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SOCIAL NETWORK OF KNOWLEDGE SOURCES AND INNOVATION BETWEEN GENERATIONS FOR CORN ECOLOGICAL SUSTAINABILITY IN GORONTALO REGENCY, INDONESIA

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Abstract: Knowledge and technology are one of the main keys to agricultural innovation. However, the availability of knowledge as the basis for innovation must be accessible to farmers easily and sustainably. This study aimed to find out the knowledge sources of farmers and how the social network of innovation develops corn farming, especially in the cultivation, processing, and marketing aspects. This study used the grounded theory method through in-depth interviews and then processed using open, axial and selective coding. This study involved26 farmers, consisting of 12 old farmers (46-65 years old) and 14 young farmers (25-45 years old). The novelty of this study is how intergenerational social networks and access to innovation were used to identify social networks as sources of the invention for both young and old farmers in corn farming practices that have been ecologically sustainable. Based on the results, there were differences in knowledge sources and social network innovation between old farmers and young farmers for corn ecological sustainability. Old farmers had the main source of local and traditional knowledge from previous generations, while young farmers had the main source of knowledge from a combination of local and modern knowledge with innovations from various actors and institutions through social media in developing corn farming.

Keywords: Social Network, Knowledge Sources, Innovation, Ecological Sustainability.

Introduction

Social network among farmers has a significant role in the exchange of knowledge and innovation in agriculture. The social network of farmers can increase the amount of information and knowledge exchange from different networks of farmers (Skaalsveen *et al*., 2020). Skaalsveen *et al*., (2020) found that intermediary farmers have a very important role because intermediary farmers are seen as having a high level of knowledge and experience in the social network of farmers. The importance of intermediary farmers is following the study on innovation adoption by Wood *et al*., (2014) where farmers take information and ideas from other farmers.

Social networks in agriculture are related to knowledge because social relations between farmers are very important for the development of knowledge sharing among farmers (Tsouvalis *et al*., 2000). Based on previous studies, knowledge focused on individuals as the main actors to solve the problems of farmers, but in further developments, the role of other actors (workers, partners and family members, advisors and officials) acts as knowledge sources for farmers (Thomas *et al*., 2020). According to Wójcik *et al*., (2019), the difference in classification between knowledge sources will not hinder the interaction process, because the formation of knowledge sources is very complex and closely related to place, environment, local knowledge, culture and regional economy. According to Lwoga *et al*., (2010), the participation of the community and the environment in knowledge creation aims at sustainable agricultural development, because knowledge creation continuously will distribute and share knowledge within and outside the

community so that ultimately there will be integration between technology, innovation, and new agricultural knowledge.

Cofré-Bravo *et al*., (2019) stated that innovation in agriculture requires access to resources such as knowledge, finance, training and emotional support and even support from actors such as peers, advisors and researchers. According to Ribot & Peluso (2003), access is all ways of supporting a person to benefit from various things. Access to resources to produce agricultural innovation is influenced by social networks because agricultural innovation is a diverse system involving many actors from the public, private, and civil sectors, so these innovations can bring new ideas, practices, and products into the agricultural system of diverse all farmers (Klerkx *et al*., 2012; Spielman *et al*., 2011). Knowledge is embedded or intentionally created to support and assist innovation to provide knowledge relevant to other resources (Mc Fadden, 2016; Klerkx *et al*., 2012; Van Rijn *et al*., 2012; Hilkens *et al*., 2018).

Other relevant factors in the social network of farmers, which constitute the primary topic of this research, are knowledge sources based on knowledge co-production and knowledge co-creation since the topic is a determining factor for collaboration between local knowledge which is typically obtained from farmers' experience and scientific knowledge. In such cases, a knowledge gap often exists, and farmers require assistance from other individuals to take advantage of knowledge sources. This is in line with findings by Arifah *et al*. (2023), active participation as a joint effort and collaboration between farmers and stakeholders, in this case, policymakers, farmers, and institutions development, determines the success of knowledge co-production-based knowledge source. The knowledge source based on knowledge co-creation is the impact of repeated interactions and knowledge sharing between farmers resulting in a new peasantry, this is following the research findings by Tolinggi *et al.,* (2023), that the sustainability of coconut farming is due to the results of knowledge co-creation from the engagement between old and young farmers.

Corn is a socio-ecological commodity in Gorontalo because historically, corn has been cultivated for decades in Gorontalo and even nationally, Gorontalo is included in the 10 (ten) contributors to national corn production. In 2002, the Gorontalo Provincial Government made corn one of the regional superior commodities (NSLC, 2018) but the superiority of corn commodity in Gorontalo has not been fully accompanied by the adoption of technological innovations by farmers in the management of corn crops. This is in line with a study by Sumarno & Hiola (2017) that the adoption of innovation by farmers towards the technology component of integrated corn crop management in Gorontalo Regency has not been optimal in both low- and high-land agroecosystems.

Furthermore, Sumarno & Hiola (2017) stated that increasing access to sources of technological innovation can be performed by increasing the frequency of outreach and dissemination of technology to all farmers. Cofré-Bravo *et al*., (2019) found that in the innovation process, farmers are always looking for the latest innovations and technologies to avoid risks so that farmers apply proven technology more to their agricultural practices. However, Cofré-Bravo *et al*., 2019) did not explore further the relationship between the social network of knowledge sources and innovation with the ecological sustainability of commodities. This study focused on identifying sources and innovations for old farmers and young farmers for corn ecological sustainability, especially in the cultivation, processing, and marketing aspects, hence, this research is crucial in providing a better understanding of who the sources and innovators of knowledge are as well as how social networks between old and young farmers are formed regarding these aspects of cultivation, processing, and marketing concerning the sustainability of corn farming.

