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Interactions pathways for information exchange among avocado value chain stakeholders

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Multi-stakeholder platforms facilitate interaction between stakeholders in the agricultural innovation system. A multi-stakeholder platform is essential to enhance the innovation of avocado value chain stakeholders and avocado planting as a climate-smart practice. Avocados can make a significant contribution to food security and nutrition. Research has shown that research on climate-smart agriculture mainly focuses on scientific and technological solutions, rather than attempting to comprehend the economic and social dimensions of this study. The study's goal was to identify the interactions between stakeholders in the avocado value chain. The data for this study were gathered using a semi-structured questionnaire and focus group discussions. The study employs the concept of an innovation systems perspective and investigates social network analysis in the context of stakeholders. Information sharing, roles and functions of stakeholders were used as proxies to denote communication. In this study, the multi-stakeholder platform's role in fostering a supportive forum was interpreted as access to information, knowledge, and resources. Findings indicate that smallholder farmers, support service providers and market stakeholders need to be strengthened and empowered to adopt and implement inclusive innovations. This was essential to ensure that stakeholders throughout the value chain had access to tools and resources to promote avocado yield for food, industry, and climate-smart practices. The study concludes that there are distinctions in the roles and responsibilities of stakeholders in the avocado innovation system. Farmers have been discovered to innovate using relevant expertise, even though they are primarily considered users of innovation. The study's recommendation is that smallholder farmers be empowered through capacity building to influence agricultural value chain development and environmental sustainability through information technology.

Key words: Avocado value chain, Centrality measure, Domain, Linkages, Multi-stakeholder, Social networks

INTRODUCTION

Multi-stakeholder platforms are intended to facilitate the innovation, exchange, and diffusion of agricultural

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innovation systems' knowledge, services, and resources (Leeuwis and Aarts 2011, Klerkx et al., 2012). They are seen as a promising vehicle for increasing and sustaining the impact of agricultural research, according to supporters (Kilelu et al., 2013; Schut et al., 2015). They seek to effectively promote and improve innovation processes throughout the agri-food value chain, particularly in emerging markets. The multi-stakeholder platform, according to van Ewijk and Ros-Tonen (2021), should be community-driven, participatory, and inclusive, to be used for the rapid exchange of information. The targeted use of a good information platform greatly simplifies the interaction of stakeholders in different locales and the exchange of information in real-time (Leventon et al., 2016). The information exchange gives smallholder farmers access to climate change mitigation techniques and benefits to cope with their effects and feedback mechanisms to the other relevant stakeholders in the agricultural value chain (Westermann et al., 2018). Studies have shown focus of climate, agriculture research has essentially remained on scientific and technological solutions (Friedman et al., 2022), and therefore information pathways to understand social and economic aspects are essential, which this study investigates. Access to extension and climate information services has been shown to improve farmers' ability to adapt their farming practices, markets, and management strategies to climate change (Juan, 2018; Friedman et al., 2022). Services grouped under social network sites, in which people connect with one another and share news, experiences, and knowledge are becoming increasingly important (Chinseu et al., 2021). Important information for avocado stakeholders includes climatic information such as seasonal climate forecasts of rainfall and temperature to smaller temporal and spatial scales (Nidumolu et al., 2020), as well as quality seedlings, planting and harvesting calendars. Through linkage and information exchange, this study aimed to help avocado farmers make better decisions about what, when, and how to manage their farms in the face of climate, input, and market variability. There are numerous information sources available to avocado stakeholders, but access to them is irregular (Krauss and Krishnan, 2022). Observation, family, friends, and social gatherings (markets, farmers' groups) are examples of informal channels. While the government is responsible for the majority of extension services, non-governmental organizations (NGOs) and community-based organizations (CBOs) have become more active in providing these formal services (Friedman et al., 2022), while smallholder farmers continue to be passive recipients of climate-smart initiatives (Chinseu et al., 2021).

There are several stakeholders along the nodes of the avocado value chain and distribution (Krauss and Krishnan, 2022). These include individuals and organizations involved in research, advisory service providers, production (avocado growers), transport and marketing, and seedling suppliers (both external and local). A stakeholder is a person or group who influences or is influenced by a decision, action or outcome. A stakeholder is a person or group who has an effect on, or can be influenced by, a decision, activity or output. Stakeholders may have hidden or clear and specific interests in an issue and act on various scales (Chinseu et al., 2021). Prior to beginning any form of research and development, it was critical to understand the stakeholder environment in order to decide who to include and how this would affect attaining the target (Chinseu et al., 2021). The role of stakeholders in the avocado value chain is largely dependent upon their own actions and behaviour. However, they are also reliant on the presence of other actors to promote their actions. Klerkx et al. (2012) argue that bringing actors together in a cohesive network improves the innovation process. It can also lead to more effective and efficient use of existing resources. And this brings about innovation in an agricultural system (Chinseu et al., 2021). This study was conceptualized based on the innovation system theory using the Agricultural Innovation System approach to bring stakeholders together in a multi-stakeholder platform (Adekunle et al., 2013). The multi-stakeholder platform represents a group of stakeholders with diverse backgrounds and interests within a study area (Schut et al., 2019). This approach enabled the development of smallholder farmers' capacity building for integrating avocados into farming systems to promote a stable agro-ecological system to mitigate land degradation forces. Leventon et al. (2016) defines the agricultural innovation system as the interactions in creating knowledge, dispersion, and usage within the agricultural value chain. It also offers a framework for analyzing complex relationships and processes that take place among multiple agents, both social and economic institutions, and organizational and technological opportunities (Lundvall, 2010). Based on the agricultural innovation system approach, Rajalahti (2012) and Anandajayasekeram (2011) classify the stakeholders along the agricultural value chain into actor domains. These actor domains were the basis for information pathways in a multi-stakeholder platform. The domains were: education and research (supply), intermediary (bridging), enterprise (market and producers), demand, and support (policy). Policymakers as well as consumers of industrial raw materials and food products are included in the demand domain. Farmers, agro-processors, transporters, input suppliers, and commodity traders are key players in this domain. The supply domain is synonymous with the education and research domain, which produces codified knowledge in the form of tacit knowledge (Onumah et al., 2021).

