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Article

Non-Face-to-Face interactions in digital extension for innovating in farming communication: A case from South Sulawesi, Indonesia

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Abstract: The utilization of digital tools in agricultural extension has facilitated information delivery through non-face-to-face interactions. Therefore, this study aimed to map the variation in digital tools used by agricultural extension workers to access and deliver information and analyse the outcomes of farmers' adoption. Data were collected through in-depth interviews with agricultural extension workers at 11 Agricultural Extension Centers. The data were processed using the N-Vivo qualitative data analysis software. The results showed that extension workers combined various digital tools as sources of extension materials and channels for delivering information to farmers. Although social interaction between agricultural extension workers and farmers occurred non-face-to-face, messages could be adopted by farmers and yield tangible outcomes. This was reflected in the asynchronous communication, allowing extension workers sufficient time to improve the quality of the delivered messages. Farmers also had sufficient time to review the received information content in this context repeatedly. These results implied that although extension content is delivered through non-face-to-face interaction, it can still drive adoption with significant outcomes.

Keywords: non-face-to-face social interaction; digital extension; asynchronous communication; delivery of information; adoption

1. Introduction

The utilization of digital tools in agricultural extension is transforming the system of innovation intermediation among actors engaged in agricultural practices (Arham et al., 2024; Munthali et al., 2018). In this context, digital technology used in e-extension and smart extension platforms effectively contributes to the delivery of agricultural innovations (Coggins et al., 2022; Kabir et al., 2023). Meanwhile, the digitization of services is influenced by the understanding of extension workers regarding digital tools (Engås et al., 2023). As stated in a previous study, digital tools such as smartphones and internet platforms can potentially enhance agricultural performance and productivity (Rajkhowa and Qaim, 2021). These tools have positively impacted farmers' yields, specifically when guided by extension workers (Fabregas et al., 2023). Moreover, agricultural extension approaches supported by digital tools can provide location-specific recommendations tailored to land conditions (Oyinbo et al., 2022).

Regarding social dynamics, the presence of digital tools in agricultural extension has reshaped the patterns of social interaction, transitioning from solely face-to-face to a combination of face-to-face and non-face-to-face interactions (Materia et al., 2015; Karubanga et al., 2019; Verduyn et al., 2021). Traditional agricultural extension

methods such as training sessions, field schools, demonstration farms, or on-site guidance all entail face-to-face interactions between extension workers and farmers or among fellow farmers (Davis et al., 2010; Liu and Peng, 2017). With the integration of digital tools, extension messages are conveyed to farmers without face-to-face interactions, while social connectedness is still fostered through online media channels (Grieve et al., 2013; Wahid et al., 2024). These tools have not only replaced the role of extension workers as channels for delivering innovations but also altered the social context.

In Indonesia, the use of digital tools in agricultural extension is motivated by the limited number of extension workers compared to farmers. This initiative started with the introduction of cyber extension by the Ministry of Agriculture of Indonesia (Guntoro et al., 2022; Rizkiansyah et al., 2022) in 2017. Subsequently, in 2019, a program named Strategic Agricultural Development Command (SADC) was introduced, where Agricultural Extension Centers (AEC) at the district level were equipped with computers and internet access. This provision enabled extension workers to interact with agricultural policymakers through Zoom meetings and WhatsApp groups to communicate with farmers (Utomo et al., 2022).

Conceptualizing the relationship between agricultural extension and the presence of digital technology initially focused more on delivering services. The concept used is digital extension tools (DET), through which farmers or other extension actors access, share, or discuss agricultural information or knowledge (Coggins et al., 2022). Another related concept is digital platforms and ecosystems. The concept of digital platforms is more technically oriented, serving as a tool that caters to all users, who should have digital skills. This includes using digital media, comprising competencies utilized when learning and working in a digital environment (Porat et al., 2018). According to Cheng et al. (2024), digital skills can significantly contribute to farmers' technical decisions and entrepreneurship. The concept of a digital ecosystem primarily refers to an anti-monopoly perspective within digital systems, from which data is generated, exchanged, and analyzed through interconnected networks of infrastructure, data sets, and distributed algorithms, allowing for comparison (Krivý, 2023). Digital ecosystems ensure that platforms operate fairly.

The concept of non-face-to-face interaction within digital technology includes various features (Lewis, 2024). In this context, digital communication transcends physical boundaries, allowing interacting parties to contact each other using multiple digital formats immediately. Contemporary digital technology also removes time constraints due to the ability to operate both synchronously and asynchronously, making it temporal. Specifically, all interactions are mediated through devices tied to specific platforms. Furthermore, digital communication is safe when disclosing information only to intended recipients. Still, non-face-to-face or asynchronous communication lacks gestures, posture, and gaze compared to face-to-face methods.

Synchronous and asynchronous communication factors play a crucial role in non-face-to-face social interaction with digital tools. Synchronous communication refers to real-time exchanges where participants can verify mutual understanding and quickly prevent misunderstandings (Panteli et al., 2019). This communication occurs through text-based platforms such as Short Message Service (SMS) and WhatsApp, audio-based platforms including conference calls and web audio conferences, or

video-based platforms, namely video conferencing, Skype, and Google Meet (Peterson, 2023). On the other hand, asynchronous communication is characterized by a slower communication rate (Walther, 1992), resulting in fewer social cues compared to synchronous contexts (Panteli et al., 2019). It also allows more time for communicating parties to carefully craft and review messages before sending, potentially enhancing the quality of communication (Berry, 2011).

The theoretical framework employed in this study is the common ground building concept (Clark and Marshall, 1981; Clark and Carlson, 1982), which argues that coordinating the content of effective communication requires the establishment of a shared foundation consisting of mutual knowledge, joint beliefs, and mutual assumptions. The common ground is continuously developed through the grounding process, where individuals and their communication partners mutually trust that they clearly understand each other's intentions and objectives in the present moment (Clark and Brennan, 1991). We also discuss the concept of common ground building tools, which refers to how the development of shared understanding in cooperative work is influenced by a series of interconnected changes in the behavior of dialogue team members (Convertino et al., 2008), where specific design features in computer-supported teamwork contribute to the development of content and standard ground processes (Convertino et al., 2009). For more complex tasks that require higher coordination, it is possible to develop common ground through more systematic in-depth on wider variations of visualization, such as social networks and timelines (Convertino et al., 2011), and to create a common ground on the use of specific information tools such as video also requires specific techniques in signaling, capturing signs, and negotiating meanings (Veinott et al., 1999).

This study used the concept of digital extension in the context of farming communication, which refers to services that use digital tools as a medium for extension actors to access and distribute agricultural information or knowledge, facilitating non-face-to-face interactions, whether synchronous or asynchronous. The concept of digital extension includes both technical and social aspects.

Several studies have focused on digital extension but only on specific aspects. Analyzed aspects include farmers' capacity to access and use telephone-based extension services (McCampbell et al., 2023), agriculture content mainly accessed by smallholders (Kirui et al., 2022), and the impact of mobile phones on rural extension (Singh et al., 2023). However, the diversity of digital tools, the patterns of knowledge flow from sources to farmers, and the outcomes of actions in applying knowledge from these channels have not been fully explored within a holistic framework. Therefore, this study aimed to fill the knowledge gap by mapping the variety of media extension workers use to access agricultural information and analyze farmers' adoption outcomes.

2. Materials and methods

This study was conducted in 11 AEC within Maros Regency, South Sulawesi Province. These AEC include Lau, Tanralili, Bantimurung, Moncongloe, Mandai, Turikale, Marusu, Maros Baru, Mallawa, Simbang, and Tompobulu (**Figure 1**). The selection was due to the location in the center of rice cultivation within Maros Regency

and its position as a center for agricultural innovation development in South Sulawesi. All selected AEC operate in low-lying areas with an altitude of <20 m above sea level. The total area of Maros Regency is 1619.12 km^2, administratively consisting of 14 sub-districts (CBS, 2023).

AEC is a government-owned agricultural extension institution tasked with providing agricultural extension services. It is a functional working unit with a working area covering one sub-district. Each AEC consists of 6-8 extension workers and is led by a coordinator.