This study's findings are consistent with earlier studies in that social networks between actors are necessary for access to innovation.

The study differs from other research in that it describes how older and younger farmers access innovation differently through social networks and discusses how this access relates to ecological sustainability in farming methods across generations.

Materials and Methods

This study used a qualitative research approach with grounded theory and exploratory methods (Corbin & Strauss, 1990). This method was chosen to guide data collection to provide a more profound understanding of the social network, knowledge sources, access to innovation, and other actors for corn farming sustainability.

The samples of this study were old farmers and young farmers on the coconut-corn intercropping farm. This study used the Badan Pusat Statistik category with old farmers aged 46-65 years and young farmers aged 25-45 years. The samples were distributed over 3 sub-districts in Gorontalo Regency, namely Bongomeme Sub-District, Tibawa Sub-District, and Pulubala Sub-District (Figure 1).

The researcher interviewed 26 farmers as research informants consisting of 12 old farmers and 14 young farmers (The author adds five statements of informants to support references in the discussion about the ecological sustainability of corn from old and young farmers in underpinning the revision of point five of the reviewer comments). The selection of farmer informants was purposeful by choosing farmer group administrators to be interviewed. The farmer group administrators were selected based on several considerations, information, and recommendations from several parties, including extension workers, village government officials, and development program assistants. Next, once no more information was relevant to the research theme, the researcher stopped interviewing informants/data saturation and gathering data.

This number refers to the saturation criterion by Corbin & Strauss (1990) where the interview ends or is terminated if no new information emerges (Cofré-Bravo *et al*., 2019). Researchers phoned the farmers who wanted to be interviewed, and after the

Figure 1: Location map

respondents agreed, researchers then conducted the interviews face-to-face. The interviews were started with open-ended questions and then structured questions according to the topic. All answers were recorded and transcribed for a duration of 30-75 minutes. Researchers also asked old farmers and young farmers about knowledge sources and access to social network innovation.

Data were analyzed with open, axial and selective coding referring to Corbin & Strauss, (1990). In open coding, researchers identified and looked at the answers from informants to assess whether or not they were related to the study in the form of transcription notes and coded according to relevant concepts. After the open coding, the data were analyzed with axial coding to generate categories. According to Bertolozzi-Caredio *et al*., (2020) axial coding was processed through deletion, purification, and integration, so that the resulting data were more comprehensive and meaningful. According to Corbin & Strauss (1990), in the axial coding stage, data were linked with subcategories, tested with other data and linked between categories. In the final stage, researchers conducted selective coding by presenting the results of interviews by building these sub-categories according to the focus of the study (Salman *et al*., 2021). Researchers used the UCINET 6 application version 6.746 to see the network structure of knowledge sources and innovations from old farmers and young farmers in corn farming distinguished by cultivation, processing, and marketing aspects.

Results and Discussion

Social Network of Knowledge Sources between Old Farmers and Young Farmers

There were differences in knowledge sources between old farmers and young farmers in corn farming. Differences in knowledge sources are categorized into three aspects namely cultivation, processing, and marketing aspects. Differences in knowledge sources between old farmers and young farmers in corn farming are presented in Table 1.

Cultivation Aspect of Corn Farming

Knowledge sources in the cultivation aspect of old farmers and young farmers had differences. Old farmers generally get knowledge of corn cultivation and farming from previous generations (parents, relatives), regional agricultural leaders (panggoba), heads of farmer groups, and extension officers. This is the following interview with old farmers:

> *I got a lot of knowledge on how to grow corn and coconuts from my parents, I also learned from Panggoba and agricultural extension workers (YP, Corn and Coconut Farmer, number 9).*

> *I got agricultural knowledge from my parents, members of farmer groups, and some from panggoba or people considered to have local knowledge, especially astrology (UH, Corn Farmers, number 19).*

Table 1: Knowledge sources between old farmers and young farmers in corn farming

Aspect	Differences in Knowledge Sources	
	Old Farmers	**Young Farmers**
Cultivation	Parents from generation to generation, Panggoba, Relatives, Head of Farmer Groups, and Extension Officers.	Relatives, Extension Officers, Agricultural Offices, Universities, BPTP Researchers, Online Media (YouTube), and Distributors of Fertilizers and Seeds.
Processing	Parents from generation to generation.	Bank Indonesia, Koperindag, Universities, Online Media (YouTube), Food Office, Corn SMEs.
Marketing	Collector farmers, relatives, and heads of farmer groups.	Corn SMEs, corn factories/entrepreneurs outside Gorontalo, Online Media (WhatsApp group), and Associations.

Source: Primary data processed from research informants, 2021.

I got knowledge on how to grow corn from my parents and relatives of fellow farmers, then I combined it with the knowledge I got from agricultural extension workers (OP, Corn Farmer, number 4).