Bridging domains are stakeholders who connect all other domains and play an integral place in the agricultural innovation system (AIS) (Suchiradipta and

Raj, 2015; Onumah et al., 2021). Extension agents, farmer cooperatives, corporate sponsors or government funding agencies, and Information communication technology providers are all included (Ibid). Support domain stakeholders include banking firms, transportation and promotional infrastructure systems, education providers, farm-level entities, commercial entities, and policy structures (Ibid). This domain has both supportive and bridging properties. Given this development, multi-stakeholder interactions classified into domains attract stakeholders' interest to exchange views on products and services among them (Nidumolu et al., 2020). Domains are defined by the relationships between stakeholders, and thus by the multi-stakeholder platform induced by mutual connections (Faulkner and Nkwake, 2017). This inter-connectedness of actors, that is, their structural integration into the network, has a significant impact on their communication and interaction, and thus contains helpful information for stakeholders along the avocado value chain. The interactions of multidisciplinary stakeholders in the avocado value chain were examined using the Social Network Analysis (SNA) method (Hermans et al., 2017). This method revealed network connections and power dynamics in an avocado multi-stakeholder platform. Identifying existing network opportunities and limitations can support steering more information sharing of climate data to farmers (Weyori et al., 2018). Policy and interventions can assist in clarifying how information flows and which core sources can be clearly aimed or augmented by legislation and intervention strategies (Freidman et al., 2022). This paper is divided into three sections: the first section is the introduction, and section two describes and elaborates on the study design, data collection, and analysis methods. The third section presents the study's findings and discussion in three parts: the first part describes the stakeholders' roles, the second discusses stakeholder network mapping, and the third describes the study's conclusions and recommendations.

METHODOLOGY

Location of the study

The research was conducted in the Upper Mara watershed in Kenya (Figure 1), which is located between the coordinates of 0045'S and 1°S latitude and 35° and 35°15' E longitude, at an elevation of 1900 to 2970m above sea level (Schmidt et al., 2009). The location was chosen due to its proximity to avocado-growing smallholder farmers. However, some interviews were done far away from the study area taking into consideration the stakeholder region of their work operations. Most of the interviews were conducted in Bomet East and neighbouring Narok West.

Research design

The study used a participatory action design and a mixed-method approach. Given their respective roles in the avocado value chain, the quantitative approach was selected to distinguish actors' power relations. This was accomplished using social network analysis and the catalogue of relational data. Key informant interviews were used in the qualitative approach to identify the thematic codes used for categorizing stakeholders into domains based on their roles/functions.

Target population

The study involved multiple stakeholders along the nodes of the avocado value chain and distribution. These include individuals and organizations involved in research, advisory service providers, production (avocado growers), transport and marketing, seedling suppliers (both external and local suppliers - Isinya Roses and local nurseries) and policy influencers. The actors were chosen based on their knowledge of what happened in the avocado value chain. These stakeholders were identified in close consultation with Bomet and Narok Counties Department of Agriculture, Livestock, Fisheries and Cooperatives (MoALF) staff, CFA and WRUA leaders, village elders and a local non-governmental organization (NGO) who assisted in the identification and categorization of stakeholders.

Sampling design

The avocado farmers from three agroecological zones and two avocado farmer group leaders were selected for interview using a stratified sampling technique giving a total of twenty (20) interviewees for this study. Key informant stakeholders, totaling nineteen (19), were purposively selected from the list of stakeholders obtained from Cis Mara Avocado Farmer Cooperative Society (CMAF) in the study location, from the demand, supply, bridging, and support domains, as well as the enterprise domains. Efforts were also made to ensure representation of women and youth in the sample where possible.

Data collection approaches

Relevant information was collected through stakeholder interviews. Key informant interviews were conducted with stakeholders from the demand, supply, bridging, and support sectors, as well as the enterprise domains (excluding farmers). Before the interview, participants who were not familiar with the concept of a multi-stakeholder platform were given an explanation. Farmer interviews were conducted with different individuals with different levels of influence and power to minimize selection bias and improve internal validity. Data collection methods used for avocado stakeholders were selected based on their respective functions. They all performed different functions, which required individual interviews as key informants to obtain detailed information about each function. Interview requests were made to selected respondents prior to the selection of key informants. The FGDs were conducted in the absence of advisory officers to allow farmers to express themselves freely and data was collected based on the availability of key informants. Baseline survey data were used to triangulate some responses.

Data analysis

Thematic analysis of avocado stakeholders in the Upper Mara watershed

Field interview data were transcribed to allow for manifest content analysis and recursive data coding using the constant comparative method. Table 1 shows how transcribed data was coded to

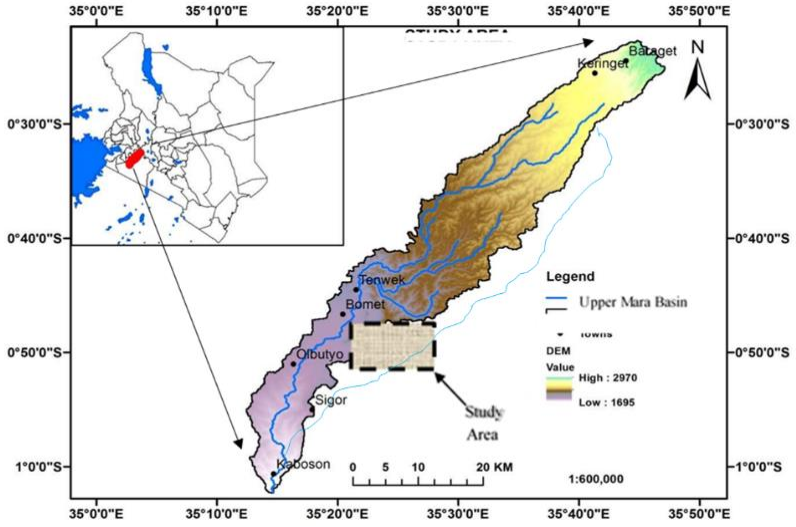

Figure 1. Map of Upper Mara Watershed.
Source: Author, 2022

Table 1. The codes and themes for analyzing stakeholders in the avocado value chain.

