledge through their participation in primarily heterogeneous networks.

In the context of agriculture, scholars have emphasised knowledge as an important decision-making tool for smallholder farmers to improve their livelihoods and food security (Mckitterick et al. 2016; Mkenda et al. 2017). However, for formal information systems to provide continuous services to meet the needs of agricultural communities of isolated and marginalised farmers, effective communication is crucial (Tamako & Thamaga-Chitja 2017). Moreover, Jennex and Assefa (2018) emphasise that integration between formal and informal knowledge systems would ensure farmers' knowledge empowerment. Thus, upscaling and institutionalising the informal knowledge systems

used by farmers would lead to access for rural communities across South Africa. By understanding how farmers use both informal and informal knowledge systems, it may be possible to gain insight into why some farmers can solve local farming issues and show good progress, while others fail, despite operating in close geographical spaces.

Knowledge and skills are essential resources for farming (Department of Agriculture, Fisheries and Forestry [DAFF] 2010). The majority of smallholder farmers in developing countries, especially in South Africa, tend to rely on the knowledge and skills that they acquire informally (Blore 2015). However, agricultural experts, such as farmers who work in other related professions, often provide agricultural advice to smallholder farmers and help to shape and strengthen their knowledge and skills (Cabrera & Cabrera 2005; Chakraborty & Chaudhuri 2018). In addition, they often trigger indigenous knowledge sharing amongst farmers (Chakraborty & Chaudhuri 2018).

Studies, including the one conducted by Senanayake (2006), consider indigenous knowledge valuable for smallholder farmers and poor communities because it has been developed over time to suit the needs of particular farmers and has led to sustainable agricultural productivity. Another source of agricultural knowledge is provided by the different development projects of NGOs and government departments. Such assistance is described in the DAFF (2011) and the Food and Agriculture Organisation (FAO) of the United Nations (2015) reports, both of which outline rural development frameworks. These frameworks were re-designed to ensure that the targeted delivery of services and collective actions allow farmers access to agricultural knowledge inputs such as group training.

This paper examines the knowledge systems available to smallholder farmers by acknowledging that rural communities contain dense, connected knowledge systems made up of different actors, who might be the receivers or sources of knowledge. According to Kaine et al. (1999), a knowledge system is any network of actors connected by both or either formal and informal social relationships. Moreover, these systems could be further interspersed with groups of actors who share one or more similar goal(s). In South Africa, agricultural knowledge and information systems are usually created conjointly by agricultural universities, agricultural colleges, research institutes, agricultural departments and different actors concerned with agricultural production and farmers (Pienaar 2013). These systems are then shared with farmers (DAFF 2011), who learn analytical skills, critical thinking and the ability to make better decisions, for example.

To understand these knowledge systems, the study examined the knowledge pools of particular farmers to see whether their access to existing AKSs might contribute to the fight against poverty and for the empowerment of small-scale farmers, who constitute the majority in developing economies (Beaman & Dillon 2018) and whose agricultural productivity is linked to their food security (Smedlund 2010). In addition, Allahyari et al. (2017) argue that productivity is greatly determined by the amount and type of information available to smallholder farmers. This assertion is supported by both Chakraborty and Chaudhuri (2018) as well as Cofré-bravo et al. (2019), who maintain that, in order to enhance their agricultural productivity small-scale farmers should have access to well-organised and relevant information.

Dolinska (2016) emphasises that a lack of skills and competence in performing agricultural activities can result in poor production. Additionally, Madukwe (2016) argues that the lack of capacity, knowledge and skills development for farmers are some of the reasons why ineffective and disempowered agricultural systems exist. Therefore, the production and circulation of agricultural knowledge for smallholder farmers have become a growing area of research in the agricultural world, to which the study hoped to contribute.

THEORETICAL FRAMEWORK

The study used Lubell et al.'s (2011, 2013) definition of AKSs as a basis from which to understand the concept. Specifically, this definition explains AKSs according to the following four core concepts: 1) programme participation; 2) social networks; 3) belief systems; and 4) practice adoption (Lubell et al.

2011, 2013). Further note that Foster and Hoffman (2013); Lubell et al. (2014) and Rosensweig (1995), explain that AKSs support three inter-related learning pathways, namely social, experiential and technical learning. Moreover, AKSs might involve a collection of actors, such as researchers, advisors, and educators, who work primarily in agricultural knowledge institutes (Chow & Chan 2008; Demiryurek et al. 2008).

Miltal et al.'s (2018) study outlined how farmers who work together tend to share resources, belong to labour associations and have years of experience. Over time, these alliances and associations generally become institutionalised as local organisations, communities, self-help groups and farmers' co-operatives (Mckitterick et al. 2016). The networks and relationships within such institutions have specific ways of engaging with each other, which are rooted in their everyday practice, and involve interaction amongst both individuals and across entire network systems.

Aside from the definition of AKSs, the present study was grounded in the sustainable livelihoods framework (SLF), which identifies five capitals, which can be classified under two main categories: 1) tangible assets (physical, natural, and financial), and 2) intangible assets (human and social) (Scoones 1998; Vorley et al. 2012). Social relations such as kinship, communities and friends all contribute in different ways to rural individuals' livelihoods and to the security/ sustainability of a diversity of livelihood strategies.