Young farmers have a variety of knowledge sources regarding corn cultivation from various parties including. Gorontalo BPTP researchers, universities, extension workers, online media (YouTube), Regency and Gorontalo Province Agricultural Offices, fertilizer and seed distributors. These are the results of interviews with young farmers:

I learned how to grow corn from farmers who are my relatives in this village. At first, I used the regular planting system, but now I've used the jajar legowo system, I saw a lot of information from YouTube, and the results from the legowo system were pretty good. I also learned about corn cultivation techniques from Youtube, such as how to trim the leaf branches during the fertilization process, I trim the leaves at the bottom of the stem so that the nutrients go directly to the corn fruit. Students from UG and UNG have also carried out corn farming counselling in this village (AM, Corn Farmers, number 14).

Sources of knowledge on processing, seeding, and fertilizing corn were obtained from seminars and training conducted by the Regency Agriculture Office for 2 weeks in 2007. In 2018, researchers from BPTP once made a corn demonstration plot here. Farmers group members and I also learned a lot about corn cultivation, especially planting techniques, corn varieties, and how to control pests and diseases (MG, Corn Farmers, number 13).

I learned agriculture from extension workers, I also participated in many trainings, through comparative studies funded by the Provincial Agriculture Office, fertilizer and seed distributors, I also attended the training which I paid for myself (AW, Corn Farmer, number 17).

The social network of knowledge sources of old farmers and young farmers in the cultivation aspect of corn farming can be seen in Figure 2.

Based on Figure 2, old farmers (P4, P9, and P19) had knowledge sources on corn cultivation from parents, panggoba, and farmer groups, while young farmers (P13, P14, and P17) had

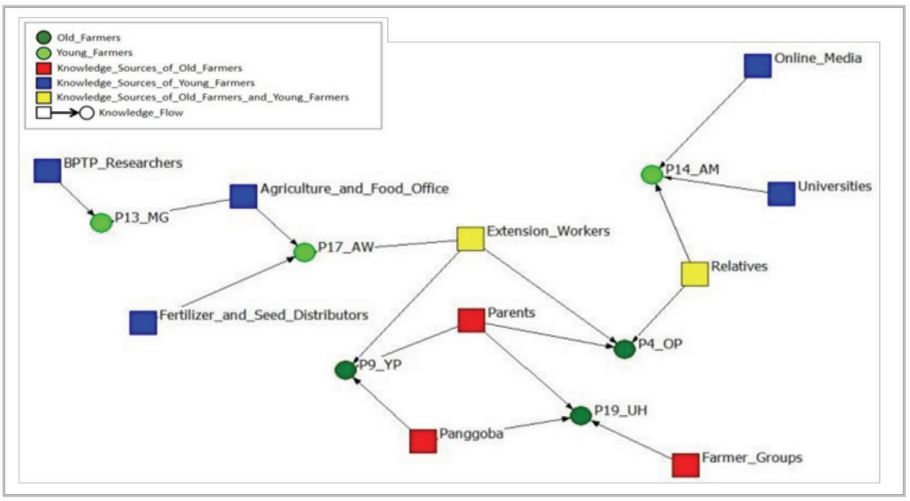

Figure 2: The social network on knowledge sources of old farmers and young farmers inthe cultivation aspect of corn farming

knowledge sources from BPTP researchers, Agriculture and Food Office, fertilizer and seed distributors, universities, and online media. Extension workers are still becoming knowledge sources for old farmers and young farmers.

Processing Aspect of Corn Farming

Knowledge of old farmers on corn processing only comes from parents from generation to generation. Corn processing is only for consumption needs, where corn is boiled with lime sothat the corn is softer to be consumed in addition to being grilled. This is an interview with old farmers:

> *I My wife uses lime to boil corn so that the corn is not hard when consumed, this knowledge comes from our parents (YL, Corn and Coconut Farmer, number 20).*

> *My parents taught me to make boiled and grilled corn, usually using grated coconut mixed with papaya leaves or banana blossoms, sliced chillies, and onions (MP, Corn and Coconut Farmer, number 2).*

Young farmers gain knowledge about processed corn with commercial and selling values, including corn flour, corn pie, corn sticks, and corn pastels. The main knowledge sources were Bank Indonesia, Recy and Provincial and Regency Cooperatives, Industry and Trade, Universities, online media (YouTube), Food Offices, and Corn SMEs. These are the results of interviews with young farmers below:

> *I got knowledge on manufacturing processed corn into corn flour from the Regency and Provincial Koperindag, cooperation with Bank Indonesia, including training in making corn flour conducted by Universitas Negeri Gorontalo lecturers (JF, Corn Farmer, number 18).*

> *I process corn into corn stick products. I first learned from YouTube, and after that, I took part in the training conducted by the Regency Food Office after I joined the SMEs (MD, Corn Farmer, number 10).*

Knowledge sources of corn farming processing between old farmers and young farmers canbe seen in Figure 3.

Based on Figure 3 old farmers (P2 and P20) had knowledge sources on corn processing from parents, panggoba, and farmer groups, while young farmers (P10 dan P18) had knowledge sources from Corn SMEs, Agriculture and Food Office, universities, online media, and Bank Indonesia.

