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MAPPING ACTOR DIVERSITY AND FUNCTIONAL ROLES IN AN AGRICULTURAL VIRTUAL PLATFORM IN UGANDA: INSIGHTS FROM M-OMULIMISA

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ABSTRACT

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Agricultural Virtual Platforms (AVPs) enable diverse actors to exchange information that addresses multidimensional farming challenges. This study examined the diversity of actors engaged in M-Omulimisa AVP and how their roles collectively facilitated information exchange. A qualitative case study involving four key informant interviews, document reviews, 21 in-depth interviews, and three focus group discussions was conducted. Data analysis employed the Agricultural Innovation Systems (AIS) framework. Findings revealed variations in the diversity of actors per domain, their attributes, and their functional roles. Actors belonged to all five domains of AIS: education and research, intermediary, enterprise, demand, and support structures domains. However, diversity within each domain remained limited, with several key actors, especially from the livestock sector, absent. Actors' attributes indicated that the majority enrolled in the AVP by invitation, had interests focused on crop enterprises, and varied capabilities. Joining the AVP by invitation partly explains the limited actor diversity within domains and the emphasis on crop enterprises. Three role categories that jointly shaped the functionality of the AVP emerged: those assigned and played, assigned but not played, and not assigned yet played. In conclusion, the platform achieved diversity across the AIS domains but not within each domain. Actors' enrolment through invitation reduced actor diversity, which subsequently limited the information sources. Further, the unperformed roles led to the evolution of roles on the AVP and undermined information exchange. This study recommends enrolment to focus on intra-domain representation of actors, especially for the livestock sector, while promoting other enrolment methods to ensure diversity.

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INTRODUCTION

Smallholder farmers need agricultural information from diverse actors to address the multidimensional challenges at different nodes of their enterprise value chains (Ayre et al., 2019). Their access to agricultural information, however, is constrained by several factors, including disconnection from information sources and

approaches for disseminating the information (Munthali et al., 2019). In the past, the linear technology transfer approach was the primary way of disseminating agricultural information to farmers. However, the approach proved ineffective due to the passive role of farmers, the dissemination of blanket recommendations that did not meet farmers' information needs, and the

lack of consideration for socio-economic diversity. Further, the approach's focus on three main actors, farmers, extension agents, and researchers, compromised the diversity of information sources. In response to the identified inadequacies, more holistic and interdisciplinary frameworks have gained prominence, most notably the Agricultural Innovation Systems (AIS) approach.

The AIS emphasises interactions and the exchange of information among multiple interdisciplinary actors, such as farmers, extension agents, insurance and financial service providers, input dealers, and researchers, to jointly address farmers' challenges (Hall et al., 2006; Klerkx and Leeuwis, 2008; Munthali et al., 2019). The AIS can be operationalized through agricultural platforms, which could be physical, virtual, or blended. Agricultural virtual platforms (AVPs), such as M-Omulimisa, which is the case for this study, are fora that use digital spaces to enable the co-presence of diverse actors without co-location. This virtual environment fosters co-creation and sharing of agricultural information in multi-modal types such as text, audio, and photographic forms (Ayre et al., 2019; Ingram and Gaskell, 2019; Munthali et al., 2018).

Agricultural virtual platforms are categorised based on several criteria, including diversity of actors, mode of information sharing adopted, and the type of digital device(s) used (Maria et al., 2021). The diversity of actors on AVPs varies depending on their attributes, such as their interests, capabilities, and roles played on the platform. In this study, the assessment of actor diversity was anchored in Rajalahti et al.'s (2008) AIS actor typology, which categorises actors into five domains: research and education, intermediary, demand, support structures, and enterprise. Hence, actor diversity encompassed both the domains occupied by the actors, and the profiling of the different types of actors within each domain.

The M-Omulimisa AVP was started in 2013 by the M-Omulimisa Agritech Company to bridge the gap between farmers and extension agents. It is a multilingual and multimedia information platform that employs both mobile and web messages to share information among actors. It uses an offline mobile device-based Short Message Service (SMS) to provide needs-based information on crop and livestock production, insurance, marketing, weather conditions, agro-inputs (chemicals, seeds), and financial services. Specifically, M-Omulimisa

uses the "Question & Answer" approach, where a user sends an information request on the AVP, and extension agents and other actors access it via the web and provide a response as a web message.

A farmer can access the AVP using either a basic or a smart mobile phone via the Unstructured Supplementary Service Data (USSD) mode or a mobile application. The USSD is a mobile phone communication protocol that allows users to access various services and information by dialling specific codes, usually starting with an asterisk (*) and ending with a hash (#). Thus, farmers using USSD on M-Omulimisa do not require airtime or internet data, while those accessing the AVP via the mobile application must have internet connectivity and a subscription to share information on the AVP via SMS or web messages. On the other hand, extension agents and other actors require a smartphone with internet to access the AVP and successfully share information.

The M-Omulimisa AVP was developed to enhance interactions between farmers and agricultural extension agents, based on the assumption that the current limited interaction between them hinders effective agricultural information exchange. This assumption further implies that farmers require frequent and meaningful engagement with extension agents to address their farming challenges effectively. However, farmers' challenges are often multifaceted, requiring information from a wide range of actors beyond extension agents. It is therefore crucial to have multidisciplinary actors on the AVP to actively engage in information sharing (Swaans et al., 2014). This would allow farmers to access agricultural information from multiple sources as and when they need it (Hermans et al., 2015; Munthali et al., 2018). In this context, the AVP offers a potential avenue for facilitating broader information sharing among farmers and diverse actors. The critical question, therefore, is whether the AVP integrates all the necessary actors and what specific roles these actors play in enhancing information sharing on the AVP. This study, therefore, contributes to the literature by focusing on the diversity of actors and the roles they played in facilitating the sharing of agricultural information on AVPs.

Analytical framework

The diversity of actors and their roles in information sharing on M-Omulimisa AVP was explored using the AIS

framework described by Rajalahti et al. (2008). The AIS framework comprises four elements: actors and their roles, patterns of interactions, attitudes and practices, and enabling environment (Hall et al., 2006). An actor may be an individual, company, or organisation which could be private or public (Hall et al., 2006; Rajalahti et al., 2008).

This study operationalised actor diversity based on Rajalahti et al. (2008) actor typology, which categorises actors into five domains: research and education, intermediary, enterprise, demand, and support structures. The *research and education domain* mainly consists of producers of research and codified knowledge, for example, national and international research organisations, universities, technical colleges, private research foundations, private companies, and Non-Government Organisations (NGOs). The *intermediary domain* comprises actors who play a catalytic role, linking diverse actors in innovation systems and facilitating information flow among them. The actors include: extension service providers, NGOs, consultants, donors, farmer and trade associations, private companies, and entrepreneurs. The *enterprise domain* consists of actors who use codified knowledge and produce tacit knowledge, namely, farmers, commodity traders, transporters, agro-based companies, industries, and input supply agents. The *demand domain* consists of actors who influence and those affected by the innovation, such as industrial consumers, final consumers, and policy-making agencies. Lastly, *support structures domain* encompasses providers of an enabling environment for production and use of knowledge, for example, financial systems, transport and marketing infrastructure, education systems, trade and farmer associations, and professional networks.

The AIS actor typology guided analysis of the diversity of actors across and within domains, as well as their roles in enabling information sharing on the M-Omulimisa AVP. This study examined actor roles on the AVP in terms of assigned and played roles; assigned and not played roles; and not assigned but played roles. Actors need to possess appropriate capabilities, such as expertise or experience, and requisite resources to effectively play their roles. They also need to have rights to access the AVP.

