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EDITED BY

Oluyede Clifford Ajayi,
Global Center on Adaptation, Netherlands

REVIEWED BY

Srinivas Katherasala,
Osmania University, India
Macire Kante,
University of Johannesburg, South Africa

*CORRESPONDENCE

Sukmawati Abdullah
✉ sukamawati.abdullah_faperta@uho.ac.id

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Rural community empowerment: strengthening the capacity of rice farmers based on cyber extension in Konda District South Konawe Regency

Sukmawati Abdullah^{1*} and Bunyamin²

¹Faculty of Agriculture, Halu Oleo University, Kendari, Indonesia, ²Faculty of Engineering, Halu Oleo University, Kendari, Indonesia

Introduction: Sustainable rural development requires strengthening farmers' capacities and leveraging Cyber Extension to address productivity stagnation, the digital divide, and limited access to information in support of the self-reliance of rice farmers. This study aims to analyze the role of capacity strengthening of rice farmers through the utilization of Cyber Extension in promoting rural community empowerment in Konda Subdistrict.

Methods: The study population comprised lowland rice farmers in Konda Subdistrict. The sample was selected using proportional random sampling. The research variables consisted of three components: farmers' capacity, utilization of Cyber Extension, and community empowerment. Data and information were described and interpreted through a logical analytical framework using both descriptive and inferential statistics within a structured analytical approach. Descriptive analysis employed class interval formulas, while inferential analysis referred to Structural Equation Modeling–Partial Least Squares (SEM-PLS), implemented using SmartPLS 3.0.

Results: Rural community empowerment in the lowland rice production centers of Konda Subdistrict is strongly influenced by farmers' capacity levels and the utilization of Cyber Extension as a digital extension instrument. Farmers' capacity was found to range from moderate to good; however, limitations persist in digital literacy and access to information technology. Structural relationship analysis revealed that farmers' capacity has a significant effect on the level of Cyber Extension utilization. Moreover, farmers' capacity exerts both a direct effect on rural community empowerment and an indirect effect mediated through Cyber Extension. These findings indicate that Cyber Extension functions as a mediating variable in the relationship between farmers' capacity and rural community empowerment.

Discussion: The findings affirm that Cyber Extension serves as a digital learning space that connects farmers to knowledge sources and extension services, while simultaneously strengthening interaction, learning processes, and the quality of decision-making in lowland rice farming management. The mediating role of Cyber Extension suggests that strengthening farmers' capacity does not automatically translate into empowerment without the support of an adaptive and inclusive digital extension system. Conceptually, these results enrich the rural community empowerment literature by proposing a model that positions Cyber Extension as a mechanism for transforming individual capacity into

collective empowerment, particularly in regions characterized by gaps in digital literacy.

KEYWORDS

agricultural development, agricultural innovation, capacity, community empowerment, cyber extension, independence

1 Introduction

Rural development plays a strategic role in ensuring national food security and improving the social welfare of communities in agrarian countries, including Indonesia (Rozaki, 2021). As a country with a strong agricultural economy, most of Indonesia's rural population depends on the agricultural sector for their livelihood, particularly on major food commodities such as paddy rice. However, despite the implementation of various agricultural development policies and programs, the productivity of paddy rice farmers in many rural areas has shown a stagnant trend over the past two decades (Yuan et al., 2022; Rachman et al., 2022). This condition indicates that the development approach that has been applied so far has not fully addressed the root causes of farmers' capacity and independence issues.

In this context, rural community empowerment can no longer be understood solely as an effort to increase income or distribute material assistance. Empowerment should be positioned as a process of strengthening the capacity of individuals and groups to manage resources, make independent decisions, and actively participate in development (Fischer and McKee, 2017). Eger et al. (2018), emphasize that sustainable empowerment can only be achieved through capacity building, not merely the transfer of resources. For farming communities, capacity building encompasses technical, managerial, and social dimensions that serve as the foundation for adaptation to climate change dynamics (Dang et al., 2019), agricultural technology developments (Coggins et al., 2022), and market and capital challenges (Miine et al., 2023). Local capacity building has been proven to strengthen farmers' resilience and adaptability in the face of environmental uncertainty and changing economic opportunities (Williams et al., 2019).