Agricultural innovation system (AIS) domain	Key themes	Selected codes
Demand	The policy promotion role	Establishing a regulatory agenda, establishing institutional structures, controlling farm product imports/exports, and selecting varieties
Supply	Innovation initiative	Avocado hi-tech innovation, improved seedling evolution, improved climate-smart practices, and avocado management practices (weeding, pruning, mulching, watering, disease, and pest control).
Enterprise	Utilization	Adoption and marketing of improved seedlings /planting avocado
	Marketing	Input supply services /avocado buying entities/sellers of avocado products
Bridging	Linkage and dissemination	Extension/advisory service providers, stakeholder-to-farmer linkage
Support	Coordination of funding/ regulatory	Assessment of innovations/ access to credit/ inputs/information/ financial assistance

Source: Author, 2022.

generate themes for stakeholder role analysis.

Social network analysis for avocado value chain stakeholder

A descriptive social network analysis (SNA) was used to help identity who had the most influence over how the system was managed. The data for the avocado multi-stakeholder platform networks were assembled in a stakeholder square (nxn) matrix, as recommended by Freeman (1990). If there is no relationship, nij=0 or nji=0.0; is assigned to the value of ji. This is useful for determining who is influential or prominent in the network by building forward and backward links. The Freeman degree of centrality (Cd) is expressed in terms of the number of connections a stakeholder has with other members of the network. The size of the node (stakeholder) indicates the stakeholder's network connectivity. SNA refers to stakeholders as nodes and the connections between them as ties in Table 2. The Freeman degree of centrality (Cd) is expressed in the equation:

$$C_d(n_i) = \frac{y_i(n_i)}{N-1}$$

where n_i is the node or avocado stakeholder of interest; Yi is the number of ties to the avocado stakeholder n_i; and N − 1 is the size of the avocado value chain network, N, less the node of interest. To create network maps and estimate centrality measures, the UCINET software was used. A full network analysis was performed because the focus of this study was not on a single stakeholder, but on the entire network of stakeholders. The procedures of Weyori et al. (2018) and Shan et al. (2018) were followed in this study, which used centrality indices such as in-degree, out-degree and closeness. The centrality measurements were analyzed to identify the strength of existing linkages as well as the degree of centrality in the avocado value chain network. The stakeholder connection

Table 2. Components of Social Network Analysis used in the study.

Element	Definition
Node	The avocado stakeholders
Tie	Links between stakeholders denote interaction between avocado value chain stakeholders
Ego	Avocado value chain stakeholders within a network
Alter	In a tie linking an ego to another avocado stakeholder, the other avocado stakeholder is referred to as an 'alter'.
Network	Graphical representation of relationships that displays points to represent avocado stakeholders and lines to represent connections with other avocado value chain stakeholders
Network size	Total number of avocado stakeholders in a network or value chain
Ego network	The network that only shows direct ties to the ego and not between alters
Network centralization	The degree to which a network revolves around a single stakeholder
Geodesic distance	The length of the shortest path between two stakeholders
Network density	Stakeholders are linked/connected as a proportion of all possible connections/linkages in a network/value chain. The density measures the 'proportion of connections that are present in a dichotomous relation.

Source: Adopted from Borgatti et al. (2013), and Hanneman and Riddle (2005).

was interpreted as a tie in the network analysis, which may be expressed as a binary metric. If a stakeholder has a link with another stakeholder that comprises information and/or resources, the tie has a value of one (Borgatti and Foster, 2003). Table 3 displays a description of the essential features of the SNA adopted in this study. The avocado value chain stakeholders were analyzed using the social network analysis (SNA) software (UCINET6, v6.584). The generated structural positions of the network's stakeholders reveal direct ego-altering ties. This was required to visualize the positions and relationships of stakeholders in the avocado value chain. The network maps were illustrated and visualized using the NetDraw 2.153 tool (Borgatti et al., 2014).

RESULTS AND DISCUSSION

Stakeholder linkages in the multi-stakeholder platform

Table 3 shows the results of a descriptive analysis of the roles of stakeholders in the avocado value chain using thematic analysis. From the analysis as depicted in Table 3, the demand domains are the Cis-mara avocado farmer cooperative society (CMAF), Water Resources Management Authority (WARMA), Kenya Plant Health Inspectorate Service and the Horticultural Crop Research Institute (HCRI). All with exception of the Cis-mara avocado farmer cooperative society (CMAF), which is a farmer's cooperative are government agencies that directly or indirectly regulate the agricultural value chain processes. The Kenya Plant Health Inspectorate Service (KEPHIS) is concerned with the regulation and policy on the control of pests and diseases both crops and livestock. The Horticultural Crop Research Institute under the Kenya Agriculture and Livestock Research Organisation (KALRO), similarly belonging to the demand domain is involved in agricultural research at zonal and national, for genetic improvements and adaptions to different agroecological regions (Oduol et al. 2017). The Water Resource Management Authority (WARMA) is involved in water resource use, by providing the regulatory policy framework for the abstraction, and conservation of water. They control the abstraction of water for irrigation by the avocado farmer as well as the conservation and protection of water bodies such as rivers, streams, and springs. The autonomy occupied by the demand plays a pivotal role in the avocado production system. With this flexibility, they may develop agriculture-specific objectives for enhancing the skills of agricultural stakeholders and agencies, which is also in line with their regulatory and policy implementation duties, as reported by MOALF and I (2019). According to farmers questioned, there appears to be significant emerging civil service support for the avocado value chain compared to other horticultural farming enterprises. Horticultural Crop Directorate (HCD) is concerned with the regulation and policy on quality and export in Kenya. Agri-tech supports the avocado farmer's provision of organic fertilizers. Both HCD and Agri-tech were identified to fall under both the support and bridging domains. The bridging domains for both are mainly agricultural advisory services and community-based facilitators and donors to the avocado farmer (Krauss and Krishnan, 2022). Biofarm, WRUA and Biologics Kenya have also been identified as domains of support in the avocado value chain. Ward extension officers, the International Partnership Service (IPS), were identified as belonging to the bridging domains. Most of the funding for avocado farming in Kenya's Rift Valley region was provided by the local government, international development agencies and individual farmers. Local financial institutions played a minimal role in funding avocado innovation activities (MOALF and I, 2019).