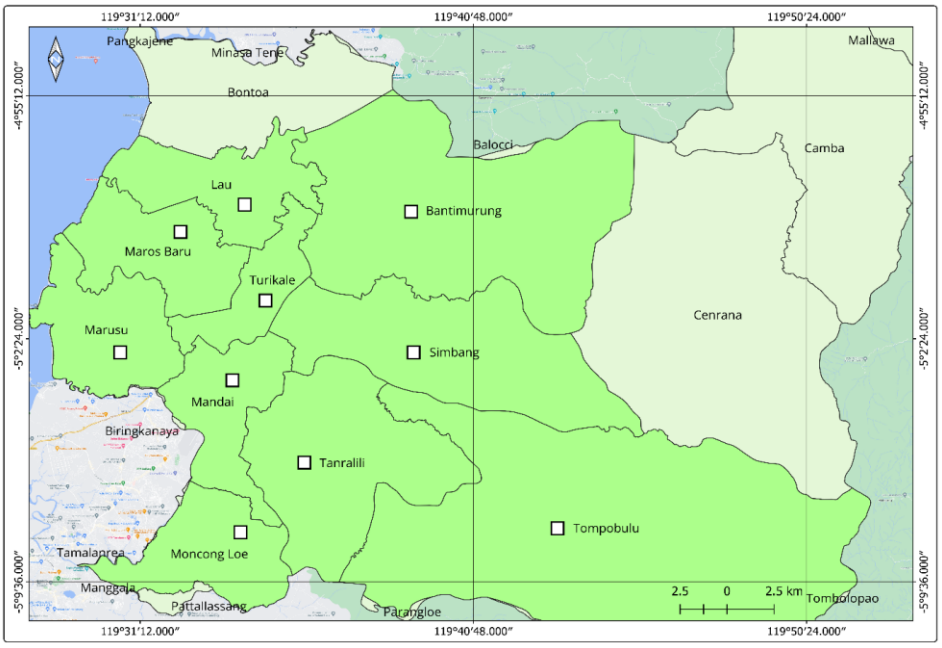

Figure 1. Map of the agricultural extension center in Maros regency.

This study used the grounded theory method which allowed direct engagement with social reality, and theoretical abstraction from field data (Charmaz, 2014). The method included data collection and categorization, as well as the formulation of substantive theories (Corbin and Strauss, 2008).

Data collection was conducted through in-depth interviews, characterized by social interaction entailing deep conversations (Rubin and Rubin, 2005). Theoretical sampling was used as a characteristic of the *grounded theory* method (Corbin and Strauss, 2008), where the acquisition and delivery of extension materials to farmers were investigated, along with the outcomes resulting from non-face-to-face interactions. Sampling was stopped once interview results reached redundancy. The selected sample consisted of 20 extension workers working in 11 AEC. The interview was conducted face-to-face, with 60-80 minutes.

All interview results in the form of field note transcriptions were processed using the N-Vivo qualitative data analysis software (Qian et al., 2023; Sifullah et al., 2023; Thummala and Hiremath, 2022), following the open, axial, and selective coding procedures inherent in the grounded *theory* method (Strauss and Corbin, 1998). The categorized data results are presented in Appendix.

3. Results and discussion

3.1. Digital platform for agricultural information sources

This study found that extension workers accessed agricultural information through various digital media platforms such as social media, websites, Zoom meetings, e-services, Play Store, and Spotify. These platforms were accessed more frequently from sources within the Ministry of Agriculture compared to non-Ministry of Agriculture sources. The social media platforms used by extension workers to access information include YouTube, WhatsApp, Instagram, Facebook, TikTok, and Telegram. Website sources utilized include the cyber extension, the official website of the Ministry of Agriculture, and personal blogs. Zoom meetings were also used as a source of information, organized under various event themes such as Minister of Agriculture Greeting Extension Workers and Farmers (MAGEF) and Have Fun Chatting (HFC). Extension workers generally access information through two primary sources: the Ministry and non-Ministry of Agriculture. This explanation serves as an abstraction summarized in **Table 1**.

Table 1. Digital sources and platforms used by extension workers to access agricultural knowledge.

Resources	**Platforms**	**Content**
Ministry of Agriculture	1) Social Media	• Youtube • WhatsApp • Instagram • Facebook • Tiktok
	2) Website	Cyber Extension
	3) Zoom Meeting	• MAGEF • HFC
	4) E-Service	• E-Allocation • E-Verification and evaluation • Agricultural Extension Management Information System (AEMS) • Planting Calendar
	5) Play Store	• My Agri • Smart Feed Agrinak • Cow Health Android Technology • Food storage
Non-Ministry of Agriculture	1) Social Media	• WhatsApp • YouTube • Instagram • Facebook • Tiktok • Telegram

Table 1. (*Continued*).

Resources	Platforms	Content
	2) Website	• Personal Blog
	3) Play Store	• JIVA
	4) Spotify	• Podcast

Extension workers utilize social media platforms to obtain diverse agricultural information that may be effectively communicated to farmers. Extension workers collect diverse digital agricultural information in the field, which is then analyzed and disseminated to farmers through various communication channels. The farmer receives the extension worker's message regarding adopting new practices in his agricultural activities and the subsequent results of implementing these practices. Through the Ministry of Agriculture's YouTube channel, extension workers gain knowledge about farmers' methods and requirements for claiming agricultural insurance, as well as techniques for cultivating crops, materials for integrated pest management, and the use of fertilizers, including organic alternatives. Through WhatsApp groups, extension workers acquired comprehensive insights into a government-implemented Youth Entrepreneur and Employment Support Services (YESS) initiative. They discovered differences in the application of fertilizer and pesticide doses between food crops and plantation crops. Also, they learned about an innovative strategy involving using *Biosaka*, a plant extract solution that functions as an elicitor to boost plant productivity. Extension workers receive information on growing practices for different crops and updates on priority operations conducted by the Ministry of Agriculture through Facebook. The extension worker receives updates on activities at the Ministry of Agriculture, the latest agricultural technologies, and information about the schedules and topics of Zoom sessions organized by The Ministry of Agriculture through Instagram and TikTok. Here is a quote from an extension worker's statement describing agricultural information obtained via social media platforms associated with the Ministry of Agriculture.

> *"I searched for information on agricultural insurance claim procedures on the Ministry of Agriculture's YouTube channel. From the videos, I learned that to claim insurance for crops damaged by floods, for example, the application as an insurance participant should be submitted before the crops are one month old. If the crops are indeed affected by floods, the insurance claim can only be processed after a field inspection by the Regency Agriculture Office, the insurance provider, and field agricultural extension workers to ensure that floods cause the damage. Therefore, I learned how to claim agricultural insurance through the Ministry of Agriculture's YouTube channel."* (Extension Worker, Sample 10).

The Ministry of Agriculture launched cyber extension as a platform that could be used by central, regional, and local extension workers to disseminate agricultural technology innovations. It is a hybrid and convergent media that utilizes internet networks, computers, and interactive digital multimedia to facilitate the rapid transformation of knowledge and new technologies in agriculture. One of the specific functions of cyber extensions is as a medium for extension workers to disseminate

field research results in scientific articles, as well as a source of agricultural research material such as the topic of suitable planting systems for specific locations and creating extension program matrices. The following extension worker revealed this one.

> *"Accessing information through cyber extension includes the latest agricultural technologies from the Ministry of Agriculture for farmers. For example, information about the latest balanced fertilization technology, suitable planting systems for specific locations, and new plant varieties can be found in cyber extension. We can also utilize cyber extension to disseminate our study through academic articles."* (Extension Worker, Sample 6).

The *Zoom Cloud Meetings* application, also known as a remote conferencing service, facilitates cellular collaboration, conversations, video meetings, and meetings through telephones and desktops. The Ministry of Agriculture also utilizes this application to disseminate information for extension workers. It is packaged within the MAGEF and the HFC programs. MAGEF is designed to enhance relations between the government and stakeholders, specifically farmers and extension workers, conducted virtually through Zoom meeting for two hours. On the other hand, HFC is a breakthrough in connecting extension workers across Indonesia. It has a digital mobile system and information space directly connected to agricultural experts. Some extension workers utilize Zoom meeting facilities through the MAGEF and HFC programs to obtain agricultural information. An extension worker illustrates it as follows.

> *"I also participate in MAGEF. The materials cover topics such as agricultural mechanization, agribusiness systems, crop cultivation techniques, pest and disease control, the impact of El Nino, as well as topics related to agricultural product exports and imports." (Extension Worker, Sample 7).*

E-services, also known as electronic public service systems, facilitate delivery from providers to users utilizing electronic devices through the Internet. In fulfilling the functions, the Ministry of Agriculture uses e-services to facilitate the delivery of information, agricultural data recording, and efficient verification through e-allocation, e-verification, and e-evaluation, the Agricultural Extension Management Information System (AEMIS), and planting calendars. E-allocation combines the Definitive Plan of Farmers' Group Needs (DPFGN) with subsidized fertilizer allocations and integrates with data in the AEMIS. The e-verification and e-evaluation application was developed by the Directorate General of Agricultural Infrastructure and Facilities in the subsidized fertilizer budget submission process. Through this application, the distribution of subsidized fertilizers can be monitored.