The user rights were either direct or indirect, where direct rights enable the actors to actively engage on the AVP to share information, while the indirect rights

permitted actors to share information through another actor with direct rights.

MATERIALS AND METHODS

Research design

This study employed a qualitative approach with a case study research design, using M-Omulimisa AVP as the case. Selection of the case was informed by the wide coverage (83% of Uganda, which is 112 districts out of 135), addressing previously cited hinderances to the use of ICTs in agriculture, and being one of the most popular platforms that provide farmer access to agricultural information (Tinzaara et al., 2025). According to Yin (2018), the qualitative case study design is appropriate for studies that seek to understand the constructed realities of individuals by examining the *how* and *why* of social phenomena. Moreover, the case study design facilitates close interaction with study participants, allowing for in-depth insights into their lived experiences. Therefore, in this study, the qualitative case study design was appropriate for examining actor diversity and their roles in the sharing of agricultural information on the AVP.

The study targeted all actors enrolled and facilitating information sharing on M-Omulimisa AVP. These included input suppliers, produce buyers, regulators, telecommunication companies, research institutions, teaching institutions, insurance and financial service providers, non-governmental organisations (NGOs), farmers, public and private extension agents, and the platform staff. The actors were considered due to the distinct roles they play in facilitating information exchange on the AVP. The diverse range of actors allowed for the collection of varied perspectives and experiences, thereby enabling an in-depth understanding of the diversity of actors across and within AIS domains and their roles in the sharing of information on the AVP.

Sampling procedure

Study participants were selected through purposive sampling based on direct involvement in sharing information through the M-Omulimisa AVP. As guided by Leavy (2017), purposive sampling was appropriate for this study, as it enabled the selection of individuals with rich experience and deep insights into the diversity of actors and their roles. Participants in the study were

farmers, public and private extension agents, and platform staff since they were directly involved in information exchange on the AVP. The participants were identified from the M-Omulimisa registration database, with guidance from the AVP administrator as indicated in the selection process (Figure 1). The actors comprised four groups of participants:

- i. M-Omulimisa AVP staff: These were four staff members from M-Omulimisa Agritech who were directly involved in the sharing of information on the AVP, namely, the AVP administrator, AVP agronomist, AVP field officer, and AVP head of operations.
- ii. Private extension agents: These consisted of three private extension agents who were NGOs' employees and supervisors of NGOs' field officers.
- iii. Public extension agents: These included six public agricultural extension agents employed by the district local governments, enrolled on the AVP, and without affiliation with NGOs. Also included two field officers who were public extension agents with affiliation to NGOs as field officers.
- iv. Representative from MAAIF: The director of extension services from the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF), was included, given his strategic oversight responsibility in extension service

delivery in Uganda and operation of digital platforms.

- v. Farmers: These were categorized into three sub-groups based on frequency of use of the AVP:
 - Low use: Farmers who used the AVP only once.
 - Medium use: Farmers who used the AVP twice.
 - High use: Farmers who used the AVP three times or more

Only the medium and high-use farmers were selected for the study. Specifically, the sample included 25 medium use farmers (18 males and seven females), and nine high use farmers (seven males and two females).

The process of selection of study participants involved three key steps, as shown in Figure 1. Firstly, audience and administrative clearance was sought through a phone call to the managing director (MD) of M-Omulimisa Agritech Company Limited to request a meeting and clearance to proceed with the study on the M-Omulimisa AVP. Secondly, a preparatory meeting was held with the MD to obtain guidance on which actors were on the M-Omulimisa AVP and how they were involved in the exchange of information. The actors were listed and prioritised based on their involvement in information sharing on the AVP. In the meeting, the MD granted permission to conduct the research and assigned user rights on the AVP.

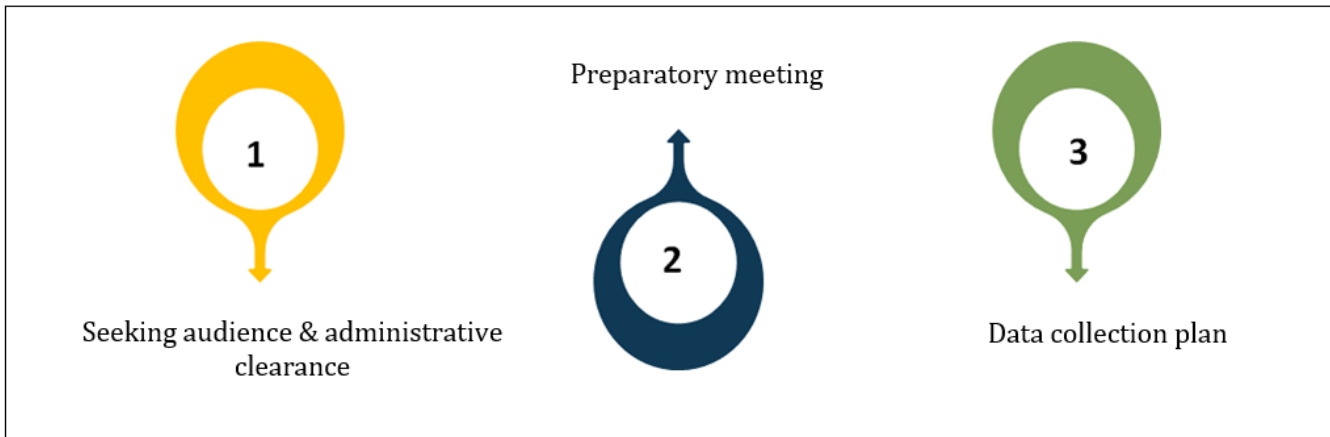


Figure 1. Selection process of study participants.

Finally, a data collection plan was developed, which involved reviews of online documents on profiles of actors followed by identification and selection of

participants. The selected participants including extension agents (public and private) and farmers were contacted on mobile phone and agreed on interview

schedules based on their willingness to participate in the study and convenience.

Data collection methods and tools

Data were collected through four key informant interviews (KIIs), document reviews, twenty-one in-depth interviews, and three focus group discussions (FGDs). The FGDs comprised five to eight farmers, each of both sexes, who had used the AVP twice. Data from farmers was collected using in-depth interviews and FGDs, while that from platform staff was collected using KIIs. KIIs were used to collect data on actors and their attributes, including expertise, enrolment method, and interests. KIIs further collected data on how and why actors played their roles during information sharing on the AVP. In-depth interviews were conducted with nine farmers and eleven extension agents (public and private) to collect data on their individual attributes, experiences with using the AVP, the roles they played in the AVP, and how and why they played those roles. The FGDs collected data on farmers' roles on the platform and how they played them. The document reviews included secondary data on organisations and their roles in the AVP, as well as farmers' frequency of use of the AVP.

The study employed multiple sources of data, which provided diverse viewpoints, enabled data triangulation, and a deeper understanding of the phenomenon of actor diversity and roles on an AVP (Creswell, 2014; Yin, 2018). This, together with supervisors' reviewing of the research instruments, enhanced data credibility, validity, and accuracy. Actual data collection was preceded by a scoping study, which enabled the identification and prioritisation of actors on the AVP, the assessment of the feasibility of conducting the study, and the design of FGD and interview guides. Data collection commenced after participants were assured of confidentiality and provided consent. Data from farmers was mainly collected using local dialects (Langi and Luganda), which allowed them to freely express themselves unless a farmer was comfortable with English.