Non-governmental organizations (NGOs) such as Agri-tech, Ever-grow, Sunculture, and the International Partnership Service (IPS) are primarily in charge of the

Table 3. Details of key stakeholders in the avocado value chain.

No.	Stakeholder	Position of Key informant	AIS Domain represented	Specific role
1.	Bio-farm	Research Manager	Support/Enterprise	Traders/advisory service
2.	Ever-grow Research	Market researcher	Supply/Market	Research/advisory/market
3.	Agri-Tech	Technical Officer	Bridging/support	Input supplier-organic manure
4.	International partnership service (IPS)- fertisoils	IPS field officer	Bridging /Enterprise	Input suppliers- organic manure/ferti-soils
5.	Sun culture irrigation	Programme Manager	Supply/Bridging	Input suppliers/irrigation equipment
6.	Kenya biologics	Lead specialist	Supply/Support	Input supply/pest and disease control
7.	Olivado	Agronomist	Supply/Market	Market/input supply
8.	Cis-mara avocado cooperative society (CMAF)	Programmes Manager	Demand/Supply/Support	Regulatory/research/advisory services/financial/market
9.	Water resource user's associations (WRUA)	Head of WRUA	Support/Supply	Regulatory resource use water/land conservation
10.	Horticultural Crops Directorate (HCD)	Regional director	Bridging/Support	Regulatory/policy on quality and export
11.	Ward Agricultural office	Extension officer	Bridging	Advisory services
12.	Community Forest Association (CFA)/ SOCOFONA	CFA chair Avocado farmer	Bridging/ Supply/Support	Advisory services/research/traders
13.	Sasini and Stabex Multi-National Company	Programme manager	Enterprise	Marketing avocado
14.	Mara Farm	Avocado farmer	Supply/Enterprise	Research information/marketing
15.	Water Resource Management Authority (WARMA)	Regional field officer	Demand	Regulatory on water provision
16.	Kenya Plant Health Inspectorate (KEPHIS)	Regional Field officer	Demand	Regulatory to control pests/diseases
17.	Horticultural Crop Research Institute (KALRO)	Horticultural Research Institute Centre director	Demand/supply	Agro-advisory / Research information
18.	Avocado seedlings suppliers (Isinya roses, local)	Enterprise manager	Supply/Enterprise	Input supplier -seedling/traders/
19.	Avocado farmer	Household head	Enterprise	Avocado grower/producer

Source: Author, 2022.

creation of improvements in water, organic fertilizer supply, and pest control for avocados (Krishnan, 2018). The supply domain includes organizations in the Upper Mara watershed that provide support and advisory services as well as financial assistance or credit to avocado farmers. They also help growers improve their avocado management procedures. Some of these field activities included disease and pest management programs, pruning, and best farming practices in general. As the exclusive developer of new and better irrigation equipment for farmers, IPS is regarded as the cornerstone of avocados in producing innovations to meet avocados' high-water demands (Krauss and Krishnan, 2022). Isinya Roses is engaged in the supply and sale of high-quality avocado seedlings, and it falls into both supply and enterprise domains. The supply domain was assigned to Mara Farm, CFA, WRUA and Olivado. Their primary function on the platform is to trade (buy) and provide advisory services, particularly market information and available funding opportunities for avocado farmers (Krishnan, 2018). Farmers grew their crops using superior Hass seedling varieties and, to a lesser degree, the Fuerte variety. Farmers collaborated directly with input service providers and avocado customers in the enterprise domain. Farmers' insufficient knowledge of ICT services was mentioned as one of the problems (Onuma et al., 2021). The selected farmers were introduced to such services through avocado farming initiatives led by supply domain players, namely Bio-farm and Olivado.

The intervention sought to introduce improved avocado variety production for export through innovative practices by farmers. Avocado growers cited the Mara Farm avocado activities and promotion as one of the strategies

from which they benefitted. Farmers reported that they are able to undertake avocado variety identification and farmer-based management strategies for maximum production because of their local knowledge and expertise. This might explain the growing body of research on farmer-led innovations, as indicated by Tambo and Wünscher (2018), Baliwada et al. (2017), and Dolinska and d'Aquino (2016). Having an innovation platform in which farmers have an important role can help them develop their skills. It also enables people to take an active role in the system rather than being mostly passive. This might lead to easier adoption and usage of technologies to boost profitability in the avocado value chain (Krauss and Krishnan, 2022). The input and output marketing function is a strong basis of the innovation system since it fosters system exchanges (Mekonnen et al., 2015; Onuma et al., 2021). Quality seedlings, organic fertilizers, insect traps with agrochemicals, irrigation equipment, and pruning tools were among the inputs provided. This provided avocado growers with assured markets, which might potentially spur the adoption of productivity-inducing technologies (Krishnan, 2018). One of the flaws in the operation of avocado market stakeholders has been identified as the issue of avocado harvesting dates. Avocado cooperative societies like CMAF and Berur cooperative society are making efforts to replace manual scales in the system with computerized ones (Krauss and Krishnan, 2022). This would ensure that farmers receive their dues, closing the trust gap between farmers and marketers even further. In addition to cooperative market involvement, the private enterprise platform helps market access advocated, as highlighted by Liverpool-Tasie et al. (2020).