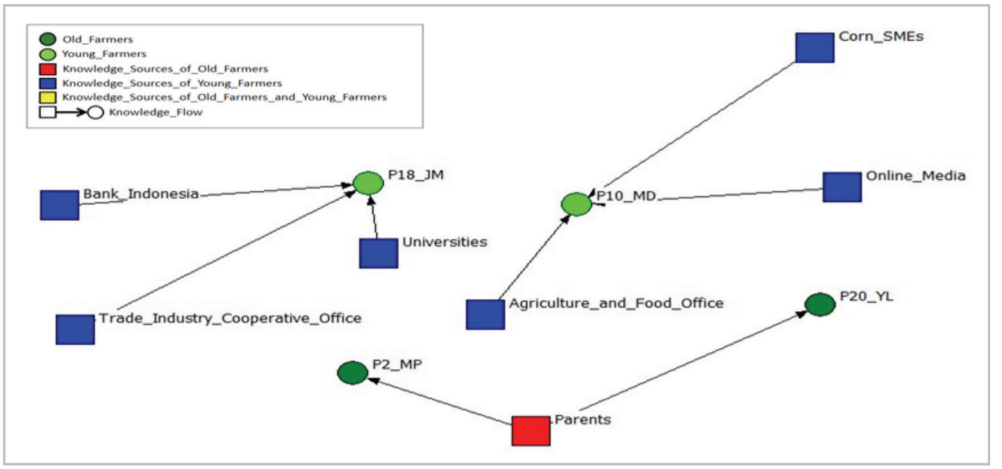

Figure 3: Social network on knowledge sources of old farmers and young farmers in processing aspect of corn farming

Marketing Aspect of Corn Farming

Corn marketing between old farmers and young farmers is different due to differences in knowledge sources. Knowledge sources of old farmers in corn marketing come from collecting traders, and heads of farmer groups, this is the interviews with old farmers:

> *I received information on corn prices from farmer groups (YL, Corn and Coconut Farmer, number 20).*
>
> *I learned about corn marketing information from who is also a member of a farmer group in a neighbouring village. I sell my harvest to collectorsto save on transportation costs (AH, Corn Farmer, number 19).*

Young farmers have high motivation to market corn outside Gorontalo because it has a significant price difference between corn prices in Gorontalo such as Makassar and Surabaya. This knowledge comes from corn SMEs, corn entrepreneurs outside Gorontalo, online media (WhatsApp group), and corn entrepreneur associations. These are the results of interviews with young farmers.

> *I got information directly from corn factories in Surabaya and Makassar because prices are higher than in Gorontalo, (AW, Corn Farmer, number 17).*
>
> *Marketing information for corn flour and corn pie is obtained through WhatsApp groups, associations, SMEs, and entrepreneurs of processed corn products from outside Gorontalo, namely Manado, Makassar, and Jakarta… (JF, Corn Farmer, number 15).*

The social network of knowledge sources of old farmers and young farmers in the the marketing aspect of corn farming can be seen in Figure 4.

Figure 4 exhibited that old farmers (P20 and P19) had knowledge sources on corn marketing from collecting traders, and farmer groups, while young farmers (P15 and P17) had knowledge sources from online media, corn SMEs, associations of corn farmers and entrepreneurs from outside Gorontalo.

The difference in knowledge sources between old farmers and young farmers in the cultivation, processing, and marketing aspects of corn farming is an interesting phenomenon. In general, knowledge of old farmers is considered traditional local knowledge sourced from parents, relatives, and panggoba from generation to generation combined with

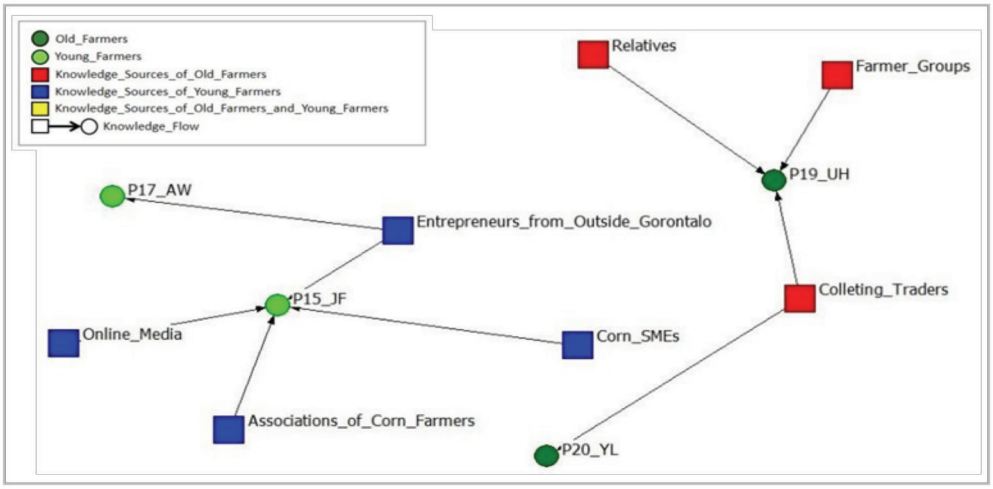

Figure 4: Social network on knowledge sources of old farmers and young farmers in marketing aspect of corn farming

knowledge from farmer groups and agricultural extension workers. This is different from young farmers who can combine knowledge from several stakeholder actors and online media, including agricultural extension workers, BPTP researchers, Food Office, Koperindag, Universities, agricultural extension workers, online media (YouTube and WhatsApp groups), banking, seed and fertilizers distributors, associations, SMEs, and corn marketing companies outside Gorontalo.

This is also in line with a study by Šūmane *et al*., (2018) farmers are more appreciative of knowledge based on local experience witnessed directly, closely related to needs and personally acquainted with the main source of knowledge. The main source of knowledge for old farmers is kinship as a means of exchanging knowledge, this is also in line with a study by Ramirez, (2013) local and traditional knowledge passed down from generation to generation, generally from father to son or from relatives influences decision-making in adopting technology.