Conversely, various studies such as those by Mercer et al. (2010); George et al. (2016); Kelen et al. (2023); and Heaton et al. (2024) show that top-down empowerment approaches tend to fail to achieve community independence. This is due to the tendency to place farmers as objects of development, rather than subjects who have the knowledge, experience, and potential to develop autonomously. This condition is still commonly found in rural areas, including among rice farming communities in Konda Subdistrict, South Konawe Regency. Farmers in this region face complex challenges, ranging from limited production resources, low human resource capacity, to minimal access to agricultural information that is timely and relevant to local needs.

In addition, rice farming practices in Konda Subdistrict are still dominated by conventional methods that are inefficient in terms of land management and production inputs. Agricultural extension patterns that still rely on face-to-face meetings and are limited by space and time further weaken the knowledge transfer process (Biswas et al., 2021; Mungai et al., 2024). These limitations are exacerbated by farmers' low capacity to adopt and adapt to developments in agricultural technology (Fadeyi et al., 2022), which

ultimately impacts the low level of innovation, production efficiency, and competitiveness of paddy rice products at both the local and national levels.

In the context of rapid economic and social change, farmers' ability to access and utilize digital technology is a key factor for the sustainability of rural agriculture. Research by Connor et al. (2021) and Li et al. (2022) confirms that the use of information and communication technology through digital extension systems or Cyber Extension has the potential to accelerate the flow of information, improve the quality of farmer learning, and expand access to agricultural innovation. However, the adoption of digital extension services is greatly influenced by the level of trust in information sources, farmers' digital literacy, and the availability of supporting infrastructure (Sen et al., 2024).

As one of the rice production canters in South Konawe Regency, Konda District has great potential to be developed through the digital transformation of the agricultural sector. However, the digital divide remains a major issue, characterized by low digital literacy among farmers, limited internet access, a lack of supporting facilities, and the suboptimal capacity of extension workers to utilize digital platforms (Antwi-Agyei and Stringer, 2021; Asante, 2024; Coggins et al., 2022; Choruma et al., 2024). As a result, the dissemination of agricultural innovations and technologies, from the production stage to post-harvest, remains slow and uneven.

Furthermore, rural community development in Indonesia still tends to be structural in nature and has not fully touched on cultural and participatory aspects (Muhhtar et al., 2023). In Konda District itself, farmers are in a relatively weak position in terms of access to information, institutions, and the development decision-making process. In this context, Cyber Extension is seen as a strategic approach to strengthen the social and economic capacity of farmers through a more inclusive and participatory extension system (Baul et al., 2024; Ragetlie et al., 2022). Through this approach, farmers not only act as recipients of information but also as active actors in the management, exchange, and development of local knowledge based on digital technology.

Cyber Extension is an information and communication technology-based agricultural extension system that utilizes the internet to provide sustainable agricultural information, training, and consultation services (Akinboye et al., 2024). This system enables two-way interaction between farmers, extension workers, researchers, and the government, thereby strengthening the agricultural innovation ecosystem. Various studies, ranging from research by Cole and Fernando (2021); Abate et al. (2023); Xu et al. (2023); and Ndimbo et al. (2025), show that the use of Cyber Extension can increase production efficiency, expand market access, strengthen farmers' social networks, and improve farmers' bargaining position in the agricultural value chain. In addition, Cyber Extension also serves as a medium for continuous learning for farmers in facing the challenges of globalization and climate change (Waaswa et al., 2021).

Strengthening farmer capacity based on Cyber Extension requires a systematic, participatory, and community-based approach. Improving digital literacy needs to be accompanied by training, continuous mentoring, and strengthening local institutions so that this system can be managed independently and sustainably (Berg et al., 2020; Shang et al., 2021). This is increasingly important in line with Indonesia's rural development policy direction, which encourages transformation towards a smart and sustainable agriculture system (Djufry et al., 2022; Klerkx et al., 2019).

Although the use of information and communication technology in agricultural extension has been widely studied, most previous studies have focused on individual technology adoption, the effectiveness of specific digital platforms, or their impact on increasing farmer productivity and income (Kansiime et al., 2019; Cole and Fernando, 2021; Li et al., 2022). This approach generally positions Cyber Extension as a technical instrument for disseminating information, thus failing to comprehensively examine its role as a mechanism for empowering rural communities based on strengthening farmers' capacities. Furthermore, studies linking Cyber Extension with farmer empowerment are mostly normative and conceptual, with limited empirical evidence describing how these digital extension systems interact with farmers' technical, managerial, and social capacity-s in the local rural context (Baul et al., 2024; Ragetlie et al., 2022). In addition, existing research tends to ignore the participatory and local institutional dimensions, thus failing to adequately explain how farmers transform from information recipients to active actors in the management and production of digital-based knowledge.