Stakeholder network mapping in the community-based multi-stakeholder platform

Figure 2 shows that the avocado farmer and the Cismara avocado farmer cooperative society (CMAF) had the greatest links with some other stakeholders in the system, proving their critical triple role as the demand, support, and supply domains, and the avocado farmer as the enterprise domain. The avocado farmer cooperative society (CMAF) was the most significant stakeholder in the community-based multi-stakeholder platform, according to the network analysis. The Horticultural Crop Directorate (HCD) and the Kenya Plant Health Inspectorate Service are the platform's key players (KEPHIS). This suggests that they made more linkages than any other stakeholder in the multi-stakeholder platform based on community (Jaitiang et al., 2022. The bridging domain is occupied by International Partnership Service (IPS), which supplies ferti-soils and organic fertilizers, and the enterprise domain is occupied by avocado seedling suppliers (Isinya roses and local avocado nurseries), Biofarm (enterprise and support domain), ever-grow, olivado, and agri-tech (supply domain), and international NGOs. Private marketing companies in the agricultural commodity value chain, Sasini and Stabex, have few ties to farmers. Community-based organizations were among the stakeholders with the fewest ties (WRUAs, CFAs, irrigation equipment suppliers, main government agency, WARMA). Although KEPHIS is a key body in the interplay of avocado stakeholders, they are only connected to a handful of the main stakeholders, which explains why they are on the periphery, as seen in Figure 1. This does not indicate a weakness in the system, however, because multinational agricultural marketing corporations provide marketing help for valued agricultural commodities. There were more reciprocated than non-reciprocal links in the multi-stakeholder platform network. HCD, CMAF, IPS, Biofarm, avocado farmer, and avocado seedling suppliers had bi-directional links with each other in the support, supply, enterprise, and bridging domains. The multi-stakeholder platform network had more reciprocal than non-reciprocal linkages. HCD, CMAF, IPS, Biofarm, avocado farmer, and avocado seedling suppliers had bi-directional links with each other in the support, supply, enterprise, and bridging domains. Avocado farmers had a significant number of network linkages, but many of them were non-reciprocal, resulting in weak bidirectional linkages (Jaitiang et al., 2022). Government agencies such as WARMA, KALRO, and KEPHIS were on the network's periphery, confirming the report of MOALF and I (2019), on how devolved agricultural enterprises to counties continue to remain a major challenge in Kenya's agriculture, especially in exchange of relevant advisory information about the agricultural commodities to the smallholder farmer. Individuals that have several relationships form close-knit groups that communicate regularly and build shared standards. Because of power dynamics, cliques in each network might present possibilities and/or limits, as well as information about who is considered a group member (Spielman et al., 2010: Dowd et al., 2014; Seifu et al., 2022). Core stakeholders are those who have access to information or other network resources that can be used to advance their interests. This may have an impact on the integration of knowledge from various actors, particularly smallholder farmers, who are critical stakeholders in the adoption of new technologies (Eidt et al., 2012). The network position of avocado farmers can both provide opportunities and impose constraints on the adoption of climate-smart practices. As a systemic activity, innovation necessitates a network strategy that allows various players to engage in the process while combining their disparate expertise (Leeuwis and Aarts, 2011; Semeon et al., 2013). Farmers' current position in the multi-stakeholder platform suggests that they have limited influence over information and resources, as well as limited feedback, despite having many connections to other stakeholders, the majority of whom are in the

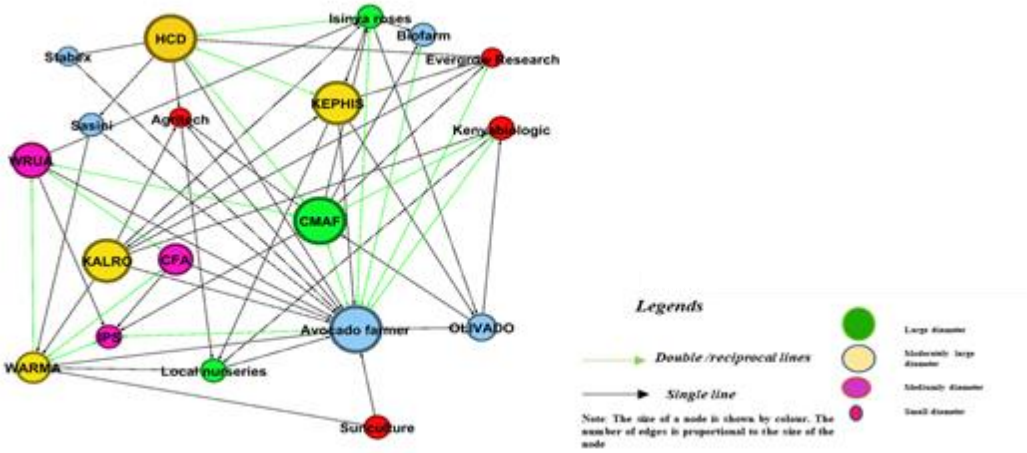

Figure 2. The avocado multi-stakeholder platform's network mapping.
Source: Author, 2022.

demand domain and are regulatory, which is not required for increasing adoption of climate-smart practices (Yamoah et al., 2020).

The SNA results revealed the edges in the network were 74 connections and nodes of 19 stakeholders in the avocado value chain. According to these findings, 15 of the 74 ties (20.27%) were reciprocated, indicating the existence of both outward (outward) and inward (inward) linkage, as indicated by the green lines in Figure 2. This suggests a low level of interaction among the stakeholders and a low density of 0.26 in the network. The size of nodes is also depicted on the network graph. The larger size of the nodes indicates the number of edges they have and turn the pathways of interaction and information exchanges among the stakeholders (Sparrow and Traoré, 2018; Liu et al., 2020). The colour of nodes represents the stakeholders either in the demand, support, bridging, enterprise (marketing), and support domains in the classification of the avocado value chain stakeholders. Although the players were linked for a number of reasons and to varying degrees, knowledge appears to be the fundamental commodity that linked them (Yamoah et al., 2020). It is stated in this respect that information sharing is incorporated into the interactions that occur among players, and that this is the major mechanism through which networks impact and shape innovations, which accords with Ramirez (2013) work on network actor interactions (Bisseleua et al., 2018). The kind of actor connections existed in the avocado value chain process since the type of information communicated varied with actor groups and the unique function of the stakeholder. The information flow in the avocado value chain follows similar network approaches as argued by Friedman et al. (2022) and Nkwake, (2019), with agricultural system context in relation to the agricultural value chain. The network metrics of centrality were utilized to identify influential actors such as the CMAF, HCD, KEPHIS, KALRO, and WARMA and reflect on their effects on the diffusion of innovation/information through the network. The network density and size also reveal how formal and informal networks are linked similarly pointed out by Siddo et al. (2018), allowing specific nodes, particularly experienced avocado growers, to disseminate information from formal groups such as advisory service providers, as demonstrated in a similar situation in India (Nidumolu et al., 2020). Finally, network interactions were employed in this study to better explain disparities in access to agricultural information in the avocado value chain, where the information flow was a close-knit structure amongst members of the smallholder farmers. Similarly, Hoang et al. (2006) highlighted the significance of family, political standing, and land ownership in determining whether people are well-linked in communities and with extension or development initiatives that include training. Dympep et al. (2019) demonstrated how farmer-to-farmer climate-smart agricultural dissemination networks link with persons of the same gender or with comparable socioeconomic attributes.