Data analysis

The analysis followed a five-step procedure as described by Yin (2016): (i) compiling and sorting the field notes from KIIs, FGDs and indepth interviews into a data base, (ii) disassembling data in the database and assigning

codes, (iii) rearranging the data to identify emerging themes, (iv) interpreting the rearranged data, and (v) drawing conclusions from the data. This enabled the identification of actor diversity and specific roles within the M-Omulimisa AVP.

Interview responses were initially translated from the local dialects into English by two local language experts: one proficient in Luganda and the other in Langi. The translations were then transcribed verbatim. The transcripts were cross-checked to eliminate errors, and later analysed thematically to identify and extract emerging themes, and attribute meaning to the narratives (Clarke and Braun, 2017).

Each participant's transcript was interrogated regarding AIS components, particularly actor diversity and roles of actors in each domain as guided by Rajalahti et al. (2008), actor typology. Accordingly, actors were categorised into five domains: research and education, intermediary, enterprise, demand, and support structures domains. The analysis considered the diversity of actors across and within domains as well as their attributes. The attributes focused on the method of enrolment, interests, and capability. In addition, actor roles in sharing information on the M-Omulimisa AVP were identified. The actor roles on the AVP were categorized into three types: assigned and played, assigned but not played, and not assigned but played.

RESULTS

Actor diversity on M-Omulimisa AVP

Actor domains on the M-Omulimisa AVP

Findings indicated that the actors engaged in M-Omulimisa AVP were diverse and spanned all five domains of the AIS framework: education and research, intermediary, demand, enterprise, and support structure. Notably, some actors, such as the Ministry of Agriculture, Animal Industries, and Fisheries (MAAIF), the Uganda Communications Commission (UCC), Aponye Uganda Limited, and Mukwano Industries Limited, belonged to more than one domain due to the multifaceted nature of their attributes and the range of roles they play. However, the diversity across domains was not uniform. In particular, there was limited diversity within the education and research and demand domains. In addition, several key actors were missing across all domains (Table 1).

Table 1. Actor domains and actor types on the M-Omulimisa Agricultural Virtual Platform.

Actor domains	Actor types involved and specific actors	Actor type missing
Education & Research	University/college: Makerere university, Bukalasa Agricultural College Research organisations: National Crop Resources Research Institute (NaCRRI)	<ul style="list-style-type: none"> • International research organisations, • Private research organisations • livestock education & research institutions • NGOs & private companies
Intermediary	NGOs: Sasakawa Africa Association (SAA), Danish Church Aid (DCA), World Vision, Commonwealth Learning, AgriNet, Germany Cooperation international (GIZ) Extension service: public and private extension agents, AVP agronomist, AVP field staff, AVP administrator Donors: World Bank, Uganda government	<ul style="list-style-type: none"> • Livestock extension agents • NGOs promoting livestock enterprises • Farmer associations • AVP moderator
Demand	Consumer of industrial raw material: Mukwano industries; Aponye Uganda Limited Policy-making agencies: Uganda Communications Commission (UCC); Ministry Agriculture Animal Industry and Fisheries (MAAIF)	<ul style="list-style-type: none"> • Food & food products consumers • National & International commodity markets • Uganda National Bureau of Standards (UNBS)
Enterprise	Farmers: crop and livestock farmers Commodity trader: Aponye Uganda Limited Input supply: NASECO seeds, Bukoola chemicals Agro-processors: Mukwano industries, Aponye Uganda Limited	<ul style="list-style-type: none"> • Transporters • Veterinary input suppliers
Support structures	Insurance: Agricultural Insurance Consortium (AIC) Financial services: Microfinance Support Centre (MSC), Meteorology: Eumetsat Advanced Retransmission Service (EARS), Communication: DMark, MTN telecom, Uganda, Airtel telecom Uganda, M-Omulimisa Agritech, Policy-making agencies: UCC, MAAIF	<ul style="list-style-type: none"> • Banks • Media • Uganda National Bureau of Standards (UNBS)

Actor domains and attributes of actors

Education and research domain

Within the education and research domain, diversity among actors on the AVP was limited with only two actor types represented: University/college, and

Research Organisation. In each actor type, there were not more than two actors present. The specific actors involved were primarily scientists engaged in the generation and dissemination of codified knowledge and technologies that other actors on the AVP, especially farmers, utilised.

Table 2. Actors and actor attributes in the domains on M-Omulimisa AVP.

DOMAINS	Attributes			
	Actor types	Enrolment	Interest	Capability
Education and research	Makerere	Invitation	Expanding markets for new technologies (soybean varieties)	Expertise in training, research & technology development
	Bukalasa	Invitation	Access to job opportunities for students	Expertise in training
	NaCRRRI	Invitation	Expanding market for new technologies	Expertise in research & technology development
Intermediary	NGOs	Requested	Remotely manage projects using the AVP	Expertise in agricultural extension & funding projects in agriculture
	Extension agents	Invitation	Provide technical agricultural information to farmers	Expertise in crop husbandry & working with farmers
	AVP administrator	Not applicable	Ensure information flow on the AVP & earn commission from sale of agro-inputs	Expertise in ICT, management of AVPs, experience in crop & livestock husbandry
	Donors	Invitation	Development of rural communities	Expertise in technical support & funding
Demand	Consumers of industrial raw materials	Invitation	Access to bulked agro-produce	Expertise in value addition of agro-produce
	Policy-making agencies	Not applicable	Ensure adherence to regulation	Expertise in designing policy & enforcing the corresponding regulatory framework
Enterprise	Farmers	Invitation & self enrolment	Access to technical agricultural information	Experience in crop & livestock production
	Commodity traders	Invitation	Access to bulked agro-produce	Expertise & experience in marketing of agro-produce
	Input supply	Invitation	Access to market for agro-input	Expertise & experience in marketing of agro-input
	Agro processor	Invitation	Access to bulked agro-produce	Expertise & experience in agro-processing
Support structures	Insurance services	Invitation	Organised farmers to access agricultural insurance	Expertise in management of agricultural insurance at low premium
	Financial services	Invitation	Organised farmers to access agricultural credit	Expertise in management of agricultural credit services at low interest rates
	Meteorology	Invitation	Access to market for weather information	Expertise in production & remote dissemination of weather information
	Communication	Invitation	Sale of services to actors on the AVP	Expertise in sim network and internet communication
	M-Omulimisa Agritech	Not applicable	Enhancing farmer access to agricultural information	Expertise in provision of mobile phone based agricultural information services
	Policy making agencies	Not applicable	Create awareness about relevant policies	Expertise in formulating policies & corresponding regulations

Regarding their attributes, findings showed that the method of enrolment on the AVP was by invitation and did not vary across and within the actor types. The primary interest of the actors largely centred on accessing markets for their newly developed technologies and exploring potential job opportunities for their students, in the case of Makerere University and Bukalasa Agricultural College. Key informant interviews revealed that the interests related to the market were largely crop-specific. For example, Makerere University aimed at expanding the market for new soybean varieties, while NaCRRI sought to promote its improved bean varieties (Table 2). However, interviews further revealed that none of the actors expressed interest in the marketing of livestock-related technologies. About capabilities, the actors had expertise in research, technology development, and training, especially the education institutions, making them valuable sources of technical information and technologies which other actors on the AVP, particularly farmers and AVP administrator benefited from.

However, several relevant actors were noticeably absent from the education and research domain. For instance, key actors from the livestock sub-sector, such as National Livestock Resources Research Institute (NaLIRRI), Makerere University College of Veterinary Medicine, Animal Resources and Biosecurity (COVABS), and the National Animal Genetic Resources Centre and Data Bank (NAGRC&DB) (Table 1). Additionally, NGOs involved in the production and dissemination of codified knowledge at both national and international levels were not represented. At the national level, they were the National Organic Agricultural Movement in Uganda (NOGAMU), and the Uganda National Farmers Federation (UNFFE). Internationally, they include the International Institute of Tropical Agriculture (IITA), which researches selected crops to address food security; Participatory Ecological Land Use Management (PELUM), which undertakes research and disseminates codified knowledge on best practices in agroecology, organic agriculture, and sustainable land management; and Access Agriculture, which develops multimedia agricultural content such as videos.