Furthermore, the AEMIS provides data on government extension institutions (province, regency, and sub-district), agricultural extension personnel (Government Employees Extension Workers, Daily Casual Extension Workers, Volunteer Extension Workers), and farmer institutions (Farmer Groups, Farmer Group Associations, and Farmer Economic Institutions). It aims to improve the quality and effectiveness of agricultural extension services. The Planting Calendar serves as a guideline or tool that provides information on recommended varieties, fertilization recommendations, balances of farming tools and machinery, livestock feed potential, climate predictions, estimated timing, planting areas, damage due to floods, droughts,

and plant pests. All this information is provided based on climate prediction conditions and land typology, with monitoring carried out at the sub-district level. Some extension workers utilize these e-services for obtaining information, as conveyed in the statements below.

> *"The e-allocation information is needed to determine whether farmers have been registered as prospective recipients of subsidized fertilizer or not. In our extension work, we also conduct group meetings to socialize the preparation of data for the AEMIS."* (Extension Worker, Sample 14).

Play Store was developed by Google and used by Android smartphone users to obtain desired applications for free or for a fee. Various types of Play Stores are available, including those related to agriculture, such as My Agri, Smart Feed Agrinak, and Food Storage. Some extension workers utilize these Play Store applications to obtain extension materials, as conveyed by the following individuals.

> *"In the form of Android applications, I access My Agri where we can consult with experts about vegetable cultivation information, and there is also a special group within the application account. I also access Smart Feed Agrinak, which contains information on how to formulate livestock feed. I also access Cow Health Android for cattle health."* (Extension Worker, Sample 8).

Aside from the Ministry of Agriculture, extension workers also obtain materials through social media platforms, websites, and Spotify. Social media platforms include WhatsApp, YouTube, Instagram, TikTok, and Telegram. Extension workers utilize the WhatsApp platform to join the "Eco-farming" group, where they exchange knowledge regarding organic agricultural practices. YouTube allows them to access materials for discussion with farmer groups such as about rice seedlings, the use of Phonska fertilizer, rice planting distance, and planting tools. Instagram presents a presentation from the Meteorology, Climatology and Geophysics Agency about weather information and forecasts that are highly beneficial for farmers in mitigating the effects of climate change. From TikTok, extension worker get comparative information on their knowledge of techniques for horticultural cultivation, seed handling, soil processing, harvesting techniques, and post-harvesting methods. Likewise, extension workers frequently utilize Telegram to acquire and distribute a wide range of agricultural information, including both specific and general topics. The following statements provided by certain extension workers revealed the use of WhatsApp and Telegram as platforms for distributing informational materials.

> *"I joined the WhatsApp group "Eco-farming" where information about organic farming systems is shared. I am more inclined to promote organic farming practices to farmers. I have previously established a demonstration plot for organic fertilization in the field. Eco-farming is privately owned, producing organic fertilizers under the name Eco-farming." (Extension Worker, Sample 13).*
>
> *"Outside of the Ministry of Agriculture, I'm also active on Telegram where agricultural information is shared continuously by the admins, twice a week, sometimes even daily. The materials shared come in the form of technical instructions, implementation guidelines, and general agricultural information. Therefore, when I open Telegram and find good agricultural information, I refer to it. These Telegram channels are created by individuals, it's not clear who created them, they are not official government Telegram channels. The materials*

can be downloaded directly in PDF and PowerPoint format or through a Google Drive link. I'm always curious, and whenever there's a technological development, I try to find out more." (Extension Worker, Sample 20).

Some extension workers use Google or Chrome search engines as a source of extension information. Obtaining knowledge about agriculture is effortless for them as they simply need to enter a term to receive an explanation. As an illustration, they input keywords related to "shallot cultivation," "corn cultivation," and "soil physics and chemistry," and then the relevant information promptly appears. Extension workers often use scientific journals to stay updated on new technology and ensure that the agricultural knowledge they utilize for research is based on scientific evidence. It is expressed as one of the following extension worker.

"When there is a new technology, I check scientific journal websites because I believe agricultural information conveyed to farmers should be based on scientific foundations." (Extension Worker, Sample 3).

Extension workers also access the Play Store for agricultural content, such as the JIVA program developed by a private company, aimed at providing corn price information and assisting farmers in selling at standard prices. Spotify is one of the digital audio streaming service applications featuring a function called podcasts, which can be used to listen to discussions or conversations. Spotify is available on various devices, including mobile phones, tablets, computers, speakers, and televisions. Extension workers utilize this program to obtain agricultural information, as stated by the following extension workers.

"I've also accessed podcasts, hosted by Mr. X Medio, an agricultural content creator. Several times, I've accessed episodes on topics such as planting fruit in polybags, poultry farming, and cattle farming." (Extension Worker, Sample 14).

This section demonstrates the existence of differences in sources, platforms, and content when it comes to utilizing digital tools in agricultural communication. Regarding agricultural information sources, there are two main categories: the Ministry of Agriculture and non-Ministry of Agriculture sources. Within each category, there are sources that are essential to the character of the agency, such as Directorates under the Minister of Agricultural Affairs, or private enterprises under the Non-Minister of Agriculture category. Additionally, there are resources that are intrinsic to individuals (for example, content creators in both the Ministry of Agriculture and Non-Ministry of Agriculture). Different forms of digital platforms used to access agricultural information include social media, websites, zoom meetings, and play stores. Zoom meetings and e-services exclusively are utilized by extension workers to get agricultural information from the Ministry of Agriculture, while Spotify is only employed for accessing data from entities other than the Ministry. The variety of agricultural information content accessed includes technical aspects of planting and livestock breeding, the latest technology, price information, agricultural insurance, and government programs in agriculture.

3.2. Delivery of information through Non-Face-to-Face Interaction

Information accessed by extension workers from both Ministry and non-Ministry of Agriculture sources is further processed in various methods. These include creating

information summaries and capturing images or videos, which are then combined with audio narration to summarize the information. Audio recordings are also made. The processed information is disseminated to farmers individually and in groups. Extension workers use social media platforms, Spotify, Zoom meetings, or websites to deliver information to farmers. This explanation serves as an abstraction, the summary of which is presented in **Table 2**.

Table 2. Forms of digital extension in delivering information to farmers.

Method	**Platforms**	
Digital (Non-Face to Face Interaction)	1) Social Media	• WhatsApp • Youtube • Tiktok • Facebook
	2) Web Site	• Cyber Extension
	3) Zoom	• Zoom Meeting
	4) Spotify	• Podcast

3.2.1. Delivery of information through social media

Although only a portion of the population access information sources through WhatsApp, all extension workers utilize this medium to deliver information to farmers. Other social media platforms used include YouTube, TikTok, and Facebook. The methods of processing and delivering information to farmers include producing instructional videos on rice seed selection, which are distributed via WhatsApp for farmers to view; sharing updates on the latest program from the Ministry of Agriculture in the farmers' WhatsApp Group; establishing a YouTube channel on behalf of the EAC and disseminating videos showcasing technological advancements in one farming group to be followed by other groups of farmers; creating specific digital content, such as information about sweet potatoes, and sharing it with farmers; serving as a content creator for various topics and distributing the content through Instagram and TikTok on behalf of the AEC where the extension worker is located; or utilizing Facebook as a primary platform for disseminating agricultural information extensively. Some farmers express their thoughts in the following sentences:.

> *"Yesterday, I created a video showing the process of seedling selection for rice field production. I shared the video on WhatsApp. Members of the farmer group watched the video." (Extension Worker, Sample 5).*
>
> *"In the end, I started making YouTube videos just for fun. The pattern is that I search for content in the district because I think if others are more technologically advanced, why can't other farmer groups use it since they are in the same district? After searching, I found one farmer group doing activities, and I uploaded the activities to YouTube. From there, gradually, I started creating more content for YouTube. The channel's name is "Millennial Field Agricultural Extension Workers of Tompobulu," owned by the Tompobulu Agricultural Extension Center…"* (Extension Worker, Sample 9).