Power relation in the avocado multi-stakeholder platform

The degree of centrality reveals how many nodes are connected to the node (Beaman and Dillon, 2018). This gives the most basic indicator of significant nodes and shows which nodes supply the most information. The centrality of betweenness denotes the proportion of shortest paths from all pairs of nodes connected to that node (Jaitiang et al., 2022). These are the centrality metrics, which represent a node's influence in the network as well as the node's function in enabling communication or acting as a bridge. The network

Table 4. Network centrality measures in the avocado multi-stakeholder platform.

Stakeholder	In-degree	Out-degree	Degree	Closeness	Betweenness
Ever-grow Research	0.07	0.01	0.04	0.36	0.00
Isinya Roses	0.04	0.03	0.04	0.45	33.5
Local Nurseries	0.01	0.03	0.02	0.43	1.78
Kenya Plant Health Inspectorate Service (KEPHIS)	0.04	0.10	0.07	0.59	43.67
Horticultural Crop Research Institutes (KALRO)	0.01	0.06	0.06	0.59	2.45
Water Resource Management Authority (WARMA)	0.10	0.03	0.08	0.43	17.15
International Partnership Service (IPS)	0.07	0.03	0.05	0.41	9.167
Sun-culture	0.00	0.07	0.01	0.41	0.00
Water Resource Users Association (WRUA)	0.04	0.07	0.06	0.47	10.42
Community Forest Association (CFA)	0.03	0.06	0.04	0.43	0.00
Agritech	0.06	0.01	0.04	0.36	0.00
Kenya biologic	0.06	0.03	0.04	0.41	0.50
Biofarm	0.04	0.03	0.04	0.45	13.00
Stabex	0.01	0.01	0.01	0.38	0.00
Olivado	0.03	0.04	0.04	0.43	0.87
Avocado farmer	0.25	0.11	0.18	0.55	162.70
Sasini	0.01	0.03	0.02	0.43	2.25
Horticultural Crop Directorate (HCD)	0.04	0.11	0.08	0.63	48.87
Cis-Mara Avocado Cooperative Society (CMAF)	0.07	0.11	0.09	0.61	51.68
Graph density	0.26				
Average weighted degree	3.90				
Modularity	0.16				
Network diameter	5				

Source: Author, 2022.

centrality measures shown in Table 4 indicate that the Cis-Mara Avocado Cooperative Society (CMAF), the avocado farmer, and the Horticultural Crop Directorate (HCD) in the Upper Mara watersheds had the highest out-degree score of 0.25, and Betweenness values of 51.7, 48.9, and 162.7 respectively, therefore more high level of influence. The avocado farmer had the highest in-degree of 0.25 (25%) meaning they received more information than any other stakeholder (Jaitiang et al., 2022). The avocado farmer, CMAF, and HCD in the avocado value chain are the most powerful because they control more interactions with other stakeholders. As compared to stakeholder classification as shown in Table 4, these stakeholders occupied four domains of the avocado multi-stakeholder platform, namely, producers, regulatory, financial services, and export or market regulations. Furthermore, as illustrated in Figure 1, the avocado farmer is seen as the bridge between the producer and consumer because they are the main player in the value chain and have a higher in-degree compared to other stakeholders. HCD, as the bridging domain, is also the most visible in the agricultural value chain since they get the majority of interactions with other stakeholders rather than individual farmers (Suchiradipta and Raj, 2015; Siddo et al., 2018). Farmers use a variety of information outlets. These portfolios, however, might differ in terms of composition and the degree of connectedness across information sources. While weighted degree centrality of 3.90 assesses the source of information farmers get and consider beneficial, betweenness centrality emphasizes how linked an information source is across the network and its ability to broaden the scope of information flows (Gumucio et al., 2020). A one-size-fits-all information offering is unlikely to suit the information demands of all stakeholders in the avocado value chain.

Although the avocado farmer was crucial in the knowledge reception from other stakeholders, they had less negotiating power owing to their low organization and capacities to decide premium avocado pricing. This necessitated the need to collaboratively exchange fresh expertise, create durable partnerships, and acquire essential market information from other actors in order to increase stakeholder interaction effectiveness. Mashavave et al. (2013) showed that better vertical linkages and information flow channels to farmers can considerably enhance their decision-making skills. Phelps et al. (2012) and Semeon et al. (2013), agree that powerful individuals have greater access and control over valuable information flows, offer positive signals, and can influence network performance. In the avocado multi-stakeholder platform, group cohesion and information

dissemination are important, with the farmer acting as a bridge to all other connections. The closeness centrality for the avocado farmer was 0.55 but it was lesser with stakeholders that occupy the demand and support domains such as HCD, CMAF, KALRO and KEPHIS as shown in Figure 1. This shows that group cohesiveness promotes interactions and connections in avocado value chain networks centred on the avocado farmer, which is consistent with Uckert et al. (2017) and Ingram et al. (2020), results on interaction in agricultural value chains. The avocado farmer is a key factor in the agricultural value chain, and Weyori et al. (2018) explored this function as a focus farmer for their study on agricultural innovation systems and farm technology adoption. They observed that focal farmers functioned as a link between other stakeholders in the value chain, particularly those in different domains for information sharing. High closeness centrality can signify important roles in the avocado value chain's demand domains for communication (Lubell et al., 2017), as well as in determining network flow (Zhang and Luo, 2017). The domains of supply, support, and bridging were thought crucial to not just supplying but also spreading knowledge among farmers (Eidt et al., 2020). These primary information sources may wield significant power and impact the sort of information that is needed and trusted (Borgatti et al., 2009). High betweenness ratings were utilized to connect information from the informal farming community to more formal sources such as the media. One disadvantage of this method of information sharing is that it relies on proper interpretation and communication among many different farmers rather than a single reliable source (Lubell et al., 2017).