Intermediary domain

The study results show that the intermediary domain exhibited moderate diversity of actor types, but with comparatively greater diversity of actors, particularly

within the NGOs and extension service actor types. Within the extension service type, both public and private extension agents were represented. Some of the public extension agents also served as field officers for specific NGO-led projects in addition to their routine government duties, while others focused exclusively on their official government duties. The private extension agents, on the other hand, were exclusively NGO extension staff, and they supervised the field officers. Other actors in the extension service actor type were AVP agronomist, AVP field staff and AVP administrator. The primary donors represented on the AVP were the World Bank and the government of Uganda, both of which provided funding in the form of competitive grants. The KIIs revealed that the AVP had secured several grants from the World Bank, including one specifically aimed at supporting the digitalisation of agricultural extension services in Uganda.

The actors in this domain joined the AVP either through invitation or by their own request. Extension service providers and donors were invited, whereas NGOs sought to be enrolled alongside their affiliated farmers and extension agents. The interests of the actors varied. NGOs were particularly interested in using the AVP for remote supervision of their agricultural project activities (Table 2). To achieve their interests, NGOs subscribed to virtual spaces that enabled extension supervisors to share training materials and receive reports from the field officers. This is illustrated by the following quotation:

“...Whenever I log in on the AVP, I expect to see which field extension agent is training on what and where, who is using the material I shared with them, and who is not... I am also able to follow up on which farmers are receiving inputs that our field extension agents are assigned to distribute...” (In-depth interview with NGO extension supervisor, May 2022).

Results from document reviews further revealed that NGOs primarily promoted projects focused on crop enterprises. In contrast, extension agents were mainly interested in providing technical agricultural information to farmers. The AVP administrator aimed at facilitating the flow of information and coordination among actors on the AVP, as well as earning commission through brokering the sale of agro-inputs and services. Donors, on the other hand, were interested in promoting rural development.

In terms of capability, actors in the intermediary domain possessed diverse capabilities (Table 2). Interviews indicated that extension agents on the AVP primarily possessed expertise in crop husbandry. However, evidence from the reviewed online documents showed that information requests on the AVP covered both crop and livestock value chains, with a substantially higher number of requests related to crops (763) than livestock (67). The online documents further revealed that crop-related requests received a comparatively higher response rate of 89% than the 22% response rate for livestock. The donors and NGOs exhibited similar capabilities that mainly related to funding, whereas the AVP administrator's expertise was in ICT, AVP management, and experience in crop and livestock husbandry.

The diversity of actors in the intermediary domain notwithstanding, there were essential actors that were not present on the AVP. These included AVP moderator, farmer associations, NGOs engaged in livestock-related initiatives, and livestock extension agents.

Demand domain

The demand domain had the least diversity in terms of actor types, and actors within the types relative to other domains. Actors represented in this domain included industrial consumers such as Mukwano Industries and Aponye Uganda Ltd, as well as policy-making agencies like UCC and MAAIF.

In terms of enrolment, the industrial consumers were enrolled through invitation. However, this method did not apply to MAAIF and UCC, whose involvement in the AVP is stipulated in their national mandates and regulatory responsibilities. Generally, the attributes of Mukwano Industries and Aponye Uganda Ltd were broadly similar; however, they differed with respect to specific crops (Table 2). For instance, Mukwano Industries mainly focused on oil seeds such as sunflower, soybean and simsim. Aponye Uganda Ltd on the other hand, was interested mainly in maize and beans. Similarly, the attributes of MAAIF and UCC did not show variation apart from the specificity of their regulatory mandate. MAAIF's interest was to ensure that only certified agro-chemicals and improved seeds were supplied to farmers, while that of UCC was to ensure adherence to regulations on the provision and use of digital services. Consistent with observations in the other domains, some critical actors were missing, and

they included consumers of food and food products, representatives from national and international commodity markets, as well as a policy-making agency: Uganda National Bureau of Standards, which oversees national standards.

Enterprise domain

Within the enterprise domain, there was relatively greater diversity of types of actors, albeit limited diversity within each actor type, except for farmers. Unlike the farmer category, all other actor types had a maximum representation of not more than two actors. The actors generally enrolled through invitation. However, farmers enrolled through both invitation and self-enrolment.

Review of online documents on actor profiles revealed that over 80% of the farmers were invited and enrolled by NGOs as project beneficiaries. Regarding interests, actors were largely interested in accessing goods and services through the AVP (Table 2). Farmers, in particular, revealed during interviews that they sought to access information on agricultural practices, markets, weather, and inputs for both crop and livestock enterprises. The commodity trader (Aponye Uganda Ltd), and agro-processors (Mukwano industries and Aponye Uganda Ltd) were mainly interested in accessing bulked agricultural produce. The input suppliers (NASECO and Bukoola) were interested in accessing markets for their products. Specifically, NASECO was interested in supplying maize seed while Bukoola supplied agro-chemicals.

The capabilities of the actors in this domain were diverse. They ranged from agricultural production (farmers), to input marketing (NASECO and Bukoola), produce marketing (Aponye Uganda Ltd), and agro-processing (Mukwano industries and Aponye Uganda Ltd). It is important to note, however, that certain key actors in the domain were absent on the AVP. These actors included producers, transporters, and suppliers of veterinary inputs like drugs, acaricides, and feeds.

Support structures domain

The support structures domain consisted of a range of actors essential for creating an enabling environment for the other actors to share information on the AVP. These included insurance, financial services, meteorology, communication, and policy-making agencies. As was the case for the enterprise domain, the support structures

domain showed more diversity of actor types, with less diversity within each actor type.

Actors within this domain enrolled on the AVP majorly through invitation, except for policy-making agencies, and M-Omulimisa Agritech. Nonetheless, the interests and expertise of the actors varied considerably (Table 2). In terms of interests, some actors, such as the Agricultural Insurance Consortium (AIC) and Microfinance Support Centre (MSC), preferred to provide insurance and financial services respectively, to farmers organised in groups. Other actors, however, offered services to all farmers regardless of whether they were in groups or not. For example, Eumetsat Advanced Retransmission Service (EARS) was interested in obtaining a market for their weather information from all farmers on the AVP. During KIIs, it was discovered that MTN Uganda and Airtel Uganda were particularly interested in expanding their customer base to increase sales for their mobile sim network and internet services while supporting farmers' access to agricultural information at no cost. Similarly, M-Omulimisa Agritech aimed to enhance farmers' access to agricultural information by facilitating their interactions with extension agents on the AVP at no cost. In contrast, DMark Company's interest was in leasing out its code. Meanwhile, MAAIF and UCC were focused on ensuring that all actors on the AVP complied with the regulations governing the supply and use of certified seeds and agrochemicals, as well as regulations related to the provision and use of digital services.

The expertise of actors within this domain also varied considerably. The MSC possessed expertise in providing loans at lower interest rates, while AIC was related to providing insurance services at affordable premium rates.