METHODOLOGY

Site selection

The study was conducted in the KwaZulu-Natal province of South Africa, specifically within the uMshwathi and Okhahlamba local municipalities. The uMshwathi Municipality consists of 13 wards, and the South-eastern area of the municipality comprises rural areas that are mainly dominated by subsistence farming (Integrated Development Plan [IDP] 2016/17-2020/2021). Smallholder farmers exist on their traditionally controlled areas located along the edges of good, arable land that is generally reserved for sugarcane and forestry farming. The rest of the land is characterised by steep hills and rugged terrain, which are less suitable for farming. However, several crops, such as maize, beans, potatoes, carrots, spinach, cabbage and sweet potatoes are still grown in this terrain. Thus, the main economic driver in the rural component of this municipality is agriculture (IDP, 2016/17-2020/2021). Similarly, Okhahlamba Local Municipality smallholder farmers mainly engage in maize, vegetables and livestock production (IDP, 2016/17-2020/2021). These farmers occupy marginal areas around the town of Bergville. Smallholder farming is of primary importance in the province, as it is the backbone of rural households. Smallholder farmers from farming households within these two chosen communities were purposively selected for the study.

Research design

The study applied a mixed-methods, triangulation approach to investigate the topic by combining both qualitative and quantitative methods. However, most of the data collected in the study was quantitative in nature. According to Creswell (2013), a combination of both quantitative and qualitative methods increases the strength of a study and reduces the possibility of research bias influencing the research process and findings.

Data collection and sampling

Data were collected between November 2019 and March 2020 from households, each of which was considered a sample unit. Structured household questionnaires, focus group discussions (FGDs), and key informant interviews were all utilised to collect data. In addition, a pre-tested structured questionnaire was utilised to collect household demographics and the socio-economic characteristics of the participants. This questionnaire was also employed to access details about institutional support services, participants' membership(s) in farmer organisations and their participation in various group activities.

The FGDs and key informant interviews provided in-depth details and rich data from selected participants who had completed the structured questionnaires. An FGD with seven

participants was conducted in each of the two selected study sites. Each group consisted of seven farmers' group members which were randomly selected from the active farmers association. Additionally, five extension officers/ advisor were purposively selected from their allocated wards and five farmers' group leaders were purposively selected from their communities.

Three isiZulu-speaking enumerators administered the questionnaires to the participating farmers. A purposive sampling technique was employed to select 219 smallholder farmers found to be linked to the DARD in the areas of Bergville and Appelsbosch. The reason for using purposive sampling was that this approach enabled the selection of farmers who were actively involved in agricultural knowledge systems, thereby ensuring rich data collection from selected participants.

Ethical considerations

Informed consent

Participants for the interview were briefed on the purpose and conduct of the research after the ethical clearance **(Protocol reference number: HSS/0488/019D)** was approved by the University of KwaZulu-Natal. It was made very clear to them that participation was voluntary, and they could withdraw from the project at any stage without penalty. All personal information of the participants were treated as confidential and remain confidential throughout the study.

Analytical tools

Food security information was collected using the Household Food Security Scale (HFIAS). This scale captures information about food insecurity and the frequency of its occurrence (USAID 2007). It should be noted that several tools can be used to measure respondent food insecurity. However, for the present study, the HFIAS was deemed the most appropriate tool for assessing specific conditions associated with food insecurity as well as the frequency of occurrence patterns for a period of 30 days (FAO 2018) because it is rapid, cost effective and easy to use. Food And Nutrition Technical Assistance [FANTA] developed the HFIAS to reflect three ways that households generally experience food insecurity namely 1) anxiety and uncertainty about the household food supply; 2) inadequate food quality; and 3) insufficient food intake and its associated physical consequences (Ballard et al. 2011; FAO 2018).

The HFIAS utilises nine occurrence questions about whether a particular condition related to the experience of food insecurity has happened during the past 4 weeks (or 30 days). Responses are coded as 1=yes and 0=no (Ballard et al. 2011; United States Agency for International Development [USAID], 2007). Each occurrence question is then followed by a frequency-of-occurrence question, which enquires about how often a reported food insecurity condition has occurred during the past 4 weeks. These occurrence questions offer three response options: 1=rarely, 2=sometimes, and 3=often (USAID 2007). In the study, based on the respondents' answers to each question, the HFIAS score was then calculated as a whole. A total score of 27 represented the most food-insecure household, while lower scores represented a respectively more food-secure households. Each household was then classified into one of four categories: 1) food secure, 2) mildly food secure, 3) moderately food secure, or 4) severely food insecure.

Data analysis

A descriptive analysis of all the variables was conducted. Data collected from the field were captured and transferred into the Statistical Package for Social Science (SPSS) software programme for computer-aided analysis. In order to establish relationships between variables and offer a review as well as an analysis of the collected data, the information (participants' responses) obtained from the fieldwork was translated from isiZulu to English, which was the language required by the computer programme. The descriptive analysis involved establishing means, frequencies and standard deviations pertaining to the studied variables. Ordered probit regression was then computed to confirm any relationship(s) between food security and socio-economic parameters, especially farmers' participation in knowledge systems, using Software for Statistics and Data Science [STATA] software.

TABLE 1: DESCRIPTION OF INDEPENDENT VARIABLES USED IN THE MODEL

Variables	Measures	H_0 sign	Rationale
Gender of respondent (GEN)	1= male; 0 = female	+/-	More female dominates agriculture in the world
Age of respondent (AGE)	Number of years	+/-	Older farmers are more engaged in farming and interested in learning
The educational level of respondents (EDUC)	Number of years in school	+/-	Educated respondents are highly exposed to opportunities, more likely to be food secure.
Marital status of respondent (MARST)	1=married;0= single	+/-	Households with married spouses can be food secure
Monthly household income	Rands (R)	+/-	Higher-income can increase farmers' engagement in knowledge systems, and food security
Agriculture as Career	1=Yes, 0=NO	+/-	Farmers with career/business motives will engage in more farming knowledge systems
Agriculture Learning Platform	1=Yes, 0=NO	+/-	Farmers with learning motive will socially interact with more actors to increase their knowledge
Participation level on local knowledge systems	1=low, 2=high	+/-	High participation will increase farmers knowledge and improve food security
Participation level on technical knowledge systems	1=low, 2 =high	+/-	High participation will increase farmers knowledge and improve food security
Participation level on scientific knowledge systems	1=low, 2=high	+/-	High participation will increase farmers knowledge and improve food security