The International Partnership Service (IPS) and agric-tech (support and enterprise domain) were key stakeholders in the avocado value chain, owing to their active involvement in avocado farming as input suppliers, primarily organic fertilizers. Policy stakeholders in the support and demand domains, such as KEPHIS, WARMA, HCD, and CMAF, as well as advisory service providers, might operate as a link between all relevant stakeholders in the value chain, such as Bio-farm, Olivado, WRUA, and ward agricultural extension officers. The extension (bridging domain) and researcher entities were also included in the avocado innovation system (supply domain). An examination of the avocado value chain revealed that the innovation platforms' knowledge-sharing mechanisms were poorly defined, and information seeking was focused on function rather than a domain. In terms of information exchange, the key influencers were stakeholders who had several roles to play and held influential positions (Sinah and Oladele, 2016). As indicated in Table 4 (closeness), the networks under research had less than a 10% degree of cohesiveness on average, which has consequences for information flow and collaborative innovation. Munthali et al. (2018) concur that low degrees of cohesiveness in networks has implications for information flow and partnerships along the agricultural value chain. Wood et al. (2014) and Bisseleua et al. (2018) observed comparable results, indicating that stakeholders with homogeneous relationships build their networks more quickly than those with loose ties. They also highlight the formation of dense networks by social peers who produce a broad consensus.

Consequently, this quantitative measure, Table 4, supports the qualitative assumption that the agricultural commodities innovation system begins with agricultural research center activities (Mwambi et al., 2016; Eidt et al., 2020). The network's peripherals included NGOs, local financial institutions, research institutes, HCD, KEPHIS, and ICT service providers in their respective fields. Similarly, Krishnan (2018) described the research as vital to the agricultural innovation system but suggested that it required a closer interaction with policy actions and other stakeholders. The removal of Bio-farm, Olivado, and Isinya Roses (NGOs) from the supply domain, as well as extension services and farmer groups from the bridging domain, would result in weaker links. As seen by their high level of Betweenness in relation to other stakeholders, they may concentrate on their own duties rather than a shared interaction role in the system. Avocado growers are important to the framework of the avocado multi-stakeholder platform, and without them, other stakeholders would be lost. According to Spielman et al. (2010), farmers and NGOs are possible sources of structural gaps in agricultural innovation systems. This might explain why smallholder farmers have little effect on the innovation system, even though they are critical to its operation.

Social, economic, and policy environment of the avocado stakeholders in Kenya

Bilateral trading agreements and contracts: Kenya has taken major strides to lower entry barriers into foreign markets through expanding trade, with a focus on regional trade agreements with the East African Community (EAC), the Common Market for East and Southern Africa (COMESA), and the European Union (EU) (Grant et al., 2015). Cross-border trade regulations continue to be a market entry barrier that impacts suppliers' participation in domestic markets. This is because of their influence on raw material imports and closeness to markets impacted by infrastructure problems (Kamau et al., 2019). Besides key trade agreements, The Ministry of Agriculture, Livestock, and Fisheries (MALF) is present in the horticulture sector and provides extension and advisory services for production support to smallholder farmers; however, delivery of these services has been reported to be weak and frequently unavailable to farmers in rural areas (Grant et al., 2015; Eidt et al., 2020). KenyaGap and GlobalGap

are collaborating to increase the acceptance of Kenyan products in the global export market (Grant et al., 2015). Kenyan avocado should only be exported from farms certified by the Horticultural Crop Directorate (HCD) and the Fresh Produce Exporters Association of Kenya (FPEAK) to fulfil minimal international criteria under the scope of these initiatives (Ibid). Avocado farmers in Kenya must compete in a global market controlled by stringent safety and social accountability criteria. The expense of developing and maintaining compliance and certification for both manufacturers and exporters favors bigger companies over small and medium-sized organizations (SMEs). However, the HCD has begun to play a larger role in ensuring quality compliance. The HCD has imposed verification requirements on Kenyan supermarkets and intermediaries (registered brokers) that supply Kenyan supermarkets, comparable to those imposed on exports to EU markets. This was done to strengthen traceability requirements and increase the number of written contracts distributed to farmers so that they could arbitrate contractual risk (Waarts and Meijerink, 2010). Furthermore, Kenyan supermarkets leverage improved product quality as a comparative advantage to offer their items regionally through their chains and subsidiaries throughout East Africa. Avocado producers were also given assistance, such as training, from the sub-county, county, and community institutions (Krishnan, 2017). The avocado value chain was mapped, and three main stakeholders were chosen to extract both interview and farm-level data to construct a universe of avocado farmers: national governments, regional supermarkets, and community members. The regional market expansion also gives an additional option to diversify markets, lowering reliance on export markets (Evers et al., 2014). According to the findings, avocado producers earn significantly more than farmers selling at wet marketplaces (Hermans et al., 2017; Krishnan, 2017). While this is a great development for farmers, the growing need for conformity to regional norms may result in market marginalization and exclusion.

Low-capital-interest microfinance loans from local banks to support avocado farming: Access to financial services and financing is a persistent difficulty for small-medium-sized enterprises (SMEs) and rural firms across Kenya. Access to finance is critical in assisting SMEs to overcome liquidity challenges, allowing them to expand their development and investment prospects (Beck et al., 2005; Morsy, 2020). When financial services are available in many areas, they are dominated by unlicensed money lenders who may take advantage of the market gap by charging exorbitantly high-interest rates (Mullineux and Murinde, 2014). Microfinance institutions (MFIs) and mobile banking have been used to bridge the financial gap for individuals who have been financially excluded, mostly agricultural commodities, particularly avocado value chain stakeholders (Napier, 2011). To lower bank credit risk for lending to high-risk groups, microfinance and other inclusive financing schemes are frequently supported by government loan guarantees (Mullineux and Murinde, 2014). This strategy enables customized loan guarantees to be tailored to certain economic sectors, with a focus on social programs, notably for historically marginalized smallholder farmers and disadvantaged urban regions. Despite the efforts of these institutional programs, avocado producers continue to confront access to finance and credit issues (Ibid). Avocado producers were linked to commercial banks and financial non-governmental organizations for technical support on financial management difficulties as well as loan availability. Farmers secured loans from farmers' cooperative associations using their avocado yield as collateral. Banks would issue overdraft loans in installments, but only when groups or individual members of groups achieved defined levels of output. However, the collateral management system was only seen in large-scale avocado fields. Farmers said they should have deposited the agreed-upon sum from each avocado transaction. The study also revealed that, because of better financial management skills, some farmers were able to secure loans from other commercial banks, including Kenya Commercial Bank (KCB), National Bank of Kenya (NBK), and Equity Bank. Improved engagement between avocado producers and institutional financial institutions has resulted in improved access to financial services and connections in the counties that practiced avocado growing. The technical help offered to individual farmers in the form of bankable business plans created confidence among the parties, resulting in access to financing for avocado investment.