3.2.2. Delivery of Information through website

Extension workers utilize website platforms to disseminate agricultural knowledge, mainly through the cyber extension channels of the Ministry of Agriculture, and also establish personal blogs. An extension worker from one of the EACs in Maros authored an article about the local consensus gatherings, sometimes known as "*Tudang Sipulung*" (local consensus meetings). Local consensus meetings are gatherings of local farmers from the Bugis-Makassar ethnicity where they share their knowledge and expertise regarding agricultural schedules and the types of crops to be grown. These meetings involve debates and reaching agreements on these matters. The participants include experienced farmers with extensive historical data on seasonal patterns covering several decades, personnel from the Climatology Agency, officials from the District Agriculture Service, farmer organizations, and scholars. The author of the paper anticipates that farmers who read it will acquire valuable insights regarding the importance of practicing simultaneous planting to prevent the growth of pests. As an example, an extension worker shared a video on his blog that discusses the application of *Biosaka* technology in rice farming where the knowledge regarding this technology is sourced from digital platforms. Through the video, he expects that farmers will acquire the knowledge and skills necessary to produce *Biosaka*, as he is informed in the following manner.

> *"On my blog, I narrate the information in the form of videos, then embed the video links. There, farmers can directly watch videos about the Biosaka technology created."* (Extension Worker, Sample 20).

3.2.3. Delivery of Information through Zoom meeting

Zoom meetings are also a channel for delivering information from extension workers to farmers. One prominent piece of information is about the YESS Program developed by the Ministry of Agriculture to produce young entrepreneurs and highly skilled workers. Information about the YESS program is passed on by the extension worker through the Zoom meeting to the farming groups, the expansion worker also discusses it with the farmers face to face. The extension worker also facilitates farmers to follow the Zoom meeting conducted by the Agricultural Human Resource Development Agency (AHRDA) of The Ministry of Agriculture in connection with various aspects of agricultural activities. It is expressed as one of the following extension worker:

> *"AHRDA also provides agricultural technology information such as crop cultivation techniques, seedling, seed production, post-harvest processing, and financial management in farming, through Zoom. Therefore, all agricultural information is delivered through digital technology."*(Extension Worker, Sample 13).

3.2.4. Delivery of information through spotify

Spotify is a popular application available on the Play Store that is frequently used for the distribution of audio-based content. An Agricultural extension worker at Tompobulu County EAC shared information regarding the progress of Ettawa goat breeding through the podcasts they produced. In addition, he also created a podcast that explores the utilization of digital technology in farming techniques, namely in the context of precision agriculture or smart farming. Despite being an amateur content

creator, this extension farmer has successfully produced a unique podcast titled 'Field Agricultural Extension Workers of Tompobulu.' Additionally, an extension worker disseminates information about the Farmers Corporation's Food Plant Area Development Program (FCFPAD) to farmers via his podcast. The plan seeks to enhance regional food crop farming by strengthening the institution of the farmer group as an economic entity responsible for overseeing the diverse business units necessary for an agricultural region. A combination of various farmer business units is called a farmer's corporation. An extension worker compiles diverse explanations about the program and subsequently communicates them to farmers via podcasts. It is delivered by an extension worker as follows.

> *"I've used FCFPAD as content in my podcast. I recorded the material and then delivered it in the podcast. I just started by introducing myself and explained that this is about FCFPAD, so let's listen to what the speakers say. Therefore, it's about recording and then delivering."* (Extension Worker, Sample 16).

This section illustrates the approach and process employed by extension workers to disseminate agricultural knowledge to farmers. Extension workers have processed agricultural information obtained from multiple digital sources and provided it to farmers. During the delivery process, extension workers and farmers are more involved in non-face to face interaction. The extension worker disseminates agricultural information to farmers using social media, websites, Zoom meetings, and Spotify. Not all agricultural information obtained by extension workers from digital sources is subsequently transmitted to farmers in a digital format. Certain agricultural extension workers lack competence in converting farm information into high-quality digital content suitable for distribution through platforms such as YouTube, TikTok, Facebook, and Podcasts. However, they are all capable of utilizing WhatsApp and Zoom meetings as media extensions.

3.3. Adoption of information by farmers through digital tools

The information conveyed by extension workers through various digital tools is adopted in diverse ways by farmers. Some farmers view the information and are interested in practicing, while others who have already practiced are yet to achieve success. Additionally, some farmers have implemented the information and achieved outcomes. A summary of these results is presented in **Table 3**.

Table 3. Level of adopting information received by farmers through digital media.

Adoption level	Description
Acknowledge and interested in practicing	The information provided by extension workers through digital tools is acknowledged by farmers who are interested in the implementation
Practiced but not yet confirmed results	Farmers have applied the information received digitally, but the results have not been confirmed.
Practiced and confirmed results	Farmers have applied the information received through digital tools and have achieved successful outcomes.

We observe a certain degree of adoption among farmers, where they recognize and have the intention to use the information provided by extension workers through digital technologies. A farmer reported witnessing the dry planting technique for rice

being demonstrated by an extension worker through the WA group. The farmer expressed an intention to adopt and execute this practice. On the other hand, an extension worker also discovered farmers' knowledge has increased through the use of digital agricultural information. However, it is necessary to continue motivating and supporting these farmers until they are both willing and capable of using this knowledge. In another case, it was found that "*Out of the 13 agricultural associations that were provided with digital material regarding Food Crop Farming Insurance, only one association proposed to enroll as an insurance participant. This indicates that 12 farmer groups are aware of the existence of a land protection strategy, but have not been motivated to become insurance participants"* (Extension Worker, Sample 14). Our findings indicate that the majority of farmers have been exposed to and acquired knowledge regarding agricultural information that is being disseminated to extension workers using online channels. However, they are now in the phase of experimenting with this information rather than fully accepting and applying it.

The adoption level, where farmers have attempted implementation but have not yet achieved success, was identified in certain situations reported by extension workers. Biosaka, when disseminated over certain digital channels, has been attempted by several farmers. However, its application was not executed in accordance with the suggested recommendations. According to the extension worker, "*Farmers believe that spraying Biosaka once is sufficient, despite the fact that it should be used on a weekly basis. Simply spraying and disregarding will certainly not be effective*" (Extension Workers, Sample 18). This indicates that the farmer has not comprehended the message conveyed by the extension worker in the exact manner that the extension worker intended. Regarding the dissemination of videos by extension farmers on rice fertilization, they expressed "*Uncertainty about the participation of farmers in rice fertilization, as mentioned in the video. However, it is undeniable that farmers' harvests have improved, suggesting that farmers may have adopted this invention*" (Extension Worker, Sample 10). At this stage of adoption, we discovered that certain farmers require more clarification to enhance the effectiveness of their implementation. This is particularly important in order to reconcile the significance of the information acquired by farmers and its interpretation through digital message.

The adoption level, where farmers have effectively used the knowledge provided by extension workers through online resources and obtained positive outcomes, has also been observed in several cases. An extension worker reported that "*Several farmers are implementing the dry-seeding technique that I demonstrated via video. Using this approach, the act of sowing is not performed immediately at the designated planting site, but rather in close proximity to their house. In addition, when it is time to harvest the seeds, the roots can be easily extracted, in contrast to the methods of directly sowing the seeds. These seeds exhibit strong growth and produce higher yields in comparison to rice that is planted directly*" (Extension Worker, Sample 9). This serves as evidence that some farmers have successfully implemented agricultural knowledge disseminated through digital media.

The outcomes of implementing digital agricultural information can also be found in the case of agricultural insurance. The extension worker reported that "*The farmers who I mentor have participated in Crop Insurance for informative purposes. Upon the occurrence of floods, the farmers proceeded to submit insurance claims and were duly*

remunerated for their incurred damages. During that period, there was only one individual who had managed to successfully obtain insurance in Maros. Afterwards, a number of farmers lodged claims and subsequently obtained compensation for their crop failures. Originally, a total of 20 hectares were suggested, however, upon examination by the insurance manager, only 16 hectares were deemed suitable for claims. The farmers got a payment of IDR 6 million per hectare, resulting in a total of IDR 96 million deposited into the farmers' collective account. By having this insurance, farmers are no longer completely responsible for the potential loss of crops caused by floods or insect diseases. Hence, the insurance program discovered with digital techniques is really advantageous" (Extension Worker, Sample 14). This demonstrates that the implementation of digital agricultural information transmission by extension workers has provided economic benefits to farmers in the form of compensation for losses caused by disasters.

Agricultural information on Biosaka also shows some cases of success in its implementation. Rice farmers achieved a significant increase in production, besides it is verified that although this technology has not been scientifically tested its advantages, it has been proven through the hard work achieves farmers. An extension worker illustrates this that *"for information about the Biosaka technology conveyed through video, farmers eventually decided to implement it. A farmer in Bantimurung, mentored by extension workers named H, achieved productivity of 8 tons per hectare of dry harvested rice. Although the Biosaka technology has not been scientifically verified for the effectiveness, farmers have proven that the technology is good and successful."* (Extension Worker, Sample 20).