The EARS had expertise in generating and remotely disseminating weather information. Actors such as MTN Uganda, Airtel Uganda, DMark and M-Omulimisa Agritech possessed well-established infrastructure and expertise in virtual communication. In particular, DMark had expertise in facilitating information sharing through bulk SMS. Additionally, M-Omulimisa Agritech had expertise in delivering mobile phone-based agricultural services. The expertise of MAAIF and UCC was in the formulation of regulations in their respective areas of mandate. Despite the diversity of actor types in this domain, some critical support actors, such as commercial banks, media, and a policy-making agency,

Uganda National Bureau of Standards (UNBS) were notably absent from the AVP.

Roles of actors on M-Omulimisa AVP

Findings revealed that actors on the AVP played three categories of roles, namely, assigned and played, assigned and not played and not assigned but played. Although all actors generally played most of their assigned roles on the AVP, some actors did not play some of the assigned roles, while others played roles that were never assigned to them (Table 3).

Actors in the education and research domain only played roles assigned to them (Table 3). Their principal roles included providing codified knowledge, providing technical agricultural support to AVP staff, and supplying improved seed technologies. During KIIs, the AVP staff indicated that the technical support they received substantially improved their technical skills in responding to information requests from farmers; however, the support was predominantly on crop-related aspects. The improved seed technologies supplied were crop-specific, including new soybean varieties from Makerere University, and bean varieties from NACRRI.

It is important to note that some NGOs on the AVP, such as Sasakawa Africa Association Uganda (SAA), had expertise to play the role of providing codified knowledge and technical support, but they were neither assigned this role nor did they perform it. Interviews with the extension supervisor at SAA revealed that the NGO possessed codified knowledge in the form of training materials covering a range of agricultural practices like climate-smart agriculture and postharvest handling technologies. In addition, SAA had produced several publications such as "Regenerative agriculture technologies for the improvement of soil health in Africa". This implies that in the current partnership with M-Omulimisa AVP, the content SAA produces is exclusively shared with its field extension agents.

In the intermediary domain, NGOs were the only actors that exclusively played the roles assigned to them, which primarily involved providing funding and promoting engagement of their project-affiliated farmers and extension agents on the AVP. Other actors fulfilled some of their assigned roles, neglected others, and at times played roles that had not been assigned to them (Table 3). In particular, all NGOs on the AVP provided funding to M-Omulimisa to deliver specialised services such as

market and weather information to their project farmers. Interviews with the AVP administrator confirmed that funds from the NGOs were the main source of funding for the AVP operations, as reflected in the quotation below.

“... Most of the funds we use for operations on M-Omulimisa come from our engagements with NGO project activities where they contract us to extend certain services to their farmers... However, we often face challenges to continue operating when we don't have funds from our collaborating NGOs...”
(Key Informant, May, 2022)

With respect to promoting engagement, document reviews showed that more than 80% of the farmers who enrolled and used the AVP were affiliated with NGOs.

Extension service actors and the AVP administrator played roles across all three role categories (Table 3). The primary

roles assigned to extension service actors included providing prompt responses to farmers' information requests and providing constant seasonal updates on agricultural activities to farmers on the AVP.

In the assigned and played roles category, KIIs showed that only the AVP agronomist consistently responded to farmers' information requests, unlike the public and private extension agents. Regarding assigned but unplayed roles, all extension service providers did not provide updates on seasonal agricultural activities to farmers. In addition, public and private extension agents did not respond to farmers' requests for a number of reasons. For instance, in-depth interviews indicated that public extension agents, particularly those not affiliated to NGOs, faced significant resource constraints which impeded their ability to respond to farmer's information requests promptly.

Table 3. Actors and actor roles on M-Omulimisa AVP.

Actors		Actor roles		
Actor domains	Specific actor	No. assigned and played	No. assigned and not played	No. not assigned but played
Education and research	Makerere University	2	0	0
	Bukalasa Agricultural College	1	0	0
	NaCRRRI	2	0	0
Intermediary	NGOs	2	0	0
	Extension services:			
	• AVP agronomist	1	1	1
	• AVP field staff	1	1	1
	• public & private extension agent	0	0	0
	AVP administrator	4	2	3
Donors	1	1	0	
Demand	Mukwano industries	2	0	0
	Aponye Uganda Ltd	2	0	0
	UCC	1	0	0
	MAAIF	1	0	0
Enterprise	Farmers	1	1	1
	NASECO seeds	2	0	0
	Bukoola chemicals	2	0	0
	Mukwano industries	2	0	0
	Aponye Uganda Ltd	2	0	0
Support structure	Airtel Uganda & MTN Uganda	2	1	0
	MSC	2	1	0
	AIC	3	0	0
	EARS	2	0	0
	Dmark	1	0	0
	M-Omulimisa Agritech	1	0	0
	MAAIF	1	0	0
	UCC	1	0	0

These constraints included not owning a smartphone, high cost of internet subscriptions, and limited access to electricity. Neither their employers (government) nor M-Omulimisa Agritech provided either financial or material support to enable them to perform their roles on the AVP. Accordingly, they were expected to use their personal funds to acquire smartphones and purchase internet data. One public extension agent expressed this challenge as follows:

“... I am aware of farmers’ frustrations due to delays or even non-response to their requests, but the task requires me as an extension worker to own a smartphone, with data and access to electricity to charge it... I thought that I would be facilitated with at least internet data bundles because the small internet packages that I buy for my personal use are very insufficient for me to perform any reasonable task on M-Omulimisa...” (Public extension agent, June 2022)

However, one of the key informants from the AVP noted that the failure of public extension agents to play their roles due to a lack of facilitation should not be attributed to the AVP, but rather MAAIF’s inability to adequately support the AVP, as illustrated in the quotation below:

“...We are not able to remunerate extension agents because we too do not have a stable income stream... We rely on the meagre resources from the short-term assignments we get from NGOs that contract us to provide services to their farmers. In my view, MAAIF is failing on its mandate to institute a regulation making it mandatory for all public extension agents and their supervisors to use the AVPs available to interact with farmers when providing extension services. With this in place all extension agents enrolled on the system will have no choice but to use it...” (KII with AVP staff, May 2022).

In contrast, public extension agents affiliated to NGOs mentioned during interviews that they were provided with smart phones and monthly internet data by their organisations. This support enabled them to use the AVP, although primarily to meet their supervisors’ performance targets, which were not necessarily aligned to their assigned roles. One public extension agent affiliated to an NGO explained the situation in the following quotation:

“... The NGO that I work with gave me a smartphone and loads for me monthly data bundles, which I use to deliver on my performance indicators such as reporting on trainings, distribution of inputs to farmers under the projects...” (In-depth interview with public extension agent affiliated to NGO, June, 2022).

Regarding roles not assigned but played by extension service actors, the AVP agronomist and AVP field staff aggregated farmers’ seasonal demands for inputs and expected harvests. One of the AVP field staff illustrated this in the following quotation:

“.....I am also in charge of collecting and aggregating farmers’ needs for inputs such as seed and fertiliser, which my supervisor sends to suppliers. My supervisor uses the same information to inform the produce buyers about the expected yield from a particular region based on the quantity of seed we distributed because we know the quantity planted per acre and the expected yield, so we can give them the estimated production ranges...” (AVP field staff, May 2022).

The roles of the AVP administrator were diverse and quite ambiguous, spanning all three categories. The assigned and played roles included sourcing and enrolling actors on the AVP; assigning roles and user rights to the actors; training new actors on AVP use; and uploading content on the AVP e-library. The assigned and not played roles related to developing a strategy for incentivising public extension agents to play their roles, and providing refresher training to existing AVP users. During interviews and FGDs, farmers noted that refresher trainings were necessary to enable them keep up with developments in AVP as shown in the quotation below;

“.....sometimes as I navigate the AVP on my smartphone, I come across new icons which I do not know how to use..... I am sure these are upgrades M-Omulimisa makes to improve its service delivery to us.... technology changes every single day and ... I imagine the changes in the AVP are made to cope with changes in technology.....I expect M-Omulimisa to often update us on the changes, but they have never done that...”