Knowledge sources of young farmers varied according to a study by Šūmane *et al*., (2018) young farmers individually can synthesize knowledge to integrate with various knowledge sources through multi-actor social networks so that knowledge exchange occurs in realizing sustainable agricultural resilience. According to (Mills *et al*., 2019) the ability of young farmers to access knowledge sources through social media in the exchange and sharing of knowledge will increase knowledge.

Social Network on Innovation between Old Farmers and Young Farmers

This section identified social networks on innovation between old farmers and young farmers in the cultivation, processing, and marketing aspect. There were differences in innovation between old farmers and young farmers in corn farming as seen in Table 2.

Social Network on Cultivation Innovation of Corn Farming

Innovation in the cultivation aspect between old farmers and young farmers had differences.Old farmers still apply traditional planting methods and equipment in the form of ploughs using cows in tillage and ordinary planting methods, wooden corn seeders, local/composite seeds, and local pest control. This is the interview with old farmers:

> *Tillage the land using cattle plough 2 times, but before ploughing, I clean the weeds by trimming them with a machete. After ploughing, I drilled holes in the soil to plant seeds by manually digging them using wooden corn seeders with pointed ends (SM, Corn Farmer, number 8).*
>
> *The corn seeds planted by parents used to be local seeds such as Momala and Motorokiki corn seeds. The seeds to be planted must be soaked in water for at least 3 hours and then drained. When planting the seeds (moludes), I use a*

Table 2: Innovation between old farmers and young farmers in corn farming

Aspect	Differences in Knowledge Sources	
	Old Farmers	**Young Farmers**
Cultivation	Ordinary planting methods, ploughs, corn seeders from wood, local/ composite seeds, pest control using local wisdom.	Coconut-corn intercropping, legowo planting method, hand tractor/Zonder, superior seeds, corn seeders, integrated pest control, corn sheller machine, chimney dryer.
Processing	Consumption of local food (milu siram), a mixture of chicken feed.	Corn flour, corn pie, corn sticks, corn pastels, and corn starch.
Marketing	Corn collector traders, farmer group leaders.	Send samples to factories outside the area, and taste test.

Source: Primary data processed from research informants, 2021.

corn seeder made of lamtoro wood with a pointed tip with 4 seeds in one hole (YH, Corn Farmer,number 12).

The pest control techniques taught by the old people still exist and are applied in this village. For rat pests, our parents use bulucui (small bamboo), and each bamboo-segment is filled with water until it is full. Bamboo that has been filled withwater is planted by plugging it into every corner and the middle of the land. This method is usually effective for caterpillar pests (AK, Corn and Coconut Farmer, number 6).

Young farmers have innovations in planting methods and the use of modern tools and technology including planting corn under coconut trees (coconut-corn intercropping), the legowo planting method and the use of technological tools such as hand tractors and zonders,superior seeds, corn seeders, integrated pest control, machinery corn sheller, and chimney dryer. This is an interview with young farmers:

I plant corn under the shade of coconut trees to produce more due to the effect of fertilization on coconut and corn. I use the legowo system. I use a corn seeder so that the corn production increases. I also use a hand tractor and zonder with assistance from the provincial agriculture office (SD, Corn and Coconut Farmer, number 16).

I use the legowo planting system, I use superior hybrid seeds since the Agropolitan program at the time of Governor FM. Urea fertilizers and compound fertilizers are used by the advice of extension workers, integrated pest control, use of machinery (tractors), use of corn shellers and chimney dryers, program assistance from the Ministry of Agriculture (MA, Corn Farmer, number 5).

The social network on the innovation of old farmers and young farmers in the cultivation aspect of corn farming can be seen in Figure 5.

Figure 5 showed old farmers (P6, P8, and P12) used local and traditional knowledge methods such as local pest control used cattle power to plough and corn seeders from pointed wood, used local/composite seeds and ordinary planting methods, while young farmers (P5 and P16) used modern cultivation innovation, using superior hybrid seeds, legowo planting method, coconut-corn intercropping, corn seeder, hand tractor, integrated pest control, corn sheller machine and chimney dryer.

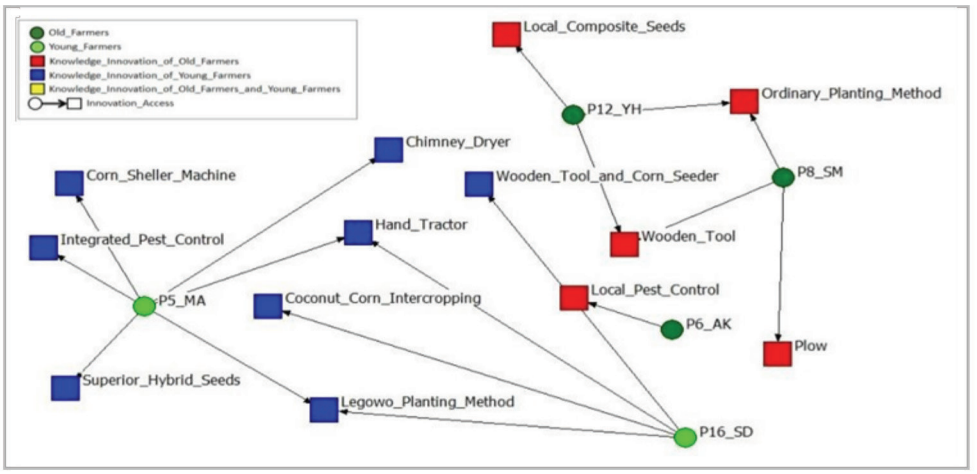

Figure 5: Social network on innovation of old farmers and young farmers in cultivation aspect of corn farming