The YESS project also follows the same principle, as its innovations are partially disseminated through online platforms. A group of young farmers have effectively adopted the technology package and the entrepreneurial qualities that were emphasized in the project. An extension worker said that *"in the YESS program, hydroponic farming is being encouraged. A millennial farmer received a competitive grant in 2022 from the Ministry of Agriculture to develop his business. The produce has already been marketed to supermarkets. Additionally, a young farmer named A, whom I initially enrolled in the program, successfully obtained a competitive grant worth Rp. 25 million. Presently, the population of his ducks has exceeded 1,000 from the initial few hundred. He was able to expand his business because his entrepreneurship flourished through digital information and direct mentoring provided by the YESS program"*. (Extension Worker, Sample 13).

The various adoption levels illustrated above indicate variation in the level of outcomes achieved through the variety of agricultural information distributed digitally by the extension worker. This is justified since there exists a disparity in digital literacy among farmers when it comes to embracing the information offered by extension workers.

3.4. Discussion

This study aimed to map the variety of digital platforms that serve as sources of extension materials, digital channels for delivering agricultural information to farmers, and the outcomes of the adoption. The analysis was based on the activities of extension

workers working at the AEC, serving as the frontline in agricultural extension services in Indonesia. Therefore, this study has specificity compared to previous studies that only discussed specific digital tools, commodities, and stages in digital extension.

The results showed that agricultural information was sourced from both the Ministry of Agriculture and external sources accessed by extension workers through various platforms, including social media, websites, Zoom meetings, e-services, Play Store, and Spotify. The digital content within these platforms is also diverse, including public platforms such as YouTube, WhatsApp, Instagram, Facebook, TikTok, and Telegram. Certain contents were also created programmatically by the government or private entities, including cyber extension, MAGEF, HFC, E-Allocation, E-Verification, and E-Evaluation, AEMS, Planting Calendar, My Agri, Smart Feed Agrinak, Cow Health Android Technology, Food Barn, personal blogs, JIVA, and podcasts. The digital channels for delivering this agricultural information to farmers are also diverse, catering to both individual and group recipients. The variety of sources and digital channels is consistent with Peterson (2023) stating that online interaction entails a wide array of platforms and content.

This study also found that adoption at the farmer level occurred at various levels including being aware and willing to practice, practicing but with unconfirmed results, and practicing with confirmed outcomes. The presence of early and late adopters is related to the asynchronous process in farmers' uptake of extension messages. This process allows farmers to take longer in deciding adoption actions (Berry, 2011; Clark and Brennan, 1991) resulting in different levels of adoption. Furthermore, the adoption actions of some farmers cannot be confirmed by extension workers. This is relevant to the anonymous characteristic in digital technology as conveyed by Lewis (2024).

The theoretical contribution of this study is that although extension content is delivered through non-face-to-face social interaction, it can still drive adoption with significant outcomes. This suggests that online non-face-to-face interactions have advantages capable of compensating for the weaknesses compared to face-to-face interaction. Online interaction can overcome discomfort caused by location, time, and institutions, providing advantages in terms of broader reach and communication channels (Qu et al., 2023).

One theoretical perspective relevant with this research is the concept of common ground building (Clark and Marshall, 1981; Clark and Carlson, 1982; Clark and Brennan, 1991). The term "farming communication through digital extensions" in this study refers to the importance of establishing a shared understanding and the process of establishing this understanding in the adoption of digital tools, as well as the results of this adoption. This indicates the necessity for the inclusion of "common ground building tools" within digital extension tools. The concept of "common ground building" has been discussed by Convertino et al. (2008), Convertino et al. (2009), and Convertino et al. (2011) across many levels of material and procedures, ranging from simple to complex. It has also been explored in relation to specific tools, such as the usage of video, as pioneered by Veinott et al. (1999).

4. Conclusion

In conclusion, this study successfully mapped the various agricultural

information sources accessed by extension workers digitally and delivered to farmers through digital channels. Based on the results, although social interaction between extension workers and farmers as information recipients occurs non-face-to-face, innovation can still be adopted with tangible outcomes. This is presumably related to the asynchronous process in digital extension, in which extension workers have sufficient time to improve the quality of the delivered information. Similarly, farmers have sufficient time to repeatedly assess the content information received.

The limitation of this research is that we are unable to track the digital skill of farmers in receiving the message delivered by the extension workers. The interaction between extension workers who have digital literacy and those who lack digital literacy may encourage mutual learning, enabling them to recognize the significance of acquiring competence in digital tools. Therefore, these aspects need to be considered in future studies.

The policy implications of the results suggest that digital extension may serve as a viable solution to the shortage of extension workers available for face-to-face and synchronous interactions with farmers. The use of digital extension, accompanied by strengthening the skills of extension workers and farmers, can enhance the effectiveness and reach of agricultural extension services.

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Conflict of interest: The authors declare that there is no conflict of interest.

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Appendix

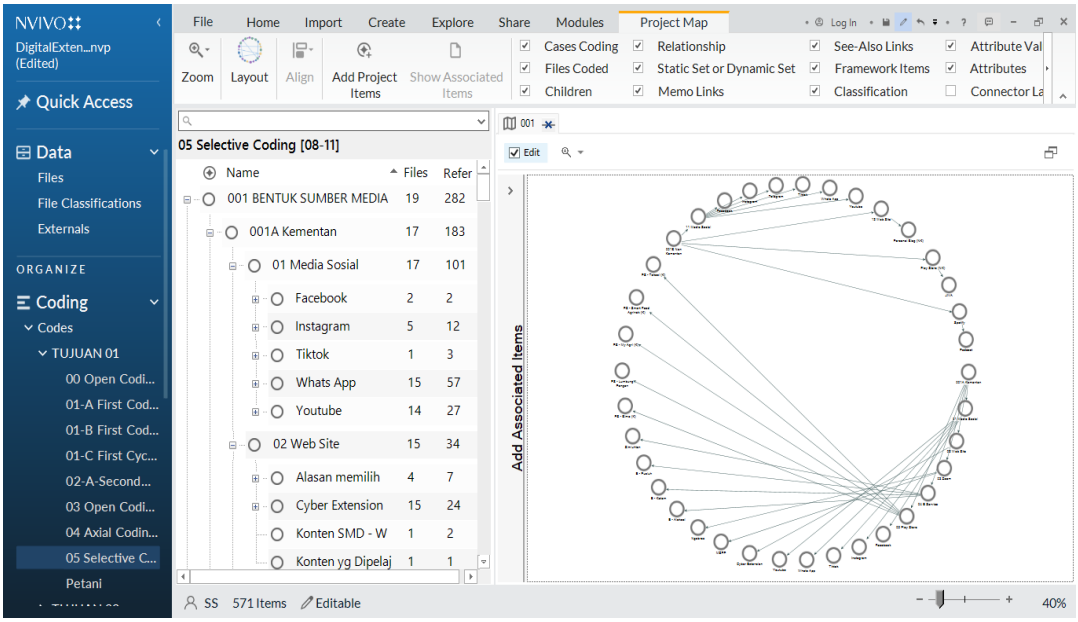

Figure A1. The categorization results of digital platforms for extension information sources in NVIVO Program.