The ‘not assigned but played’ roles related to responding to farmers’ information requests and brokerage supply

of inputs (seed, agrochemicals), as well as loan and insurance services to farmers. Interviews with the AVP administrator showed that playing these roles was mainly instigated by the dynamics that were happening on the AVP, such as the failure of extension agents to provide prompt responses. For instance, the AVP administrator mentioned that complaints from farmers about non-response, coupled with cases where farmers repeatedly sent the same requests, compelled him to respond. Regarding the brokerage role, evidence from KIIs revealed that the role emerged due to the changing needs of farmers on the AVP. The AVP administrator explained in the quote below.

“... The M-Omulimisa platform was initially created for farmers and extension agents to share production information. As time went by, farmers’ needs evolved, and they started demanding information spanning entire enterprise value chains besides agricultural practices... farmers demanded information on prices and source of market for their produce, and how to use agro-inputs like improved seed, fertilisers, and herbicides... This pushed me to search for suppliers to provide farmers with the demanded information... I also started to aggregate farmers’ needs for inputs and arranged for deliveries of the inputs to the farmers. I also aggregated farmers’ produce and arranged for pick up by the traders. The transactions boosted our income from the commission earned, and we have now expanded to supplying insurance and financial services...”

Donors’ roles fell into two categories: assigned and played, and assigned but not played (Table 3). None of the donors played roles beyond those formally assigned to them. For their primary role, donors provided financial support for AVP operations through grants. In the category of assigned and played roles, donors provided grant funding. However, in the assigned and not played category, KIIs revealed that the donors did not provide funding regularly. The funds were in form of grants that were highly competitive and tied to specific donor-driven projects which limited consistent availability of funds for AVP operations.

In the demand domain, all actors exclusively played roles that were assigned to them (Table 3). None of the actors played roles not assigned to them. The roles Mukwano Industries and Aponye Uganda Limited played

as industrial consumers of raw materials were mainly providing information on markets and the purchasing of agricultural produce. The roles of UCC were to certify digital service providers and provide guidelines on the provision and use of digital services while those of MAAIF involved providing information on the certification of technologies and agrochemicals. During KIIs, actors mentioned that certification by UCC required detailed identification of each actor enrolled and using the AVP and mandated that all information shared on the AVP should be restricted to only agricultural content. Furthermore, KIIs indicated that MAAIF provided guidance on certified improved seed varieties and agrochemicals recommended for use in Uganda. With respect to Mukwano Industries and Aponye Uganda Limited, their roles in providing information on prices and markets to farmers were played through the AVP administrator.

In the enterprise domain, the roles of actors were largely in the category of ‘assigned and played’ except farmers whose roles spread over the three categories (Table 3). The assigned and played role of farmers was requesting technical agricultural information through the AVP. In the assigned and not played role of farmers, key informants from the AVP widely reported that farmers have not utilised the AVP as adequately as they were expected based on the numbers of those who used the AVP *vis a vis* the registered. Corroboratively, evidence from the netnographic interactions showed that of 13500 farmers enrolled on the AVP, only 9.77% played their role of requesting information at least once during the study period of three years. Moreover, online records further showed that out of the registered farmers, only 2.3% requested information more than once in the same period. Lastly, the role that farmers played but was not assigned to them related to following up on their requests, which did not receive responses at least twelve hours after they were received on the AVP. Farmers reported that when faced with cases of non-response to their request, they often take on the additional responsibility of following up on their requests. Secondary data from the netnographic interaction revealed how farmers played the role in the following statement: “*Nze XY (name withheld) mubuza lwaki temunziramu bibuzo byange, buzibu ki* (English translation as: Me farmer XY, I am asking why are you not responding to my questions, what is the problem?)”. Farmers expressed that they were interested in

receiving prompt response to their requests and were dissatisfied with the delays and non-responses that they oftenly experienced, as illustrated in the quotation below:

“.....As a farmer, if I go to the garden and find that my maize is turning yellow, and I ask M-Omulimisa why my maize is turning yellow, I would wish to get the answer there and then so that I can address the problem before leaving the garden, because not doing so will mean that the problem will continue to worsen.Many times, the response takes a long time to come and other times I do not receive a response at all” (In-depth interview with a farmer, August 2022)

Unfortunately, reports from farmers involved in the FGDs and review of online documents indicated that although farmers took on this additional responsibility, the staff at the AVP did not take any action.

Unlike the farmers, NASECO, Bukoola chemicals, Mukwano industries and Aponye Uganda Ltd played all the roles that were assigned to them. Specifically, NASECO and Bukoola chemicals provided information on recommended use, prices, and supplied technologies within their interest, that is, seed for NASECO and agrochemicals for Bukoola chemicals. Mukwano Industries and Aponye Uganda Ltd provided information on prices, quantities, and purchased agricultural produce from farmers. However, findings from FGDs and KIIs indicated that these actors played their roles through the aggregator and brokerage role of the AVP staff.

In the support domain, roles of actors were mainly in the assigned and played role category apart from Airtel, Uganda & MTN, Uganda, and MSC, which had assigned and not played roles as well (Table 3). The assigned and played role of MTN, Uganda & Airtel, Uganda, included enabling cost free information exchange for farmers on the AVP via mobile sim network and provision of a strong and stable sim network and internet connectivity. Nonetheless, findings from the FGDs and in-depth interviews showed that both MTN, Uganda & Airtel, Uganda had failed to ensure strong and stable sim network coverage in many rural areas. The MSC's assigned and played role involved providing information on agricultural financing and offering low-interest loan facilities, which farmers accessed in the form of input loans. Concerning the assigned and not played role, participants in the FGDs and KIIs reported that MSC

sometimes fails to disburse funds on time, thereby impeding farmers from implementing planned seasonal activities.

The roles of Agricultural Insurance Consortium (AIC) belonged entirely to the assigned and played role category, and they comprised the provision of insurance cover at affordable premium rates and information on agricultural insurance, as well as compensation to farmers with insurance cover in case they incurred losses. Key informants noted that AIC has insured all the input loans that farmers accessed through the AVP. Eumetsat Advanced Retransmission Service (EARS) also played its assigned roles by providing precise weather information and submission of seasonal weather reports to AIC, which are used to determine compensation to farmers. A key informant explained that the role of EARS emerged after AIC required farmers receiving loans to adopt some risk mitigation measures, such as using highly accurate weather information to reduce exposure to weather-related losses. Farmers participating in FGDs reported that the weather information provided was accurate in more than 80% of cases. DMark's assigned and played role consisted of providing bulk messaging services to the AVP using the code (8228), which it leased at a subsidised fee. Similarly, M-Omulimisa Agritech played its assigned role of enabling cost free information sharing for farmers on the AVP using designated keywords and passwords for farmers and extension agents, respectively. The assigned and played roles of Uganda Communications Commission (UCC) and Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) involved providing regulatory guidance to actors on the AVP during the sharing of information and supply of approved technologies, respectively. Key informants explained that UCC issued guidelines on actor enrolment and the kind of information permitted for sharing on the AVPs. The guidelines required all actors on the AVP to be identified by full name, telephone contact, physical location (village, parish, subcounty and district), while all shared information was to be strictly agricultural. MAAIF, in turn, provided lists of technologies certified for use in Uganda, and key informants reported that they were essential reference tools when playing the aggregator and brokerage roles.