Specifically, the ordered probit model was operated as follows:

Farmer's household food security = f (gender, age, educational level, marital status, monthly household income, agriculture as career, agriculture learning platform, level of participation level in local knowledge systems, level of participation in technical knowledge systems, and level of participation level in scientific knowledge systems) ……[1]

The respective category for food security was unobserved and was denoted by the latent variable qi*. The latent equation below modelled how qi* varied with personal characteristics. qi* = Xi ……..……...[2]

Where variable qi*measured the utility derived by individual i from either food secure or mildly food secure or moderately food insecure or severely food insecure. i = 1, 2, 3……..(n)

n represented the total number of respondents. Each individual i belonged to one of the four food security groups.

X was a vector of exogenous variables listed in Table 1 below.

Results and Discussion

Table 2 below presents the demographic and socio-economic characteristics of the sample of 219 smallholder farmers who participated in this study.

The majority (66.2%) of the respondents were female farmers, with (33.8%) being male. These demographics agreed with the findings of Thamaga-Chitja & Morojele (2014), who note that there is a significant presence of women in agricultural production in most rural communities of South Africa. According to the current study survey, most respondents were also found to be older, which is supported by the Integrated Development Plan (IDP 2018), which reports that South African smallholder farmers' average age tends to be between 45 and 60 years old. This age range is also a common trend for many rural communities across most of sub-Saharan Africa, where people retire from urban life to settle in rural communities, as indicated by FAO (2018). Furthermore, the results of the study indicated that most farmers were married. These findings aligned with how most participants in this study took part in agricultural production primarily as a means to feed their families.

Most (34.7%) of the farmers from the sampled population were found to have achieved a high school level of education. This number was

TABLE 2: FARMER'S DEMOGRAPHICS

Sample characteristics	Categories	Frequency	Percentage%
Gender	Female	145	66.2
	Male	74	33.8
Age	21-35	26	11.9
	36-45	24	11.0
	46-55	56	25.6
	56-65	64	29.2
	>65	49	22.4
Marital status	Single	52	23.7
	Married	138	63.0
	Divorced	4	1.8
	Widowed	25	11.4
Education	None, can't read and write	52	23.7
	None can read and write	26	11.9
	Primary school (1-7)	60	27.4
	High School (8-12)	76	34.7
	Vocational training	3	1.4
	Diploma/degree	2	0.9
HH Income	Less than 1000	46	21.0
	1001-1500	60	27.4
	1501-3500	104	47.5
	3501 and more	9	4.1

n= 219 Source: A household survey (2020)

followed by farmers (27.4%) who had only attended primary school. Approximately 23.7% of the surveyed farmers were found to have not attended any formal or informal schooling and could not read or write, which is corroborated by Mkeni et al.'s (2010) study that found a high level of illiteracy amongst smallholder farmers in rural areas of South Africa. The inability to read and write has been noted in the literature as restricting the opportunity of smallholder farmers to learn new farming techniques (Tamako & Thamaga-Chitja 2017). This indicates a need for more experiential and verbal modes of knowledge dissemination.

The lack of formal education among smallholder farmers in rural areas may affect their willingness and motivation to know and learn more about agriculture. Furthermore, low levels of education tend to hinder farmers' ability to access relevant information, improve farming methods and/or sustain their food production. Farmers' performance has also been found to be directly linked to their human capital endowment. In South Africa, for example, various forms of both formal and informal training have been designed and organised specifically to enhance and expand farmers' human capital (DAFF 2011).

Farmers who took part in the current study's survey were found to earn different income. In total, 21.0% of the participant farmers earned less than R1,000 per month, while 27.4% of the farmers earned between R1,001 and R1,500. The majority (47.5%) of the participating farmers were found to earn between R1,501 and R3,500 per month, with the remaining 4.1% earning over R3,501 per month. Of note is that a significant number of the participating farmers (48.4%) also received a pension grant, based on their age.

Table 3 below, shows the multiple sources of income used by farmers to sustain their households. The majority of the surveyed farmers (57.1%) were found to depend on pension grants as their source of income. This was followed by 26.9% of farmers who receive governmental social grants to sustain their households. These grants supported the majority of farmers with household incomes ranging from R1, 500-R3, 500 per month (South African Social Security Agency [SASSA], 2020, 2021). A further 21.9% of the surveyed farmers were found to depend on the sales of their fresh produce to retail stores and/or local community members.

TABLE 3: FARMERS' SOURCE OF INCOME

Source of income	Respondents frequency (n=219)	Percentages %
Remittance		
No	*190*	*86.8*
Yes	*29*	*13.2*
Government grants		
No	*160*	*73.1*
Yes	*59*	*26.9*
Pension		
No	*94*	*42.9*
Yes	*125*	*57.1*
Farm Produce sale		
No	*171*	*78.1*
Yes	*48*	*21.9*
Salary/wages		
No	*204*	*93.2*
Yes	*15*	*6.8*

Note multiple responses by farmers

Knowledge systems utilised by smallholder farmers

The study demonstrated that smallholder farmers operate and interact with multiple actors who function within AKSs. These actors consist of individuals and/or organisations operating in local, scientific and/or technical knowledge systems. The local knowledge systems of smallholder farmers were found to consist of savings clubs; farmers' groups and unions; cooperatives; farmers' labour associations; middlemen (intermediaries); and fellow farmers operating within the community. These systems are generally used by farmers to acquire and share information on aspects such as fertilisers, insecticide spraying techniques, seed variety, planting schemes and new farming techniques. Such knowledge systems also consist of institutional communication channels; such as the DARD; radio programmes; and fellow farmers. Moreover, these systems are often led and driven by farmers who direct the knowledge flow of agrarian practices between farmers and other agricultural organisations. However, this direction is held together by governmental regulations, as well as the trust and values shared by the farmers themselves.