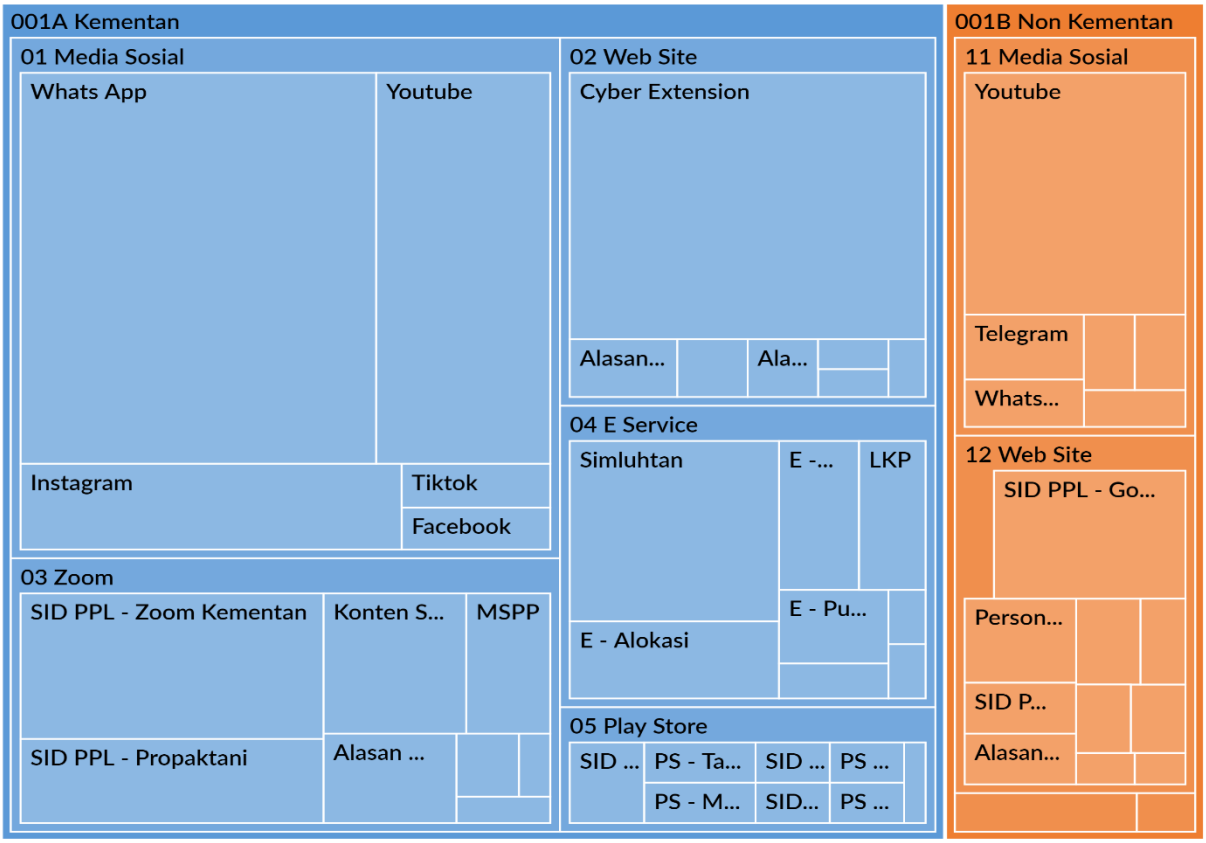

Figure A2. The categorization results of digital platforms for extension information sources in the form of a hierarchy chart.

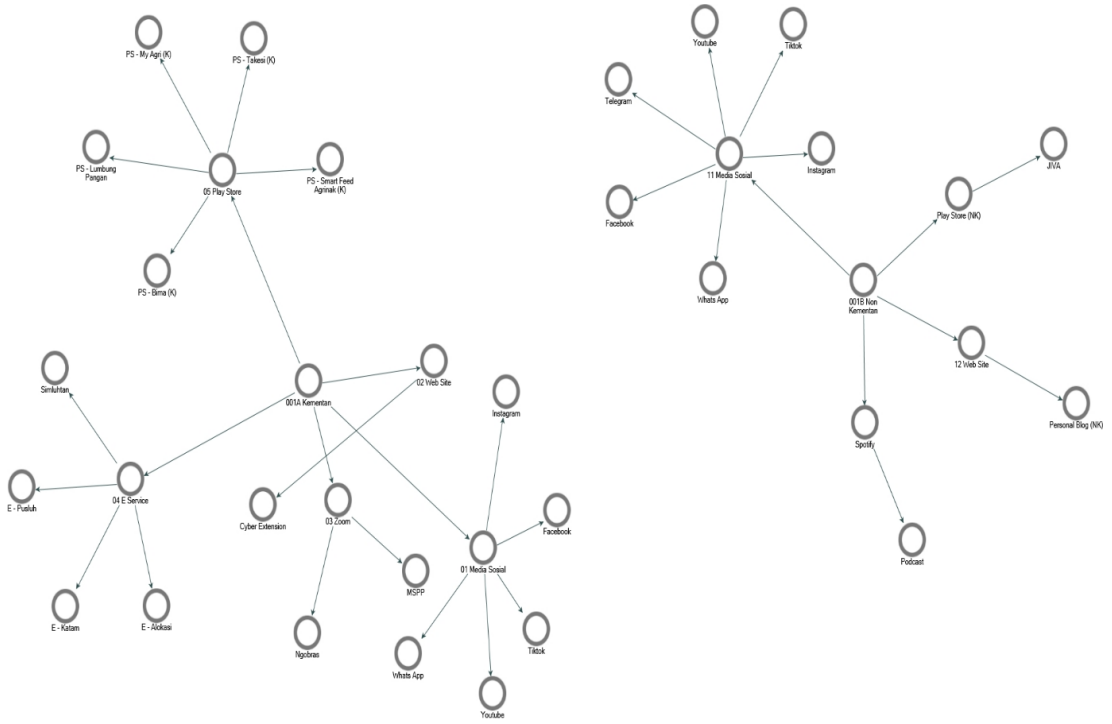

Figure A3. The categorization results of digital platforms for extension information sources in map form.

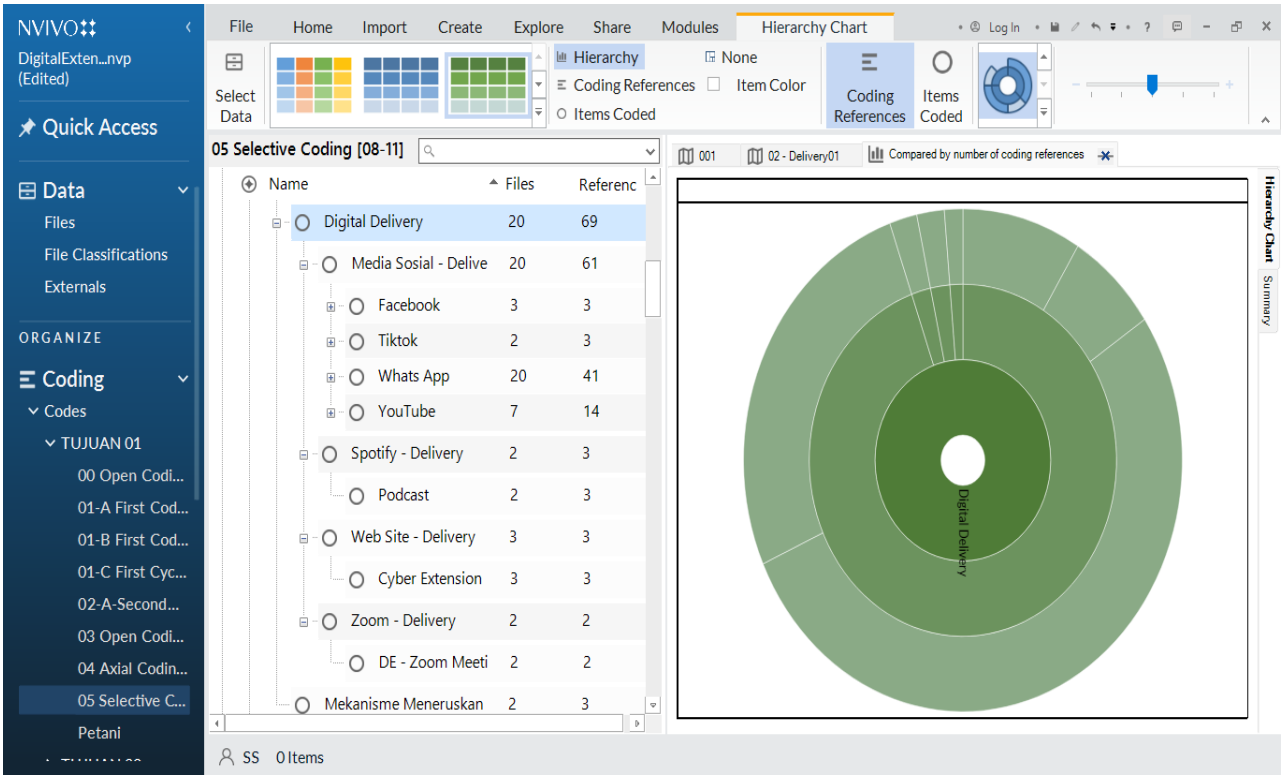

Figure A4. The categorization results of digital extension forms in delivering information to farmers (Non-Face-to-Face Interaction) in the NVIVO program.