DISCUSSION

The study employed the Agricultural Innovation Systems (AIS) framework (Rajalahti et al., 2008) to assess the

diversity of actors enrolled on M-Omulimisa Agricultural Virtual Platform (AVP) and the roles they played. Findings indicated that actors were diverse and represented all five AIS domains: education and research, intermediary, demand, enterprise, and support structures. However, the diversity varied across domains and was particularly limited in the education and research, and demand domains, each of which had no more than two actor types. Representation within actor types was also restricted, with only two specific actors represented in several actor types. This limited representation within actor types affected multiple domains beyond education and research, and demand domains. For example, actor types such as commodity traders, input supply, and agro-processors in the enterprise domain; insurance, financial services, and meteorology actor types in the support structures domain; and donors in the intermediary domain were each represented by only one or two specific actors. Specifically, the presence of only Makerere University and NaCRRI as sources for technologies and technical information, NASECO and Bukoola chemicals as input supplies, and Mukwano Industries and Aponye Uganda Limited as industrial consumers and agro-processors, and only Aponye Uganda Limited as a commodity trader implied that the AVP did not offer a broad range of service providers from which actors, particularly farmers, could choose. The absence of alternative sources for information, inputs, and other services poses several risks, including limited access to adequate technical information and technologies, and increased vulnerability of farmers to dominance and manipulation due to a lack of competing service providers.

Beyond limited diversity and representation, several critical actors were entirely missing on the AVP. These included key actors in the livestock sector, that is, scientists (education and research domain), extension agents (intermediary domain), and livestock related input suppliers (enterprise domain), Uganda Nation Bureau of Standards (demand and support structures domains), as well as AVP moderator (intermediary domain), banks and media (support structures domain), and farmer associations (enterprise domain). The absence of these actors had important implications. A moderator, for instance, would be essential for following up on requests with pending responses and ensuring that platform management appreciates and addresses the effect of missing actors. The farmer associations

would have promoted a strengthened collective voice to potentially enhance farmers' motivation to engage more regularly on the AVP. Similarly, the inclusion of livestock value chain actors would have expanded the scope of technical information and technologies available, such as inputs for various livestock enterprises. Relatedly, banks would provide loans to farmers in circumstances where MSC is unable to disburse funds on time, as well as those who did not belong to groups, while the media would enhance awareness and publicity of the AVP and its benefits. Lastly, UNBS would ensure the quality of inputs that farmers received through the AVP. The limited diversity and absence of actors across domains may be partly attributed to the absence of some actors, such as the media. Overall, the limited diversity of actor types and the absence of key actors further constrained the platform's ability to provide varied sources of agricultural information and technologies. Accordingly, Aker et al. (2016) contend that agricultural information is associated with nuances and requires diverse sources to adequately meet farmers' information needs. Thus, the limited sources of information on the AVP adversely affects its functionality and consequently its ability to facilitate the sharing of agricultural information that addresses farmers' needs.

Analysis of actor attributes in relation to enrolment method, interest, and capabilities revealed patterns of convergence across all domains. For example, actor enrolment on the AVP predominantly relied on invitations, particularly for all actors who were not farmers. This method is largely subjective, prone to personal bias, and restrictive. This could have potentially limited the actors present on the AVP to those known and perceived as relevant. Consequently, the invitation-based enrolment approach likely excluded actors who were unfamiliar to the conveners or who may have been erroneously deemed lacking in capabilities. This pattern likely contributes to the explanation for the limited diversity and absence of certain actors on the AVP. Notably, the provision for self-enrolment would be critical towards mitigating the limitations of the invitation method on the AVP. However, its potential became relegated when it was restricted to farmers. Nevertheless, the provision may be considered as an effort to enhance farmers' capabilities to use the AVP and to promote the adoption of digital devices in agriculture. This approach aligns with the concerns of ICT4Ag, ICT4D, and HCI4D scholars who advocate for

direct farmer engagement with digital technologies and for their empowerment to demand involvement in ICT fora (Emeana et al., 2020; Klerkx et al., 2019). Similarly, Hall et al. (2006) commend such approaches for being inclusive, empowering, and cognisant of the rural poor as actors in development processes.

Results on actor interests on the AVP revealed a strong inclination towards crop enterprises, a pattern evident across most domains. This trend may be attributed to the influence of NGOs, which actively promoted crop-oriented enterprises among farmers. Correspondingly, it was established from online documents that more than 80% of farmers enrolled on the AVP who accessed information and technologies on crop enterprises were affiliated with NGOs. Consequently, the farmers' information needs widely stimulated the presence of actors with interests in crop-related enterprises across domains. For example, within the education and research, intermediary, demand (excluding policy-making agencies), and enterprise domains, actors' interests were crop-oriented. Several actors had an interest in specific crops: Makerere University, NaCRRI, and NASECO focused on seed for improved varieties of soybean, beans, and maize, respectively, while Mukwano Industries and Aponye Uganda Ltd concentrated on sesame & soybeans, and beans & maize correspondingly. Evidence from online documents further showed that NGO-led projects were largely oriented towards maize, soybeans, and bean value chains. Moreover, 91.93% (763) of crop-related information shared through the AVP concerned value chains of the crop enterprises that NGOs promoted. The strong convergence around crop enterprises and within specific crop value chains limited the availability of information and technologies for livestock enterprises and other less prioritised crops. The AVP's apparent bias towards crop-related content, therefore, partly reflects its reliance on NGOs' activities.

A similar pattern of convergence was evident in actor capabilities. For instance, actors such as the Donors and NGOs tended to cluster around rural development initiatives, while Mukwano industries and Aponye Uganda Ltd converged around value addition, particularly processing of agricultural produce, albeit for different crops. This convergence of capabilities further constrained the diversity of service providers as well as services and technologies available on the AVP, leaving actors with few alternatives. Overall, the widespread convergence observed in the actor attributes negatively

affected diversity on the AVP in terms of sources for information, technologies, and other services. Islam et al. (2019) argue that such convergence within the actor platform undermines heterogeneity since it consolidates actors in homogenous groups. Although actors in agricultural innovation systems (AIS) are generally sought based on their capabilities, focal actors tend to be intentional, not necessarily to source allies with common interests, but rather those whose interests strategically align with their own (Birke and Knierim, 2020; Hermans et al., 2015; and Sarker et al., 2006).

Findings revealed that roles prescribed and assigned to actors were appropriate, given their capabilities and interests. Three categories of roles were evident on the AVP: assigned and played, assigned and not played, and not assigned but played. The categories were interrelated and collectively shaped the functionality of the AVP in various ways. The role that actors from education and research played in providing technical support to AVP staff was central in enabling AVP administrators to respond to farmers' information requests. Even though the AVP administrator played the role, it was not assigned to him due to limitations in his expertise. Consequently, the technical support was timely and important to address the emerging challenge of private and public extension agents abandoning a role that was collectively assigned to them to ensure that farmers obtain prompt responses to their information requests. The failure to commit to the assigned role undermined the timeliness of the information farmers obtained from the AVP. In innovation platforms roles of actors are interdependent such that failure of some actors to commit to their roles affects the roles of others as well as the quality of services networks provide (Birke and Knierim, 2020). Much as the AVP administrator's providing responses to farmers' information requests was critical in redeeming the timeliness of information, showed commitment and it negatively affected the quality of information that farmers obtained from the AVP in terms of technical correctness, given that the role fell outside the expertise. Whereas commitment to the role is critical for the relevance of the AVP, the quality of information provided in terms of its ability to respond to the specific needs of the actors takes precedence. Certainly, the quality of information that aligns with actors' needs attains greater relevance and effectiveness in addressing the challenges for which it is intended (Babu and Glendenning, 2019).