It should be noted that social relationships and bonds formed by smallholder farmers could help farmers to better frame their knowledge systems. Thus, the experience and knowledge of farmers could be exchanged and transferred through practices, such as scheduled meetings, field days/visits and discussion mechanisms aimed at integrating farmers' theoretical and practical knowledge. This sharing indicates that farmers are receivers, holders and transmitters of knowledge, since there is often an intense circulation of knowledge produced in and exchanged amongst farmers' 'knowledge pools' and/or 'niches. Thus, knowledge systems grow because of the social learning path often undertaken by smallholder farmers, which is based on social networks that form amongst farmers themselves, as explained by the conceptual model of AKSs presented by Hoffman et al. (2013). Similarly, according to Landini et al. (2017), social learning, which was experienced by the farmers in the study, involves a process of exchanging and reflecting about experiences, values and ideas to understand problems and find solutions. However, the scientific knowledge systems of smallholder farmers are associated with research institutions and NGOs (FAO 2017).

According to a 2017 FAO report, African communities are organised around family relations that play an important role in agriculture, which was observed during the study of the smallholder farmers in KwaZulu-Natal. The knowledge systems of farmers at both the Bergville and Appelsbosch study locations were found to revolve around family member, community farmers, the DAFF and the private sector. A similar study conducted by Boz and Ozcatalbas (2010) revealed that family members, neighbourhood farmers, extension

services, input providers, and mass media form key sources of information for Turkish farmers.

Local knowledge systems

The farmers who participated in this study were found to employ various ways of receiving and sharing local knowledge. These farmers tended to build knowledge with each other as well as with external information and knowledge providers. The various local knowledge channels included farmers' group associations (unions), fellow farmers, cooperatives, middlemen, community labour organisations and committees for agriculture, and financial savings clubs.

Farmers' group associations

Approximately 99.5% of the farmers in the study participated in some form of farmers' group association where they gained and shared agricultural knowledge. These participants noted that they tended to form farmers' groups as a way to gain access to agricultural extension and educational services more easily. Most people in rural communities are also related to one another and belong to only a few kinship groups. These kinship networks are particularly important for gaining access to knowledge, especially for elderly and illiterate farmers.

Farmers were generally found to hold monthly meetings and participate in field visits with an agricultural advisor, along with their fellow farmers in order to learn and observe technical skills. During these meetings and experiential learning opportunities, farmers discussed issues ranging from seed/fertiliser varieties to soil preparation. The participating farmers explained that the topics discussed had improved their yields, and that they had gained sufficient produce for both consumption and selling to generate income. The noted farmers' associations were also found to have branches at the village level, where they offered farmers the opportunity to participate in governmental programmes and development projects targeting smallholder farmers. These findings agreed with those of Rahutami et al. (2012), Mtega et al. (2016) and Mkenda et al. (2017) who indicate that farmers use knowledge gained from formal farmers' associations that provide training courses, advice, field days, and demonstrations.

Fellow farmers

Approximately 86.3% of the study respondents indicated that they interacted with fellow farmers regarding agricultural knowledge. Rogers (1983) explains that when individuals frequently interact through local networks, they are more likely to exchange knowledge and observe one another's behaviours. The participated farmers explained during the FGDs that through consultations and visiting other farmers' fields, they were able to gain information on how to address challenges. They would learn how their fellow farmers overcame an issue, which led to them implementing similar solutions. The participants noted that fellow farmers were generally open to other farmers who wanted to learn.

Successful farmers have a strong influence on their peers and can transfer knowledge more convincingly to them. Thus, farmers learn better from other farmers than they would do by attending workshops presented by the government (Saad et al. 2018). Klerkx and Proctor (2013) similarly reports that farmers mostly consider their successful colleagues as trustworthy sources of information, owing to their practical experience in similar environmental conditions.

Cooperatives

Of the participating farmers, around 48.4% indicated that they tended to engage in farmer cooperatives as one of their main knowledge platforms. Thus, apart from being members of farmers' group associations and interacting with fellow farmers, farmers often participate in other formal and informal social systems, such as cooperatives that provide farmers with access to scientific knowledge, which they might use in order to achieve better yield production. In addition, the social relations established through participation in cooperatives allow farmers to share information amongst themselves. During the FGDs, participating farmers clarified that through their cooperative, they were able to attend monthly meetings with extension advisors. Cooperative meetings were generally arranged telephonically and followed by field demonstrations. During these meetings, the farmers discussed inputs, such as seed varieties, fertilisers and pesticides to apply during planting session. Furthermore, they discussed harvesting methods and received market information.

Middlemen

Almost 23.3% of the participating farmers indicated that they had regular interactions with market middlemen when they sold their produce. According to the participants, these middlemen often arrived in small vans known as 'bakkies' to collect produce at the farm gate. Other actors in this chain included buyers of agricultural produce/products who bought the farmers' harvests and who were often the primary source of income for farmers. Middlemen were also mentioned by the participating farmers as being important sources of information, especially with regard to aspects, such as pricing and the best season for harvesting different types of produce. During the FGDs, the farmers explained that they often talked to traders about what the market needed and when best to harvest their fresh produce. During harvesting season, both exporters and traders visited the participating farmers' fields to collect their produce.