Based on this description, this study uses an integrative approach that positions Cyber Extension not only as a digital extension medium, but also as an instrument for empowering rural communities that is oriented towards strengthening the multidimensional capacity of farmers. This study aims to analyze the role of strengthening the capacity of rice farmers based on the use of Cyber Extension in promoting rural community empowerment in Konda District, South Konawe Regency. It empirically examines the level of farmer capacity, the level of utilization of Cyber Extension as a digital extension system, and the level of rural community empowerment. Furthermore, this study analyzes the influence of farmer capacity on the utilization of Cyber Extension and rural community empowerment, the direct influence of Cyber Extension utilization on community empowerment, and the mediating role of Cyber Extension in the relationship between farmer capacity and rural community empowerment. Ultimately, this research aims to formulate or develop a contextual, participatory, and sustainable model of rural community empowerment through strengthening farmer capacity based on digital extension.

2 Materials and methods

2.1 Research design

This research was conducted from February to May 2025 in Konda District, South Konawe Regency, Indonesia. This study used a quantitative approach with an exploratory survey design to analyze the relationship between farmer capacity, the use of Cyber Extension, and rural community empowerment in rice production canters in Konda District, South Konawe Regency. The research population

included all paddy rice farmers active in the area, totaling 215 people. The sample frame was compiled based on a list of active farmer group members obtained from field agricultural extension workers and local agricultural agencies in 2024, so that all population units had an equal chance of being selected as respondents in the study.

The sample size was determined using the Slovin formula with a margin of error of 5%, resulting in 140 respondents. Respondents were selected through proportional random sampling, in which the number of samples in each farmer group was determined proportionally based on the size of the group, and then respondents were randomly selected from the list of active farmer group members. Data collection was carried out through field observations, structured surveys using questionnaires, and documentation studies. All questionnaires distributed were returned and deemed suitable for analysis, resulting in a response rate of 100 percent. However, this study has the potential for sampling bias because it only covers farmers who are members of active farmer groups, so the results of the study are exploratory and need to be interpreted contextually.

2.2 Research variables

The variables in this study consist of three parts, namely farmer capacity, utilization of Cyber Extension, and community empowerment. The farmer capacity variable (X1) includes: (X1.1) farmers' ability to manage their farms, (X1.2) Decision-making ability, (X1.3) Ability to optimize available resources, (X1.4) farmers' practical knowledge in running their farms, (X1.5) practical skills in running farming businesses, (X1.6) Ability to interact and cooperate, (X1.7) Ability to build social networks, (X1.8) Ability to adapt to the environment, (X1.9) Ability to solve problems together, and (X1.10) Ability to communicate effectively. Cyber Extension utilization variables (X2) which include: (X2.1) Media for the dissemination of agricultural information, (X2.2) Facilitating farmers' access to agricultural information, (X2.3) Learning tools for farmers, (X2.4) Tools for agricultural development facilitation activities, (X2.5) Information exchange media, and (X2.6) Media for documenting agricultural information at the local level. Then for the rural community empowerment variable (Y), which includes: (Y1) Farming business development, (Y2) Improving access to capital for farmers, (Y3) Developing local potential, (Y4) Improving the capacity of individual farmers, (Y5) Improving welfare through job creation, (Y6) Training and mentoring activities, (Y7) Strengthening village institutions, (Y8) Management of accountable, open, and transparent institutions, (Y9) Development of basic regional infrastructure, (Y10) Increased access to information and technology, and (Y11) Easy access to resources in a fair manner. Variable measurement was carried out using a Likert scale (Harpe, 2015; Robinson, 2023), namely: very high/good (score = 5), high/good (score = 4), moderate/fair (3), low/poor (score = 2), and very low/poor (score = 1).

2.3 Data analysis

Data and information were described and interpreted according to logical flow through the application of descriptive and inferential statistics using a systems approach and analysis. Descriptive analysis was used to describe and explain in detail and depth the conditions of

farmer capacity, the use of Cyber Extension, and rural community empowerment. Descriptive analysis was conducted using class interval formulas to categorize data into three groups, namely low, medium, and high. Thus, the categories found were low/poor (values 1–2.3), medium/fair (2.4–3.6), and high/good (3.7–5).