Social Network on Processing Innovation of Corn Farming

Innovation in the processing aspect between old farmers and young farmers had differences. Old farmers lack innovation in processing corn into products with added economic value. Old farmers generally lack knowledge in corn processing because, after harvest, most of the corn is sold in a shelled form to factories or collecting traders. Corn is usually consumed as simple food preparations and some are made in the form of a mixture of chicken feed. They do not process corn into other processed products that have added value to corn products due to a lack of knowledge to process corn into commercially processed products and other factors because corn processing still requires additional costs. These are interviews with old farmers:

> *I My wife makes corn for local food (milusiram), for family consumption and also for sale…I don't make other products due to a lack of knowledge and still need more money (AR, Corn and Coconut Farmer, number 1).*

> *I sell most of it to factories, and some of it I make for mixed animal feed because I have a chicken coop, it's good enough to save on feed costs (YH, Corn Farmer, number 12).*

Young farmers have several innovations in processed corn including corn flour, corn pie, corn sticks, corn pastels, and corn starch. This corn processing innovation is obtained from interaction with several parties through training and seminars. These are the interviews with young farmers.

> *I made corn flour after receiving training from several agencies such as Koperindag, banking, and universities. I started to open a business using corn ingredients such as corn pie, corn sticks, and corn pastels (JF, Corn Farmer, number15).*

> *This corn business came from my parents who still used traditional equipment. Currently, I have used electric tools and machines so that in one day I can produce 30 kg (RD, Corn Farmer, number 3).*

The social network of innovation of old farmers and young farmers in the processing aspect of corn farming can be seen in Figure 6. Results showed that old farmers (P1, and P12) have not innovated because corn is still processed in the form of local food and is used as a mixture of chicken feed, while young farmers (P3 and P15) innovate in processing corn into other processed products with commercial added value to increase income.

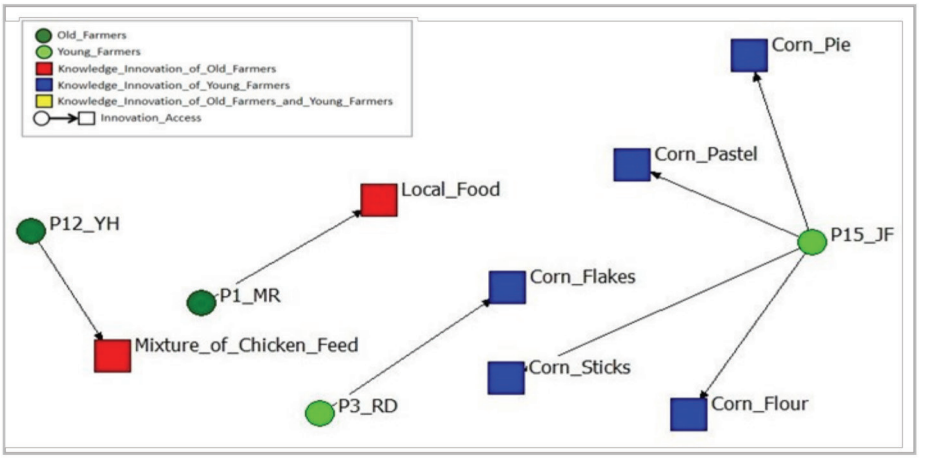

Figure 6: Social Network on Innovation of old farmers and young farmers in cultivation aspect of corn farming

Processed corn products can be in the form of corn flour, corn sticks, and corn pie.

Social Network on Marketing Innovation of Corn Farming

Innovation in the marketing aspect between old farmers and young farmers had differences. Old farmers market corn to traders who usually buy corn by visiting farmers during the harvest season or selling corn through group leaders who already have a marketing network to corn factories. These are interviews with old farmers:

> *I sell corn to collectors who have been my customers for a long time, usually, they buy corn directly from the field during the harvest season (AH, Corn Farmer, number 7).*
>
> *We as members of a farmer group sell our crops through the head of the farmergroup to the corn factory, so we only enjoy the results of the sale, but sometimes we also sell through the existing WhatsApp group (NH, Corn and Coconut Farmer, number 11).*

Young farmers have innovations in marketing the corn by sending samples to corn factories such as in Makassar or Surabaya because the price is higher than in Gorontalo, as well as doing a taste test. These are interviews with young farmers:

> *I sent samples of corn to factories in Makassar and Surabaya to get a higher price than in Gorontalo with a price difference of Rp. 150-200 per kg (SL, Corn Farmer, number 21).*
>
> *I did a consumer taste test for marketing the pie corn to 3 regions, namely Gorontalo, Makassar, and Manado, from this test, I could tell that Gorontalo people generally like chocolate-flavoured corn pie, Makassar people like green bean-flavoured corn pie, and Manado people taste cheese-flavoured corn pie (JF, Corn Farmer, number 15).*

The social network on the innovation of old and young farmers in the marketing of corn farming can be seen in Figure 7. Old farmers (P7, and P11) market corn by collecting traders and farmer group leaders, while young farmers (P15 and P21) have innovations in marketing corn by doing a taste test to find out consumer tastes and sending corn samples to companies outside Gorontalo.