Community labour organisations and committees

Only 6.4% of the participating farmers shared that they engaged in a community labour organisation, with 20.5% of the farmers indicating interactions with the local committee for agricultural knowledge. The farmers who took part in the study explained that these committee channels offered information to village authorities, and community meetings were then scheduled in order for the information to reach the farmers within the organisation and any interested outsiders. Generally, the people who hold positions within such committees include village heads, retired educators and representatives of mass organisations, such as farmers' associations or cooperatives. These individuals share their experiences and any information gained through networks outside the community. This platform allows farmers, regardless of whether they participate or do not participate in farmers' groups to engage in community associations that demonstrate labour unity and share resources, such as tractors and planting schedules.

Financial/saving clubs (stokvels)

A small percentage (5.0%) of the participating farmers indicated that they engaged in community savings clubs (also known as financial clubs or 'stokvels'). These participants had been mobilised to form savings and credit associations so that they could easily acquire capital for their agricultural activities. These clubs generally consisted of farmers from a village who meet monthly to discuss technical and investment matters relating to agriculture. In addition, the farmers who participated in the study revealed that these financial clubs provided them with opportunities for learning skills related to credit access and minimising costs. The financial club platform was used by these farmers to save money for buying agricultural inputs and to pay for tractors during the planting season.

Technical knowledge systems

Farmers need technical skills and knowledge to build agricultural resilience and practise sustainable farming. According to Murugani and Chitja (2019), technical skills are the ingredients of productivity in farming, which trigger agricultural development and innovation. The following subsections explain how the participants gained technical skills.

Field demonstration/visits

Field visits were selected by an overwhelming 98.2% of the respondents. Farmers were found to obtain technical knowledge by taking part in field demonstrations organised by development agencies, agricultural advisors and fellow farmers. Field demonstrations also appeared to be the main means by which farmers were enabled to obtain technically based agricultural information. The participating farmers explained that farm demonstrations and visits often provided them with tangible evidence of other farmers' successes. Furthermore, during the discussions, which were part of these demonstrations, farmers were able to both acquire and share knowledge about farming problems and possible solutions. These findings suggest that frequent visits to other farms can prove valuable for farmers' technical knowledge acquisition and development.

Television and radio programmes

Approximately 32.9% of the study respondents shared that listening to the radio and/or watching television stations that broadcast agricultural programmes to farmers were a source of technical information for them. Both these sources broadcast programmes related to various aspects of agriculture, with guest

speakers who are often agricultural specialists and/or successful farmers who share their knowledge. From these programmes, farmers gain the opportunity to listen to experts, especially successful farmers, who share their farming journeys and provide insights related to their different specialities. Daudu et al. (2009) reports that farmers often use posters and television/radio programmes as knowledge sources, especially when the sources use the local language for farmers to understand and apply the knowledge. However, the participants from the study learned less frequently through these platforms, compared to other knowledge sources, as farmers require physical evidence.

Agricultural exhibitions

Around 44.3% of the respondents indicated that they attended agricultural exhibitions to acquire technical knowledge. The participating farmers explained that attending agricultural exhibitions contributed to their understanding of new information, including technical skills. An article in the magazine "Farmer's Weekly" (2017) emphasises that through attending exhibitions, farmers can learn from their colleagues about ways in which to address farming challenges. This learning platform is powerful, as it enables farmers to draw helpful conclusions based on their own experiences that tend to have a significant impact on their ultimate practice.

Booklets and pamphlets

While 64.4% of the participating farmers indicated that they used booklets aimed at sharing and acquiring agricultural knowledge, the respondents explained during the FGDs that they preferred participating in extension activities, such as training and demonstrations, where they generally received written information. Some of the booklets used by the farmers included instructions and application procedures. A study conducted by Daudu et al. (2009) illustrates that farmer are not only users of agricultural extension staff but also booklets and posters as sources of knowledge.

Scientific Knowledge Systems

Scientific knowledge helps farmers to understand the techniques of and reasons for continuously evolving farming methods. The finding in the study revealed that farmers integrate different systems in order to acquire scientific knowledge and indicated that the scientific knowledge systems of smallholder farmers can include research and educational institutions as well as NGOs.

Research institutions

Of the participating farmers, 24.2% shared that engagement in educational platforms provided by research institutions (agricultural research institutions and universities) helped them gain scientific knowledge. A further 21.5% of the respondents mentioned that they actively engaged with the Department of Health to learn about producing nutritional crops, which are essential for well-being. Approximately 59.4% of the respondents indicated that they took part in training and workshops arranged by research institutions. However, during the FGDs, the participating farmers revealed that not every farmer was given the opportunity to take part in training arranged by research institutions. Instead, these institutions organised demonstrations whereby the farmers who had been trained could transfer knowledge to other farmers. The limited use of research institutions noted by the study is corroborated by Metelerkamp et al. (2020), who note that farmers in their study only made a few references to an accredited training institution as their direct knowledge-learning network.

Non-governmental organisations

NGOs, which include agricultural experts from both the private and public sector, were used by approximately 18.7% of the study's participating farmers to access knowledge, especially about new technology; water irrigation; and seed and fertiliser varieties. During the FGDs, the participating farmers maintained that NGOs provided several services, including agricultural extension and education services, to them, usually in the form of training. Farmers who were trained by NGOs were required to train other farmers operating within their communities. The participating farmers explained that they received information from NGOs about seed varieties, new farming techniques and agricultural inputs by attending training courses.