Further analysis was conducted using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with several methodological considerations. First, PLS-SEM is appropriate for exploratory research and model development, especially when the relationship between constructs still requires empirical testing in a specific local context. Second, this method is effective for medium sample sizes and does not require strict assumptions of normal distribution, making it relevant to the characteristics of survey data on rural farming communities. Third, PLS-SEM allows for the simultaneous testing of direct and indirect relationships (mediating effects) between farmer capacity, Cyber Extension utilization, and rural community empowerment. In addition, this approach provides the advantage of evaluating measurement models and structural models simultaneously, thereby capturing the complexity of latent relationships in the process of digital extension-based empowerment.

Inferential analysis refers to Structural Equation Modeling–Partial Least Squares (SEM-PLS) analysis conducted using the SmartPLS 3.0 program. SEM analysis is an equation model of PLS using a variance-based or component-based structural equation modeling approach. This analysis aims to build or develop theory (Henseler, 2018; Hair et al., 2019). SEM-PLS analysis itself consists of four stages, namely measurement model design, outer model, inner model, and hypothesis testing.

In evaluating the relationship between indicators and latent variables to be observed, the role of the outer model is very important in a standard research framework. Several criteria are set for a model to be valid. These criteria are convergent validity, discriminant validity, composite reliability, and Cronbach's alpha. A factor loading value >0.50 is the standard value for measuring convergent validity (Cheung et al., 2024; Guenther et al., 2023). In formulating a research model, an Average Variance Extracted (AVE) value >0.50 is a general requirement. A Heterotrait-Monotrait Ratio (HTMT) value <0.90 is a general prerequisite. The AVE and HTMT values represent Discriminant Validity. In addition, composite reliability and Cronbach's alpha values >0.70 are requirements that must be met. The collinearity test was conducted using the Variance Inflation Factor (VIF) with a VIF value requirement of <5.0 for the model to be accepted.

The next stage is the inner model, which aims to describe the relationship between data and latent variables in the theory to be developed. The tests consist of Path Coefficient analysis, R -square (R^2), Goodness of Fit (GoF), and Q -square (Q^2). Path Coefficient shows the direction (positive or negative) of the influence between latent variables. A positive relationship is indicated by a Path Coefficient value close to $+1$, and vice versa (Sarstedt et al., 2021). The R -square (R^2) test aims to measure the extent to which exogenous variables explain endogenous variables. The Goodness of Fit (GoF) analysis aims to see the extent to which the observed data is consistent with the proposed model. Goodness of Fit formula = $\sqrt{(AVE \times R^2)}$ (Tenenhaus et al., 2004). Q -square analysis assesses the model in terms of predictive relevance. A higher Q -square value (>0) indicates better predictive relevance of the proposed model, and vice versa (Chin, 1998).

2.4 Research hypotheses

The hypotheses were tested using the Bootstrapping method in the SmartPLS 3.0 program. The hypotheses proposed in this study are:

H1: The capacity of rice farmers has a significant effect on the use of Cyber Extension as a digital extension system in Konda District.

H2: The capacity of rice farmers has a significant effect on the empowerment of rural communities in Konda District.

H3: The utilization of Cyber Extension has a significant effect on rural community empowerment in Konda District.

H4: The capacity of rice farmers through the use of Cyber Extension has a significant effect on rural community empowerment in Konda District.

3 Results and discussion

3.1 Farmer capacity

Farmer capacity is one of the main factors in achieving successful agricultural development, especially in rural community empowerment programs. According to Chambers and Conway (1992); Uphoff and Dazzo (2016), farmer capacity is the ability of farmers to manage and utilize resources, apply agricultural innovations, and make appropriate decisions to increase the productivity of their farms while maintaining sustainability. Farmer capacity is not only measured by technical ability, but also by the managerial and social abilities of farmers, which support each other in forming the ability to adapt to change. In this study, the capacity of rice farmers in Konda District can be seen in Table 1.

Table 1 above shows that the capacity level of rice farmers in Konda Subdistrict is in the moderate category with an average score of 3.58. This means that rice farmers have sufficient capacity to run and manage their farms. In addition, this situation shows that there is still potential for developing or increasing farmer capacity. Based on the farmer capacity indicators, out of the 10 indicators, only three are in the high category, while the other seven are in the moderate category. The farmer capacity indicators in the high category are farmers' ability to manage their farms (3.79), their ability to adapt to the environment (4.39), and their ability to solve problems together (3.82). Meanwhile, the farmer capacity indicators in the moderate category are decision-making ability (3.33), the ability to optimize available resources (3.22), practical knowledge of farming (3.55), practical farming skills (3.38), ability to interact and cooperate (3.29), ability to build social networks (3.46), and ability to communicate effectively (3.59).