Based on data from the Gorontalo Provincial Agriculture Office cited by NSLC, (2018), farmers' corn marketing in Gorontalo is commonly through traders in the sub-district capital, wholesalers, and the feed industry. In the research location, there were 36 sub-

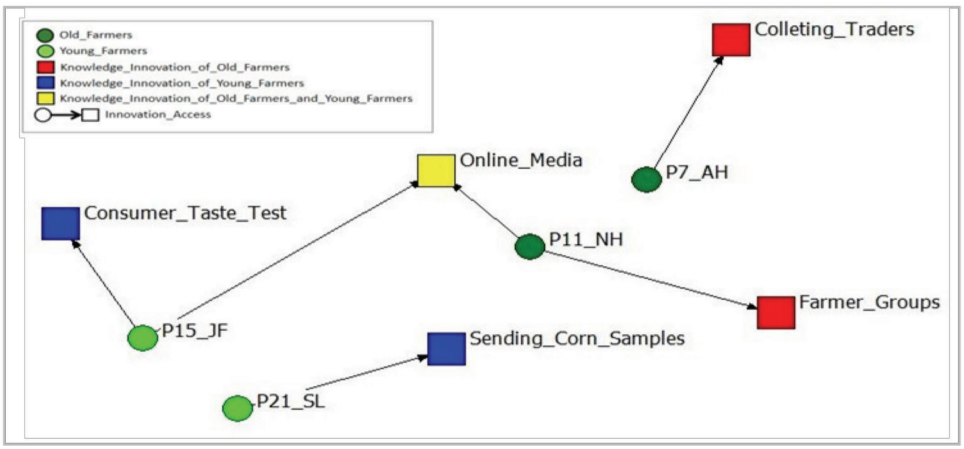

Figure 7: Social Network on Innovation of old farmers and young farmers in cultivation aspect of corn farming

district traders, 7 animal feed industries, and 4 wholesalers. Traders in the sub-district possess a marketing strategy as fertilizers and agricultural inputs traders who have access to farmer groups in rural areas, wholesalers, and the feed industry. Sub-district traders have technology and facilities such as drying tanks, transport trucks, moisture gauges, and dryers. Wholesalers and the feed industry have modern technologies such as large-scale dryers, warehouses, container trucks, and drying floors.

The market price of farmers' corn purchased by traders is IDR 2,750/kg with a moisture content of 23% and IDR 2,950/kg with a moisture content of 17%. Wholesalers and the feed industry purchase corn from farmers and traders for IDR 3,150-3,550/kg with a moisture content of 14%. The application of corn water quality standards from traders, wholesalers, and the feed industry has influenced the farmers' behaviour in the utilization of superior seed variety technology, and balanced fertilization spacing in the aspects of corn farming. This is in line with the research findings of research by Jamil *et al.,* (2018), that the success factor in applying technology in producing quality farmer products is the availability of capital, the utilization of superior seed varieties, setting spacing according to plant population, balanced fertilization according to recommendations and intensity counselling.

Utilization of technology in harvest and postharvest aspects, such as corn thresher/ sheller and dryer to meet corn quality and quality standards. The use of simple corn sheller technology has increased the percentage increase in corn production by 20% or 300 kg/ hour in the corn sorting process, while the use of drying machine technology will dry shelled corn with a moisture content below 30% at a drying speed of 4% per/hour and a temperature drying 65^{o}C (Kevin *et al.*, 2022; Ijah *et al.,* 2021). Another consequence of the technology application is based on research findings from Hunowu *et al.,* (2021), that changes in farmer behaviour regarding the use of technology and significant investments result in farmers paying investors a high cost for labour and the use of technology for agricultural production facilities.

The difference in innovation between old farmers and young farmers is due to the lack of knowledge in cultivation and product processing, limited access to information on knowledge sources and information media, especially corn processing and marketing, as well as lack of access to policymakers in the government sector to manage technology equipment for corn cultivation and processing. According to Ramirez (2013) in addition to gaining knowledge through kinship, farmers must have access to innovation externally that has a different social network for the adoption of technological innovations to occur. The existence of access to innovation with other actors is revealed in a study by Dolinska & d'Aquino (2016) approach to access innovation in social networks will connect farmers with other actors in the learning process to increase knowledge. The relationship between the social network of innovation between old farmers and young farmers following the results of research conclusions from Tolinggi *et al.,* (2023) occurs because there is an attachment between old farmers and young farmers.

Knowledge Sources, Innovation, Corn Ecological Sustainability

Knowledge sources and innovation between old farmers and young farmers have differences in cultivation, processing, and marketing aspects. Knowledge sources, networks and social relations of farmers in corn farming are the difference in producing agricultural productivity. The characteristics of corn farming's cultivation, processing, and marketing are different according to the sources of information and innovation networks of elderly farmers and young farmers. Agricultural production differences are produced by variations in the sources of knowledge, networks, and social relationships generated by farmers in corn farming activities. The ecological sustainability of farmers' corn farming is based on the knowledge and innovation activities of farmers

that they carry out to maintain the sustainability of agricultural practices. This can be viewed in the interview of old and young corn farming farmers below.

I produce my own organic fertilizer for my property, some of which I sell. My objective is to utilize organic fertilizers to improve soil fertility… (SA, corn farmer, informant number 23).

I haven't applied organic fertilization yet, but I'm still using a combination of organic and non-organic fertilizers to maintain corn production in the field. However, I have started to reduce the dosage of using non-organic fertilizers, thus, production input costs have started to decrease by about 30% each planting season... (DB, corn farmer, informant number, 11).