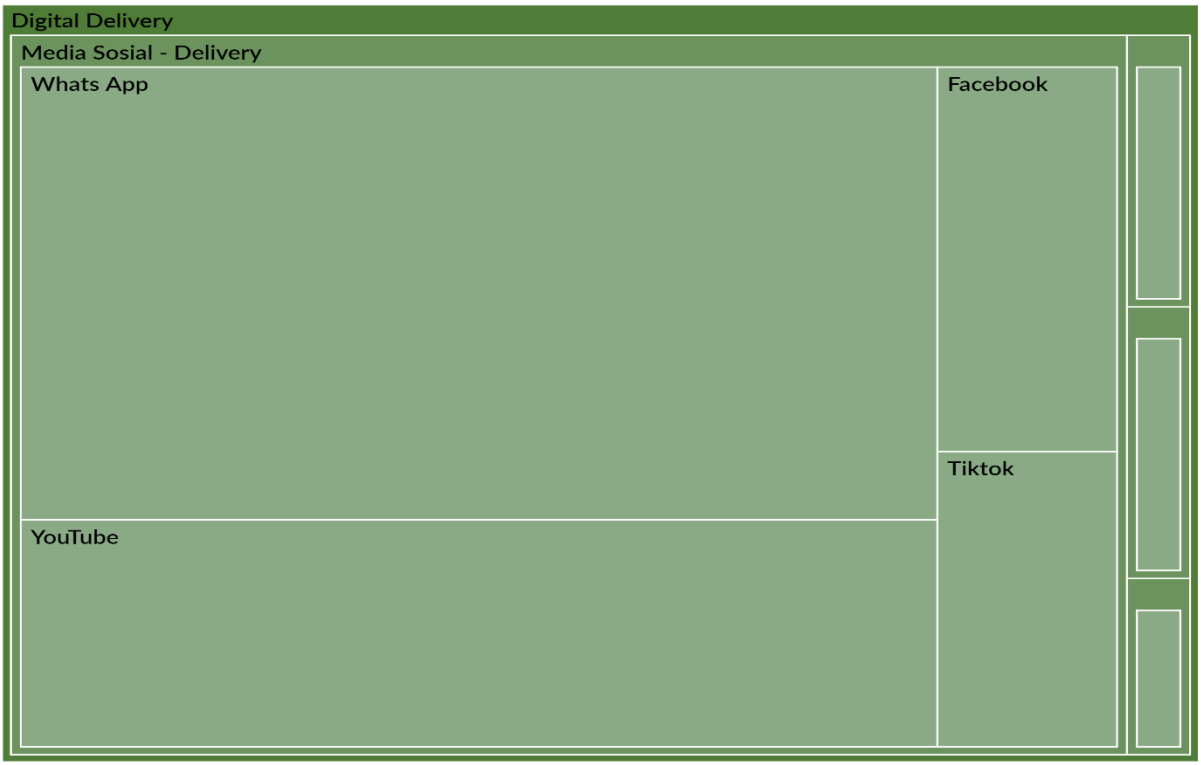

Figure A5. The categorization results of digital extension forms in delivering information to farmers (Non-Face-to-Face Interaction) in the form of a hierarchy chart.

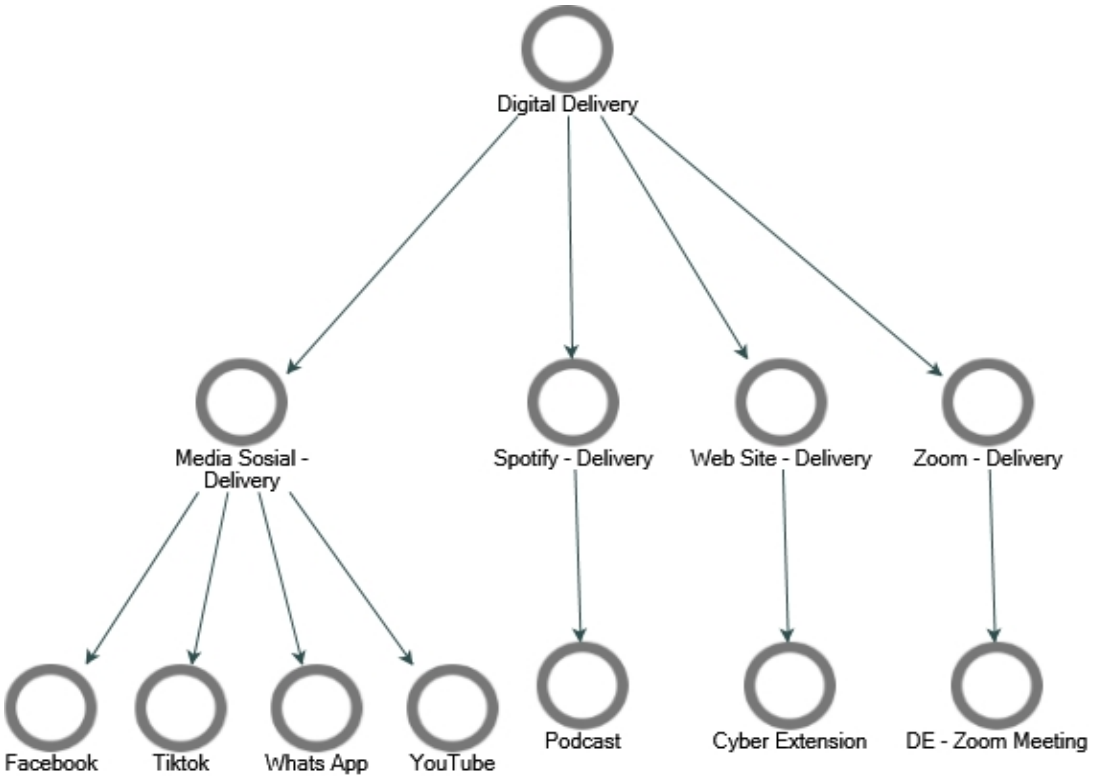

Figure A6. The categorization results of digital extension forms in delivering information to farmers (Non-Face-to-Face) in the form of a project map.

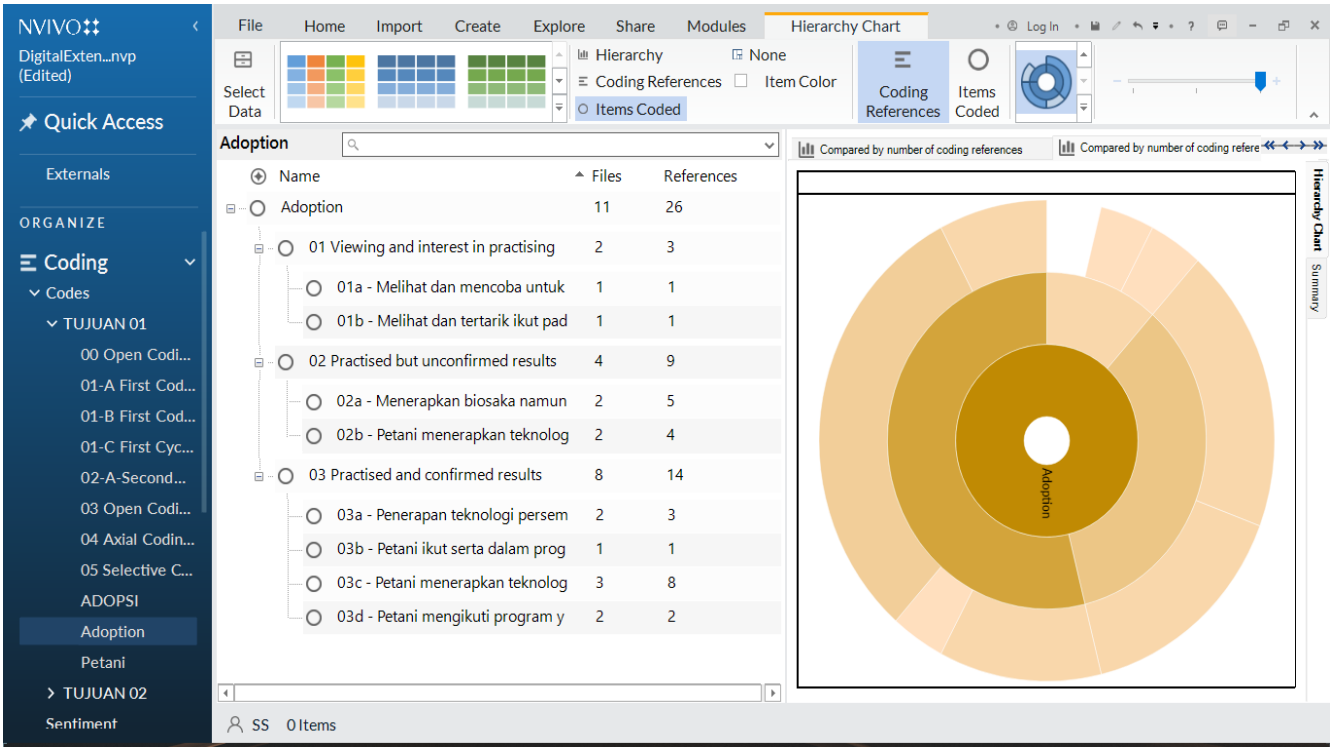

Figure A7. The categorization results of adoption levels of information received by farmers through digital media.