The Kenyan government has devoted greater resources to expanding assistance and investment options for SMEs to stimulate the development of shared value initiatives and strategic agri-business strategies. SMEs have been shown to boost profit margins for smallholder farmers as compared to exporters, making this channel vital for the country's huge farming population's economic development and livelihood security. To assist SMEs and avocado farmers, the potential of mobile technology, e-commerce, agronomic knowledge intensification methods (especially addressing harvest losses) and enhancing value chain efficiency should be highlighted. Kenya has emerged as a hub for telecommunications innovation, with mobile phone-based financial services playing an important part in the country's overall economic growth (Kimenyi et al., 2015). Kenya has some of the highest rates of internet connectivity in Sub-Saharan Africa. The advent of 4G/4G LTE connections has made e-commerce, e-based services, and other technologies more accessible (Kenyan Market, 2019). Mpesa, a mobile phone-based money transfer system introduced in 2007 and now used throughout Kenya, has altered the business scene (Gikunda et al., 2014). M-Pesa has resulted in the

establishment of jobs, access to credit, the generation of revenue, and the formation of social capital among families and friends. M-Pesa has also spawned several more mobile phone-based technologies. The creation of M-Farm gives up-to-date market pricing and information directly to high-value crop stakeholders via an app or SMS. The program also links farmers directly with purchasers, bypassing the traditional intermediary (Solon, 2017). Many farmers' adoption of this technology will most certainly alter the transparency and information accessible to avocado producers across the country, as well as the flow of products.

Policy information pathway to support avocado-farmers activities and livelihoods: Kenya's government has been pushing private-sector participation to integrate smallholder farmers into inclusive and sustainable value chains. As a result, the presence of significant international firms operating in the avocado value chain has increased. In 2010, the Bill and Melinda Gates Foundation collaborated with Techno Serve to integrate 50,000 smallholder avocado, mango, and passion-fruit producers into processing businesses (Grant et al., 2015). However, it is vital to recognize that supply chain integration can result in path dependence, in which various partners along the supply chain become dependent on one another (Mutonyi et al., 2018). Land ownership in avocado-growing areas is frequently on ancestral land, which has resulted in small plots due to subdivision for ownership, or communal and collaboratively managed land that lacks formal land titles. According to Grant et al. (2015), without land tenure, investors have difficulties acquiring or leasing land for extended periods of time and consequently have problems getting credit from banks to secure returns on investment. According to Ros-Tonen et al. (2019), market integration development attempts might have 'adverse inclusion' concerns where the structural market, tenure circumstances, and farmers' limited access to assets can lead to avocado value chain involvement without material profits and buildup. Kenya's micro, small, and medium-sized enterprise (MSME) service blueprinting will be determined by whether the counties provide an enabling environment and make the licensing procedure simple and affordable. The Kenyan Constitution assigns county governments' trade development and regulation tasks, such as markets, trade licenses, and fair-trading practices (KIPPRA, 2013). Small and medium-sized enterprises (SMEs) play an important role in achieving the SDGs, particularly in agricultural value chains, the promotion of inclusive and sustainable economic growth, the creation of employment and decent jobs, the promotion of sustainable industrialization and fostering innovation, and the reduction of inequality (OECD, 2017).

However, processor SMEs have several obstacles, such as limited innovation and product development, inability to access both domestic and international markets, inability to get inexpensive funding, and arduous and lengthy processes in quality standards and certification (KAM, 2019). Furthermore, they confront limited market access, which limits their growth and competitiveness and is passed on to resource-poor smallholder farmers who rely on agriculture. Some affirmative action and targeted interventions by government policies might help them gain market share (OECD, 2017; KAM, 2019).

Conclusion

Avocado farmers, an enterprise/marketing domain network, were more closed and conservative, with information largely being supplied and received within the same organizations. The study highlighted how much of a platform's power is captured by a few stakeholders; highlighting the distinction between highly cohesive information exchange platforms and more open networks. A high network betweenness centrality might suggest a proclivity to establish tight groupings and trust. The overlapping of a highly centralized supply, demand, and support domain network with a more open bridging domain network showed information bridging across several sources. This has ramifications for avocado value chain operations in the sense that growers with diversified connections may be able to address their vulnerabilities more effectively.

Policy and access to information, knowledge and resources will be critical in promoting avocado by farmers. An ideal approach would include feedback mechanisms so that producer organizations may demand innovations and evidence supplied by research organizations. Strengthening and empowering farmers, advisory services, and marketing organizations is crucial for the adoption and application of inclusive innovations along the avocado value chains. Farmers, not just users, should be acknowledged as major actors that create breakthroughs. Farmers' engagement in the avocado innovation platform should be carefully considered during the planning process. Extension and policymakers should be key in the overall governance since they have the ability to link many parties. Private sector engagement, particularly in non-governmental groups, should be promoted. This is the first research to use the SNA technique to examine the avocado value chain in Kenya. Farmers' and extension actors' roles and effectiveness in the innovation system, as established in previous studies, are underscored. Private sector entities may play a vital role in fostering deeper and more collaborative relationships among avocado multi-stakeholder platform participants.

RECOMMENDATIONS

Smallholder farmers should be empowered via improved training and education so that they can influence the

development of agricultural value chains and environmental sustainability. For a more robust agricultural research system, researchers should collaborate more with intermediate, enterprise, and support service or domain stakeholders, as supported by suitable regulations. This study recommends that using a system's approach to innovation could have profound implications on how we interact with information flows or channels. When dealing with power imbalances and deciding the amount to which various stakeholders engage in the process, it is vital to pay particular attention to context. According to the theoretical implications of this study, using the system approach to develop innovations could have significant implications for our understanding of human society.

According to a study on innovation system thinking, diversity and interactions are critical in the agricultural value chain process and environmental sustainability. This study adds to the body of knowledge on agricultural systems approaches and community-based studies for rural development.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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