I use an ox plough for tillage so that the soil remains loose, since the majority of farmers in this village currently use the TOT (No-Tillage) system, the land is sprayed with herbicides then directly planting the corn (YL, corn farmers, informant number 22)

I have been farming corn for approximately 40 years, and until the present day I still plant local varieties, namely momala and baby corn (Binthe kiki) which are usually grown by my parents and are superior in disease and hot climates resistance… probably as a result of their suitability for the Gorontalo climate (UH, corn farmer, informant number 19)

The prevalent pests at this location are green caterpillars and the disease is leaf blight, which locals refer to as tabongo. To prevent the spreads, I naturally spray it with soapy water or tobacco and remove leaf-blighted corn plants from the field (HS, farmer corn, informant number 24)

The land in this village is generally on slopes, thus, the farmer plant by polyculture by integrating corn with plantation crops such as cocoa and candlenut. I created a terraced system to prevent landslides (LD, cocoa and corn farmer, informant number 26).

I have planted corn since the Agropolitan program under Mr. Fadel Governor. I rotated corn and peanuts to avoid pests and diseases (OP, corn farmer, informant number 4).

I made a natural pesticide, i.e., Coryne Bactery, from boiled water of potatoes mixed with sugar which was fermented for 14 days and mixed with bacteria provided by the Horticulture and Plantation Plant Protection Agency (BPTHP), while making my own fertilizer, the bacteria are obtained from nature such as bamboo roots and mimosa roots (Putri malu) then mixed with rice bran water which was fermented for 14 days, we used pesticides and organic fertilizers on corn and vegetable crops (RML, corn and vegetable farmers, informant number 20).

Based on interview results with the old and young corn farmers, some of their efforts are in preserving the ecological sustainability of corn. Old farmers generally carry out activities for tillage by using conventional ploughs and organic fertilizers to maintain soil fertility, employing local varieties. These old farmers made efforts are to increase the soil fertility of corn plants on dry land with green compost fertilization technology, traditional tillage using reared livestock, and the use of local traditional seed varieties that dry-climates tolerant (Chutia & Borah, 2012; Keban *et al*., 2019; Idham *et al.,* 2021). Young farmers use integrated pest management, which includes crop rotation, the production of natural pesticides and herbicides using natural microorganisms, and the prevention of soil erosion by creating terracing combined with polyculture systems planting on land with a slope of more than 15 degrees.

This is following the research findings by Patel *et al*., (2020), that traditional agricultural practices, such as locally accessible biological pest control methods, crop diversification, and terraced systems, possess the potential to lessen the adverse effects of climate change. In general, the system of ecological sustainability between old and young farmers in corn farming occurs because their social network contributes to access to information and innovation. This social network serves as necessary social capital in the livelihood systems since access relies on social relations (Salman *et al.*, 2021). Based on the findings of Mwangi *et al.,* (2020), farmers' access to social relations through an innovation system approach from various stakeholders is a process to promote and expand knowledge sharing and interactive learning.

Collaboration of knowledge sources and social networks of old farmers and young farmers is interesting, where the potential between generations can combine local and traditional knowledge that regenerates from generation to generation with modern knowledge based on technological innovation using information media to ensure the sustainability of corn ecology as a social identity in Gorontalo. Traditional and modern knowledge must be integrated (Šūmane *et al*., 2018) found that the potential for local traditional knowledge will be optimal through integration with various types of knowledge and multi-actor social networks so that exchanges and knowledge sharing occur in the innovation process. The diversity of knowledge sources and information in social networks will play a big role in the use of technological innovations for farmers (Vishnu *et al*., 2019). Based on the description above, the grounded theory framework in this study has a relationship between concepts, specifically access to innovation as causal, where social networks are the source of interaction for innovation, and ecological sustainability of corn as a consequence.

Conclusion

There were differences in social networks on knowledge sources between old farmers and young farmers in the cultivation, processing, and marketing aspects. Old farmers use local knowledge sourced from previous generations combined with knowledge obtained from interactions in farmer groups and agricultural extension workers, while young farmers with knowledge come from various actors and different institutions including agricultural extension workers, BPTP researchers, Food Office, Koperindag, Universities, extension workers agriculture, online media (YouTube and WhatsApp groups), banks, seed and fertilizer distributors, associations, SMEs, and corn marketing companies outside Gorontalo, in addition,young farmers also used online media (YouTube, WhatsApp group) as knowledge sources. The difference in innovation between old farmers and young farmers is due to the lack of innovation in cultivation and product processing, limited access to knowledge sources and information media, especially corn processing and marketing, as well as lack of access to policymakers in the regional government sector managing corn cultivation and processing technology equipment. Another finding in this study is that the ecological sustainability of old farmers' corn farming is generally by carrying out activities for tillage using conventional ploughs and organic fertilizers to maintain soil fertility and utilizing local varieties. While young farmers practice integrated pest control with crop rotation and the production of natural pesticides and herbicides from natural microorganisms to prevent soil erosion by terracing. In general, the ecological sustainability system between old and young farmers in corn farming activities occurs because their social network contributes to accessing knowledge and innovation in carrying out their farming activities. The policy implications of this research are to submit recommendations to local

governments to establish centres of knowledge such as Agro Techno Park, specifically corn commodities. This centre aims to collaborate on developing relevant technology by utilizing information sources from the government, industry, universities, and the community in producing appropriate technology.

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