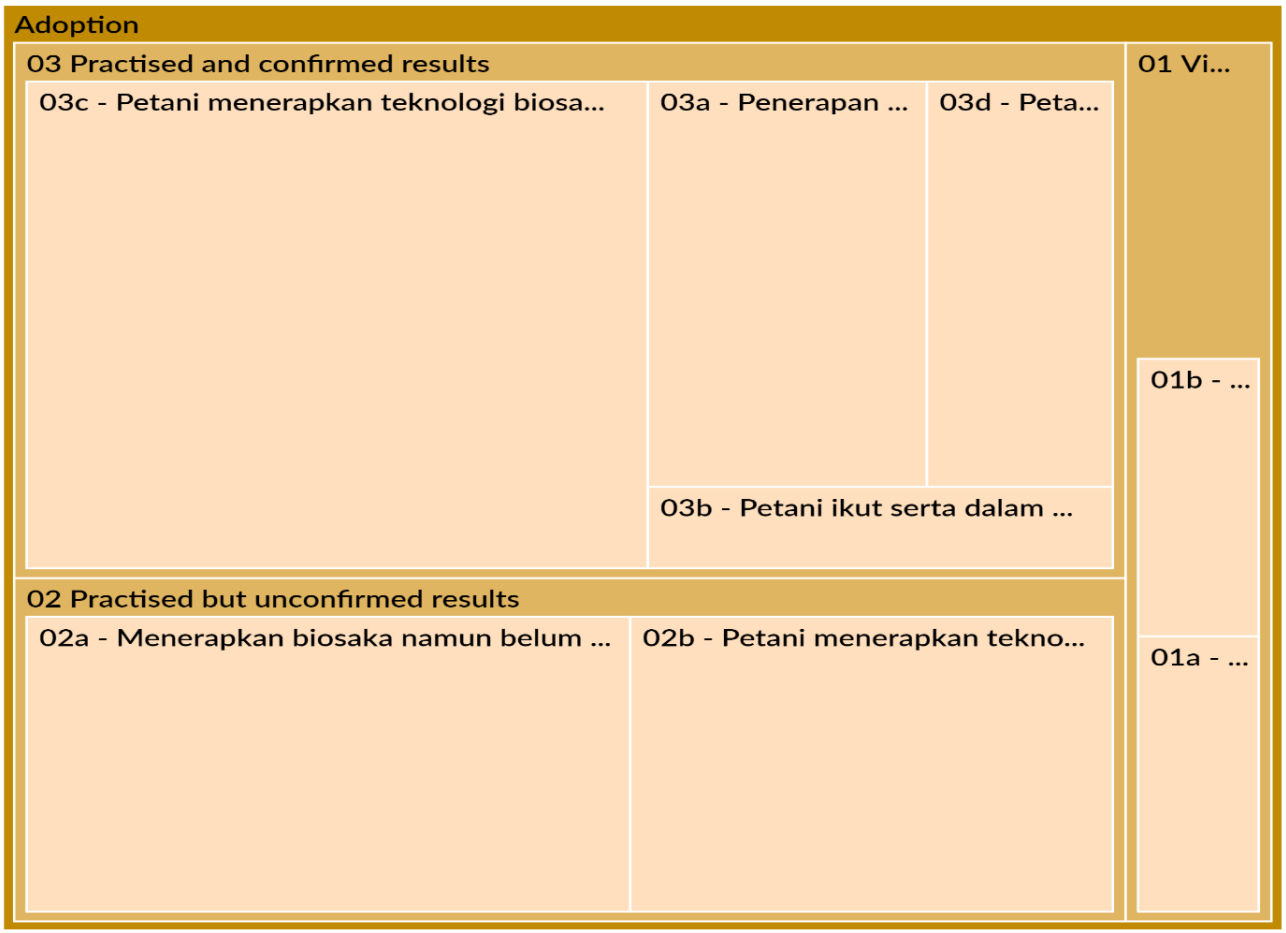

Figure A8. The categorization results of adoption levels of information received by farmers through digital media in the form of a hierarchy chart.

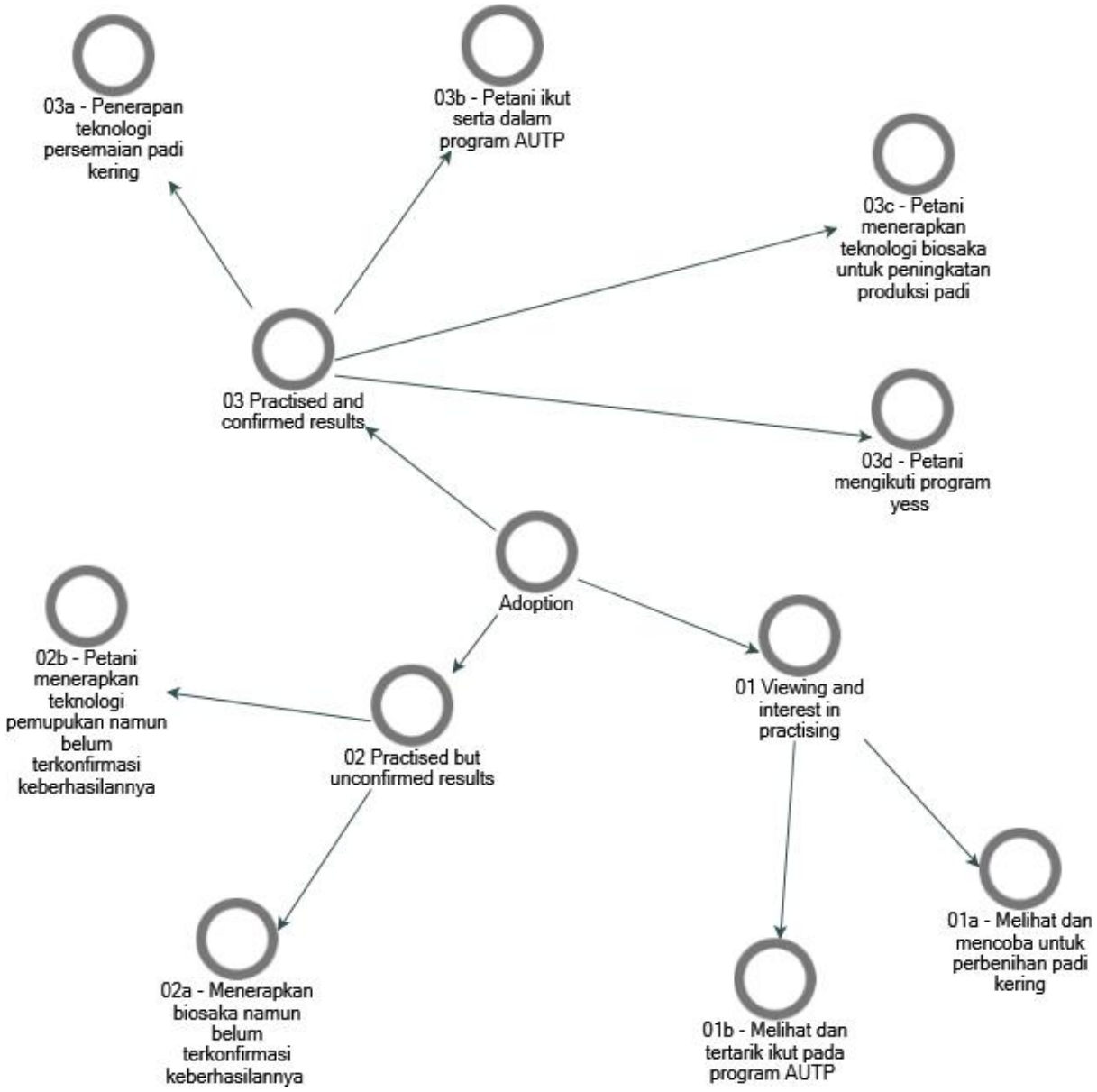

Figure A9. The categorization results of adoption levels of information received by farmers through digital media in the form of a project map.