From the gathered data, it became clear that the farmers gained agricultural knowledge by participating in meetings organised by development agencies, such as NGOs that

TABLE 4: KNOWLEDGE TYPES AND SOURCES OF FARMERS

	N=219	%	Knowledge Forms
Farmers group	218	99.5	Local knowledge
Fellow farmers	189	86.3	Local knowledge
Cooperatives	106	48.4	Local knowledge
Trade business	51	23.3	Local knowledge
Labour-Organisation	14	6.4	Local knowledge
Local committee	45	20.5	Local knowledge
Financial credits clubs	11	5.0	Local knowledge
Field visits	215	98.2	Technical knowledge
TV/Radio	72	32.9	Technical knowledge
Agricultural Exhibitions	97	44.3	Technical knowledge
Booklets	141	64.4	Technical knowledge
Educational groups/Institutions	53	24.2	Scientific knowledge
Health Programmes	47	21.5	Scientific knowledge
DAFF Training/workshops	130	59.4	Scientific knowledge
NGO's	41	18.7	Scientific knowledge

TABLE 5: RANKED AGRICULTURAL TOPIC DISCUSSED ON KNOWLEDGE SYSTEMS BY FARMERS

Local systems topic	Ranking	Scientific systems	Ranking
Soil preparation	1	Climate change and adaptation	1
Crop variety	2	Soil preparation	2
Seed variety	3	Crop variety	3
Herbicides and pesticides	4	Seed variety	4
Climate change and adaptation	5	Markets and prices	5
Crop harvesting methods	6	Herbicides and pesticides	6
Markets and prices	7	Crop harvesting methods	7

normally consisted of specialised, independent advisors who provided information on goods and services such as the sale of feed, pesticides and fertilisers to farmers. However, officials at the head of both NGOs and private sector organisations were rarely in direct contact with farmers. The study findings showed that the provision of NGO and private sector knowledge system to farmers in the Bergville and Appelsbosch study locations tended to materialise from the bottom level. Officials who functioned higher up in the hierarchy were responsible for facilitating and governing the procedures of the system, whilst those at ground level met with the farmers.

In meeting with farmers, NGOs ensure the integration of their knowledge system with famers' local knowledge networks that leads to a cohesive socio-technical system, the maintenance of existing farming production processes and the building of new ones. Lubell et al. (2014) maintain that these systems provide a technical learning pathway to farmers through various extension and/or research institution services.

Ranking of Knowledge Transferred through Knowledge Systems

As agricultural knowledge flows from and across different systems and actors, the farmers who participated in the study were asked to list and rank, according to importance, the agricultural information obtained from them. Table 5 below presents this ranking of the agricultural information obtained from knowledge systems. The participating farmers arranged the topics from the highest prioritised information from local, technical and scientific knowledge systems to the lowest, along with the activities resulting from the knowledge. The farmers explained that they faced growing water scarcity, as well as degradation and climate change, the knowledge about which was useful. Moreover, they maintained that technical knowledge and skills related to soil preparation led to better productivity.

Scientific knowledge about seed and crop varieties were also highlighted as important, especially with respect to the changing climate. According to Tamako and Thamaga-Chitja

TABLE 6: INCREASED AGRICULTURAL KNOWLEDGE OF FARMERS

Agricultural knowledge	Strongly disagree	disagree	indifferent	agree	Strongly agree
Soil preparation	2.7	6.8	12.3	55.7	22.4
Crop harvesting/ storage	2.7	9.6	11	45.7	31.1
Crop variety	4.1	10	10	50.7	25.1
Market information	6.4	14.6	8.2	50.2	20.5
Herbicides and pesticides application	7.3	11.4	10.5	50.7	20.1

TABLE 7: FARMERS' HOUSEHOLD FOOD SECURITY CATEGORIES

Categories	N=219	%
Food secure	65	29.7
Mildly food secure	39	17.8
Moderately food insecure	64	29.2
Severely food insecure	51	23.3

(2017), climate change has a significant impact on agriculture. Thus, knowledge about adaptation strategies and ways to build resilience is important for agricultural production. The participants maintained that scientific knowledge about seed/crop varieties and types of fertilisers/herbicides helped them meet their own household food demands. The respondents noted that they needed to know the types of fertilisers/herbicides that would have the most positive impact on their crops. Such knowledge reduced production loss due to insects feeding on their crops.

Farmers' Increased Agricultural Knowledge

The farmers indicated areas of increased agricultural knowledge due to access to knowledge systems, which is presented in Table 6 below. Most of the respondents agreed or strongly agreed that they had increased their knowledge of soil preparation, crop harvesting/ storage, crop variety, market information and the application of pesticides. The participants asserted that their production had increased owing to increased knowledge, which had, in turn, improved their household food supply. According to Sheikh et al. (2016), when farmers have the necessary agricultural knowledge and skills, their performance is improved.

Food Security Levels

In the study, it was found that the HFIAS average ranged from 0 to 27, with higher scores implying greater food insecurity. Approximately 29.7% of the surveyed farmers' households were found to be food secure, whereas 17.8% were mildly food-insecure. Moderately food insecure households were reported by 29.2% of the study participants, while severely food insecure households were reported by 23.3% of the participating farmers (see Table 7 below).

Association between Food Security and Socio-Economic Parameters

Chi-square test results indicate whether there is an association between variables and whether it is significant. In the case of the study, chi-square tests were conducted to determine the relationship between household food security and different socio-economic parameters (see Table 8 below). Although these tests provided by the survey showed no association between household security and gender, educational level, motive of producing for consumption or participation in agriculture for career purposes, they did indicate a significant relationship between the marital status of farmers and household food security ($p<0.02$). This suggests that married farmers can better support their families financially and socially because of access to multiple sources of income.