Moreover, the quality of information users receive influences their perception of system reliability (Asanprakit and Kraiwanit, 2023; Jiang et al., 2021; Zhuang et al., 2023 and Zhu et al., 2020). Attributes of both information and the AVP are therefore critical in fostering users' commitment to the platform as their means of sharing information. Literature affirms that information relevant to users' needs enhances trust and sustained engagement with virtual systems (Jiang et al., 2021; Zhuang et al., 2023; Zhu et al., 2020). It can thus be argued that when actors obtain adequate and relevant information, they are better positioned to address their farming challenges and consequently, more likely to fulfil their roles on the AVP. Conversely, delays in obtaining responses may explain farmers' limited engagement on the AVP.

The role NGOs played, particularly in providing funding for platform activities and their central involvement in farmers' enrolment, while encouraging their use of the AVP, shows a reliance on NGOs. The study found that NGOs enrolled nearly all farmers who used the AVP during the study period, with more than 80% of users being registered through NGO affiliated projects. The NGOs funded M-Omulimisa to extend services to farmers under the different projects. However, Emeana et al. (2020) highlight that reliance on external funding poses a major challenge for the sustainability of digital innovations, a concern that is evident in this case. Because NGO-led activities are time-bound, dependence on them introduces long-term sustainability risk for agricultural virtual platforms. This challenge is further compounded by the traditionally low levels of digitalisation in the agricultural sector. Since the agricultural sector has traditionally been non-digital, the project approach hinders continued use of the AVP, which is critical for sustainability (Munthali et al., 2019). The brokerage and aggregator roles which the AVP staff played emerged due to changes in actors' information needs. For instance, farmers needed information on inputs such as improved seed varieties, herbicides, fertilisers, and services, including loans and market linkages for agro-produce in addition to that on agricultural practices. The emergence of these roles highlights the critical contribution of the intermediary actors in agricultural innovation systems, particularly of bridging diverse actors to facilitate farmers' access to resources (Hall et al., 2006; Klerkx and Leeuwis, 2008; Rajalahti et al., 2008). Consistent with Weyori et al.

(2018), the AVP acted as an innovation platform that supports resource-constrained actors, such as farmers, to obtain inputs and services they would otherwise struggle to access independently. Through these intermediation roles, AVP staff effectively enhanced farmers' access to technologies, financial services, including loans and insurance, and markets for their produce.

In addition, playing the brokerage roles attracted commission from the supply of technologies and services, which supplemented the AVP's income. The income generated ensures the sustainability of the AVP activities even in the absence of grant funds, which are not always available given that they are seasonal, competed for, and dependent upon donors' interests. Indeed, the strategy of M-Omulimisa to generate income to fund its activities reveals the efforts of the AVP management towards ensuring self-sustenance. Emeana et al. (2020) opine that many of the AVPs developed in Africa are short-lived and do not spread beyond their pilot areas largely because they lack financial stability and self-sustenance. Furthermore, Schut et al. (2019) and Sanyang et al. (2019) suggest that agricultural platforms need to be proactive with internal and external sources of funding to enhance the sustainability of their activities.

Furthermore, findings revealed that there were farmers who played a role that was never assigned to them in following up on their information requests when they did not receive responses promptly. The farmers who sent requests on the AVP and followed up on responses represent empowered actors with the capability to demand accountability. Chen and Tseng (2011) and Chen et al. (2018) posit that actors with capabilities are confident and very clear about their information needs as well as how to meet them. According to Hermans et al. (2015), the capabilities of individual actors motivate them to accomplish their roles in innovation networks.

Lastly, findings revealed a central role that was not played, that is, developing strategies for incentivising public extension agents and providing refresher training for farmers. Given that the role was related to extension agents whom the AVP specifically targeted to enhance interaction with farmers, it is critical for achieving the goal of the AVP. Therefore, the AVP administrator ought to have given it immediate attention. Failing to play this role defeats the purpose for which the AVP exists and may, to a large extent, explain the inadequate

involvement of the farmers and extension agents in the AVP. Indeed, Ayre et al. (2019) contend that the pluralistic AIS approach implemented on digital innovations presents daily challenges for farmers and extension advisors since it is a significant departure from their routine due to new sources and types of information, knowledge, skills, and digital devices. Eastwood et al. (2019) argue that the usefulness of digital innovations such as agricultural virtual platforms is largely constrained by practices that disregard users' contexts and needs as well as expectations from the platforms. As such Ingram and Gaskell (2019) recommend iterative interactions among managers of digital innovations, farmers, and extension providers to enhance utilisation. Overall, as Hall et al. (2006) noted, in innovative systems, as circumstances change roles of actors evolve, and their relative importance changes, the dynamics of the AVP resulted into changes in the roles of actors. For instance, some actors, such as the AVP staff, played multiple roles, while for the administrator, the roles instead became ambiguous.

CONCLUSIONS AND RECOMMENDATIONS

Diversity of actor types and actors within actor types across all domains on an AVP, as prescribed in the AIS framework, is critical if AVPs are to be functional. The actors engaged on the M-Omulimisa AVP were diverse, representing all five domains of AIS: *education and research, intermediary, demand, enterprise, and support structure*. The overall diversity notwithstanding, emphasis was largely on the diversity across domains rather than within domains, to the extent that all domains had missing actors who were key. For instance, within all domains, there was limited diversity of actor types and actors within actor types, particularly in the education, research, and demand domains. Some critical actors were completely absent across all domains, particularly actors in the livestock sector. The limited diversity and absence of critical actors on the AVP implied that actors who used the AVP had limited sources of services, such as information and technologies, with restricted alternatives or caused a complete lack of a service.

The limitations in the diversity of actors on the AVP were largely due to widespread convergence of actor attributes, especially in the method of enrolling actors on the AVP and their capabilities. Convergence of attributes led to the consolidation of actors into homogeneous groups within

domains or actor types and actors belonging to multiple domains or actor types. The generalised convergence implied that the likelihood of one actor offering different types of services was greatly enhanced.

This study therefore recommends immediate enrolment to address the missing actors, particularly those in the livestock sector and media, while paying attention to the diversity of actor types as well as actors within actor types. This will necessitate shifting from invitation as the main method of actor enrolment to emphasising others, like self-enrolment, while permitting multiple actors to engage in sourcing and enrolling of actors that are not farmers. Findings further indicated that the roles of actors in extension service (intermediary domain) were dynamic and changed with respect to actors' commitment to the roles assigned, needs of farmers, and incentives tied to the roles. Public extension agents abandoned their roles of responding to farmers' requests when they were not incentivised by M-Omulimisa. This led to an evolution of platform staff roles, with the administrator specifically taking on the additional role of responding to farmers' requests, albeit with the limitation in capability. Reliance on the AVP administrator to respond to farmers' information requests without the involvement of extension agents implied that the diversity of actors to provide information was further compromised. Given that agricultural information is highly context-specific and is associated with nuances, the dissemination of information from limited sources compromises its quality and predisposes the AVP to adverse effects. Utilisation of such information by farmers risks the AVP of losing its trust among farmers as well as attracting legal sanctions, which may threaten its sustainability. The management of the AVP needs to work out a strategy to incentivise extension agents to win back their attention and encourage active engagement on the AVP. The strategy may take advantage of the existing intermediation with input supply and produce marketing that the AVP administrator is brokering, since it has already shown potential for earning income. This will address the challenge of incentives and ensure the sustainability of the AVP since it is key in achieving the National Development plan as well as the Sustainable Development Goals, which propose to use ICTs to promote development.

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