In general, the capacity of rice farmers in Konda Subdistrict has demonstrated that farmers have a fairly good basic ability to manage their businesses. Therefore, strategic actions are needed to jointly strengthen managerial, technical, and social aspects. Strengthening farmer capacity aims to enhance the competitiveness of the agricultural sector and accelerate the adoption of appropriate innovations in line with farmers' needs (Tambo and Wünscher, 2018). Additionally, it will have an impact on the economic independence of

TABLE 1 Capacity of rice farmers.

No.	Farmer capacity indicators	Average value	Category
1	Farmers' ability to manage their farms	3.79	High
2	Decision-making ability	3.33	Moderate
3	Ability to optimize available resources	3.22	Moderate
4	Farmers' practical knowledge in running their farms	3.55	Moderate
5	Practical skills in running a farming business	3.38	Moderate
6	Ability to interact and cooperate	3.29	Moderate
7	Ability to build social networks	3.46	Moderate
8	Ability to adapt to the environment	4.39	High
9	Ability to solve problems together	3.82	High
10	Effective communication skills	3.59	Moderate
Average farmer capacity		3.58	Medium

farming households in terms of sustainability. [Vrabcová and Urbancová \(2023\)](#) state that managerial skills, technical skills, and market access are the main factors in enhancing the competitiveness of sustainable farming through agricultural innovation.

3.2 Use of cyber extension

Cyber Extension is an agricultural extension system based on information and communication technology that aims to expand the coverage of extension services to target audiences or farmers. In addition, Cyber Extension can be defined as a medium for information, communication, and education that utilizes the internet as a medium of interaction between farmers, extension workers, the government, researchers, and the private sector ([Akinboye et al., 2024](#)). By using this system, farmers are able to access various agricultural information, ranging from technological innovations, market prices, government policies, and others. The use of Cyber Extension has a positive impact on farmers ([Zhang et al., 2016](#)). Farmers are able to easily access and search for agricultural information according to their needs. In this study, the level of Cyber Extension utilization in Konda District can be seen in [Table 2](#).

[Table 2](#) shows that the level of Cyber Extension utilization by rice farmers in Konda Subdistrict is in the moderate category with an average score of 3.34. This result indicates that farmers are aware of and have begun to utilize Cyber Extension as a means of extension and community empowerment, although it has not been utilized to its

TABLE 2 Utilization of cyber extension.

No.	Cyber extension utilization indicators	Average score	Category
1	Media for the dissemination and distribution of agricultural information	3.36	Moderate
2	Facilitating farmers' access to agricultural information	3.51	Moderate
3	Learning tools for farmers	3.35	Moderate
4	Facilities for agricultural development facilitation activities	3.21	Moderate
5	Information exchange media	3.24	Moderate
6	Local agricultural information documentation media	3.38	Moderate
Average utilization of cyber extension		3.34	Moderate

full potential. The integration of Cyber Extension into farmers' daily activities has not yet become a habit. Therefore, extension workers play a role as intermediaries for farmers in obtaining the agricultural information they need. This can be seen from the indicators of Cyber Extension utilization, which are all in the moderate category. These indicators are the media for the dissemination of agricultural information (3.36), facilitating farmers' access to agricultural information (3.51), learning tools for farmers (3.35), tools for development facilitation activities (3.21), information exchange media (3.24), and media for documenting agricultural information at the local level (3.38).

The use of Cyber Extension is still in its early stages among rice farmers in Konda District in their journey toward digital transformation in the agricultural sector. Many factors hinder this digital transformation process, ranging from inadequate internet networks, lack of knowledge in using technology, and limited assistance in digital literacy. This situation has resulted in most rice farmers still not being accustomed to using the Cyber Extension system to increase the productivity of their farms. Therefore, the use of Cyber Extension through strengthening the digital capacity of farmers and extension workers needs to be carried out ([Afzal et al., 2016](#)). The government and related institutions need to take action to support the integration of the Cyber Extension system. [Mushi et al. \(2024\)](#) found that the integration of digital agricultural systems through platforms or applications provides potential benefits and convenience for farmers in accessing technical information, markets, and capital services. Active efforts will encourage farmers to play an active role, not just as recipients of information and benefits, in

accelerating community empowerment activities. Arnés et al. (2018), found that the learning process for farmers through appropriate digital agricultural systems will encourage community participation, increase confidence, and improve the ability to identify, test, and apply new innovations, thereby impacting community empowerment as seen through increased participation, capacity, and resource management.