The chi-square tests results revealed a significant relationship between participation in AKSs and household food security ($p<0005$). This suggests that most of the surveyed farmers were motivated to learn new ways of producing food and improving their household food security through access to knowledge about good farming practices. Therefore, knowledge is crucial to the amount of effort farmers make to

TABLE 8: ASSOCIATION BETWEEN SOCIO-ECONOMIC AND FOOD SECURITY PARAMETERS OF SMALLHOLDER FARMERS

Variables	Category	Food Secure		Food Insecure		N	P-value
		Food secure (n=65)%	*Mildly-food secure (n=39)%*	*Moderately food insecure (n=64)%*	*Severely food insure (n=51) %*		
Gender	Female Male	17.8 11.9	13.2 4.6	20.1 9.1	15.1 8.2	145 74	ns
Education	Formal Informal	17.4 12.3	11.9 5.9	20.1 9.1	15.1 8.2	141 78	ns
Marital status	Single Married	5.0 24.7	3.7 14.2	11.0 18.3	4.1 19.2	52 167	**
Producing for consumption	No Yes	3.7 26	2.3 15.5	2.3 26.9	1.8 21.5	22 197	ns
Engage in Agriculture for learning	Yes No	18.3 11.4	16 1.8	16.9 12.3	14.6 8.7	144 75	***
Engage in Agriculture with business motives	Yes No	18.7 11	12.3 5.5	22.4 6.8	15.1 8.2	150 69	ns
Local knowledge participation level	Low High	0 29.7	0 27.8	0.5 28.7	0 23.3	1 218	**
Technical knowledge participation level	Low High	0.5 29.2	5.9 11.8	8.2 21.1	7.8 15.5	49 170	***
Scientific knowledge participation level	Low High	24.2 5.5	16.4 1.4	23.7 5.5	15.5 7.8	175 44	**

*Note: *** and ** means significant at 1% and 5% levels of significance, respectively. ns= not statistically significant. Source: Study Household Survey (2020)*

improve their agricultural activity. Moreover, according to Lubell et al. (2014), knowledge and skills encourage individuals to learn, acquire more information and increase their participation in knowledge networks, leading to a mindset and attitude, which motivate them to undertake initiatives and perform tasks.

The chi-square test results presented in Table 8 below indicated a statistically significant relationship between household food security and farmers' level of participation in local knowledge systems ($p<0.03$). The participating farmers explained that local knowledge is based on farmers' practical skills and experience. Similarly, Nordström and Ljung (2005), Niewolny and Lillard (2010) as well as Simpson and De Loë (2017) maintain that farmers regard their fellow farmers as trustworthy sources of knowledge because of their practical experience. Thus, they learn from fellow farmers' opinions and agricultural performance, which leads to them imitating their practices. The current study's results suggest that socially active farmers generally gain more agricultural knowledge through their interactions, which means that social relationships can be useful capital.

The chi-square test results presented in Table 8 below revealed the statistically significant relationship between household food security and farmers' participation in technical knowledge systems ($p<0.000$). The participating farmers observed that the technical knowledge that they received during training and demonstrations tended to help them improve their skills related to performing field activities. Such improvements, in turn, tended to aid their crop production. This finding suggests that learning may take place in the field, local gardens, or at community halls.

The chi-square test results presented in Table 8 below revealed a statistically significant relationship between household food security and farmers' levels of participation in scientific knowledge systems. Specifically, it was found that scientific knowledge systems provided the farmers participating in the study with new information and skills. The farmers explained that environmental conditions are changing; therefore, they thought that new scientific knowledge is crucial for building agricultural resilience.

TABLE 9: ASSOCIATION BETWEEN FOOD SECURITY AND SOCIO-ECONOMIC PARAMETERS OF SMALLHOLDER FARMERS.

	Coefficients			Marginal Effects			
				Food secure		*Food insecure*	
	Value	*Robust St. Error*	*P>z*	*Food secure*	*Mildly food secure*	*Moderately food insecure*	*Severely food insecure*
Gender	-0.152	0.154	0.325	0.0525	0.0097	-0.0191	-0.0422
Age	-0.084	0.075	0.260	0.0281	0.0057	-0.0100	-0.0238
Education	0.004	0.158	0.982	0.0105	0.0021	-0.0038	-0.0089
Marital status	0.008	0.205	0.970	-0.0078	-0.0016	0.0028	0.0065
Income	-0.227	0.100	0.024	0.0854**	0.0175**	-0.0305**	-0.0725**
Producing for consumption	0.165	0.247	0.506	-0.0668	-0.0103	0.0265	0.0507
Engage in Agriculture for learning	0.212	0.158	0.182	-0.0622	-0.0149	0.0209	0.0552
Engage in Agriculture as career	0.160	0.165	0.336	-0.0645	-0.0147	0.0215	0.0578
Local knowledge participation level	-0.449	0.183	0.015	0.1794***	0.0368**	-0.0639**	-0.1522***
Technical knowledge participation level	-0.533	0.132	0.000	0.1904***	0.0390***	-0.0679***	-0.1616***
Scientific knowledge participation level	0.766	0.198	0.000	-0.2988***	-0.0612***	0.1065***	0.2535***
/cut1 2.984221 .6210631 /cut2 2.436341 .6130995 /cut3 1.535098 .6061646							

N =219 LR X2 = ***; Pseudo R2=0.08; Log likelihood = 274.73
Note: *, **, ***, means the coefficient is statistically significant at 10%, 5%, and 1% levels, respectively: Household Survey (2020)

Association between Smallholder Farmers' Food Security and Socio-Economic Parameters (Linear and Ordered Probit Regression Analyses Results)

Before running a model to test for a relationship between socio-economic parameters and food security, it was necessary to compute a linear regression to test for multicollinearity amongst the independent variables. The following independent variables were found to have significant tolerance values and were, thus, included in the model: 1) participation level related to local, technical, and scientific knowledge systems; sex and educational level of farmers; household income; marital status; and motivation for participation in farming. Once this analysis had been completed, an ordered probit regression analysis was computed in order to establish a relationship between food security and knowledge systems along with other variables. In the ordered probit regression model, the reciprocal of the tolerance value measures the impact of collinearity amongst variables (VIF). In the current study, there was a low correlation amongst the variables, as the VIFs were in acceptable ranges.

The ordered probit regression model was used to determine farmers' characteristics that might predict farmers' household food security. The results revealed that all of the estimated coefficients were statistically significant, since the LR statistic had a p-value of less than 1%. The pseudo R2 value was recorded at around 8%, which indicated the suitability of the model. The chi-square test results presented earlier in Table 8 above indicated that the participating farmers' characteristics (gender, educational level, production for household consumption and motives for practicing agriculture as a career) were not statistically significant determinants of their household food security.

The orbit regression model outcome showed that the monthly income of farmers was statistically significant in relation to food security ($p<0.01$). As mentioned above, the results

revealed that the majority of the farmers (47.5%) earned between R1, 501 and R3, 500 per month, which included government and pension grants. A unit increase in this income increased the probability of farmers' households being food secure or mildly food secure by 8.5% and 1.7%, respectively. Such an increase also decreased the probability of households being moderately food insecure or severely food insecure by 3.0% and 7.2%, respectively. The study revealed that the majority of farmers who participated in this study were dependent on government pensions and social grants. These sources of income play a significant role in rural households across South Africa, as they help them to buy food, contribute to savings clubs and pay for funerals/ burials, for example (SASSA, 2020; 2021).

The orbit regression model indicated that the participation of the respondents in local agricultural knowledge systems had a significant impact on their household food security ($p<0.05$). Farmers' participation levels in local knowledge systems was modelled as 1=low and 2=high. A unit increase in farmers who participated in local knowledge systems was found to increase the possibility of farmers' households being food secure or mildly food secure by 17.9% and 3.6%, respectively. Furthermore, this increase was found to decrease the possibility of farmers' households being moderately food insecure or severely food insecure by 6.3% and 15.2%, respectively.

The model indicated that the participation of farmers in technical knowledge systems had a significant impact on their household food security ($p<0.05$). The participation levels of farmers in local knowledge systems was modelled as 1=low, 2=high. A unit increase in farmers who participated in technical knowledge systems was found to increase the possibility of farmers' households being food secure or mildly food secure by 19% and 3.9%, respectively. This same increase also decreased the likelihood of farmers' households being moderately food insecure or severely food insecure by 6.8% and 16.2%, respectively.

The farmers explained that the practical training and field demonstrations provided by NGO extension advisors, especially regarding the adoption of new farming methods, improved their production and food security. Furthermore, the farmers indicated that practical agricultural training often provided them with detailed information about fertiliser and pesticide use, which could improve their yields. Scholars such as Ingram (2018) argue that farmers' productivity not only depends on mental capacity but also practical and physical skills.

The model indicated that the participation of the farmers in scientific knowledge systems had a significant impact on their household food security ($p<0.05$). Farmers' participation levels in scientific knowledge systems were modelled as 1=low, 2=high. A unit increase in farmers who participated in scientific knowledge systems was found to decrease the likelihood of households being food secure or mildly food secure by 29.8% and 6.1%, respectively. The increase also increased the possibility of households being moderately food insecure or severely food insecure by 10.6% and 25%, respectively.

During the FGDs, the participating farmers explained that their participation in scientific knowledge systems exposed them to additional soft skills i.e., leadership, communication, teamwork, new ideas and experiences that they could integrate into available local and individual experiential knowledge. This finding was in line with Rangarajan and Chitja's (2020) finding that the empowerment of farmers through both local and scientific knowledge could lead to farmers using their new and existing experience and skills in solving problems, as their confidence in what they had already experienced and known might have been validated. Other researchers have argued that scientific and technical knowledge require continuous updating, particularly for farmers operating in a changing environmental and/or food supply/demand conditions (Castella et al. 2006; Thamaga-Chitja & Morojele, 2014).

CONCLUSION AND RECOMMENDATIONS

The study sought to describe the AKSs accessed by smallholder farmers operating in the province of KwaZulu-Natal and the implication of these networks on food security. The study findings revealed that farmers operating in the Appelsbosch and Bergville areas of KwaZulu-Natal were actively engaged in a variety of local, technical, and scientific

knowledge systems. Apart from increasing the farmers' agricultural knowledge and skills, these systems served multiple purposes, including improving food production and access to markets.

The showed that some of the knowledge systems accessed in the Bergville and Appelsbosch areas were transferred by officials at ground level to farmers, who then spread the information to fellow farmers. The partnerships and collaboration of knowledge systems utilised by farmers bring together people with different capacities, which leads to the widening of farmers' range of skills on an individual and community level. However, no single system was found to serve the agricultural knowledge needs of small-scale farmers adequately. Therefore, it becomes important to have integrated and transformational agricultural knowledge to ensure effective and efficient information delivery to farmers.

Subsequently, the majority of small-scale farmers in rural communities are illiterate adults of an older age, it is common for farmers to interact with extension officers in the form of attending farmers' meetings and/or practical demonstrations in order to understand the technical knowledge and skills that play an important role in productive farming practices. This type of provision of technical knowledge ensures that farmers have access to agricultural knowledge in the form of a narrative and hands-on activity.

The farmers are generally dependent on social connections for accessing and mobilising the necessary knowledge to improve their household food security. Thus, farmers need to be socially active to access integrated AKSs (local, technical and scientific) and, ultimately, reach higher levels of food security. This social interaction would increase their motivation for and attitudes towards agricultural endeavour, which would enhance the extent of their efforts to improve productivity.

The study confirmed the effectiveness of AKS in empowering smallholder farmers in rural communities with knowledge. However, the classification and assessment of these knowledge systems requires continuous revision. Therefore, the DARD, various NGOs and other stakeholders need to have continued access to updated information in order to promote transformative initiatives and integrated knowledge platforms that empower farmers to produce food sustainably. The two areas studied indicated a visible interaction between farmers and interrelated formal and informal knowledge systems. This route should be guided by goals, norms and transparency.

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