3.3 Empowerment of rural communities

Rural community empowerment is a process of improving the capabilities and independence of communities through active participation in managing their potential to achieve prosperity. Gutierrez (2023) states that participation in development activities does not always result in empowerment. Therefore, appropriate and sustainable strategies are needed to achieve the goals of empowerment. In empowerment activities, communities are not only limited to being objects of development, but also subjects in development who play a role in the planning, implementation, and supervision of activities (Haldane et al., 2019; Luisi and Hämel, 2021). In this study, rural community empowerment is divided into four dimensions, namely economic, social, institutional, and infrastructure and community access. From these four dimensions, rural community empowerment is then measured based on eleven indicators. The results of the study related to rural community empowerment in Konda District can be seen in Table 3.

Table 3 shows that rural community empowerment in Konda Subdistrict is in the moderate category with an average score of 3.48. This result means that efforts in community empowerment activities have been quite successful, but in terms of achieving independence and welfare for the farming community, they have not been maximized. Of all the indicators measuring rural community empowerment, only 4 are in the high category, while the other 6 are in the moderate category. The indicators in the high category are agricultural development (4.17), strengthening village institutions (3.69), accountable and transparent management of institutions (3.79), and development of basic regional infrastructure (4.29). The indicators in the moderate category are increasing access to capital for farmers (2.87), development of local potential (3.49), improvement of individual capacity (3.41), improvement of welfare through increased employment (3.01), training and mentoring activities (3.31), improvement of access to information and technology (2.81), and ease of access to resources in a fair manner (3.41). Most indicators are still classified as moderate, indicating that there is still potential for further improvement.

Community empowerment activities in Konda Subdistrict are still limited to strengthening basic and institutional capacities, and have not yet fully led to farmer independence. Empowerment activities should be aimed at strengthening human resource capacity, adopting agricultural technology (Shikuku, 2019), and developing farmers' entrepreneurial skills in order to encourage the community to adapt to existing changes and challenges and to be able to identify and take advantage of market opportunities (Takahashi et al., 2020). In addition, a partnership network needs to be established between farmers, extension workers, the government, and capital institutions to develop farmers' access to information, business capital, and innovation in the agricultural sector. Rural community empowerment

TABLE 3 Rural community empowerment.

No.	Rural community empowerment indicators	Average score	Category
1	Agricultural development	4.17	High
2	Improving access to capital for farmers	2.87	Moderate
3	Development of local potential	3.49	Moderate
4	Improvement of individual farmer capacity	3.41	Moderate
5	Improvement of welfare through job creation	3.01	Moderate
6	Training and mentoring activities	3.31	Moderate
7	Strengthening village institutions	3.69	High
8	Accountable and transparent institutional management	3.79	High
9	Regional basic infrastructure development	4.29	High
10	Improved access to information and technology	2.81	Moderate
11	Ease of access to resources in a fair manner	3.41	Moderate
Average rural community empowerment		3.48	Moderate

strategies need to be developed based on the principles of participation and sustainability to improve economic welfare and strengthen social independence and community capacity in independently managing village potential for development (Berg et al., 2020). A study by Dushkova and Ivlieva (2024) found that empowerment programs designed based on the principles of participation and sustainability will increase the capacity of communities to manage local resources and minimize risks.

3.4 The influence of farmer capacity through the use of cyber extension on rural community empowerment

Farmer capacity is one of the main factors in achieving successful agricultural development, especially in rural community empowerment programs. Farmer capacity can be improved through various activities such as training, mentoring, and agricultural extension (Norton and Alwang, 2020). However, conventional methods still face major problems, especially in terms of space and time limitations. In today's digital era, there is a need for an approach based on information and communication technology so that the process of increasing farmer capacity can continue and be sustainable

(Baul et al., 2024). Extension and training activities as well as information dissemination can be carried out by utilizing the Cyber Extension system. Cyber Extension itself is a medium for information, communication, and education that utilizes the internet as a medium of interaction between farmers, extension workers, the government, researchers, and the private sector (Akinboye et al., 2024). Proper utilization of Cyber Extension will increase farmers' capacity, empowering them to independently achieve prosperity, which will indirectly impact the empowerment of rural communities.

The influence of farmer capacity through the use of Cyber Extension on rural community empowerment in this study was analyzed using SmartPLS 3.0 software. The results of the analysis of the influence of farmer capacity through the use of Cyber Extension on rural community empowerment were measured from the Bootstrapping analysis output in SmartPLS, which is presented in Table 4.

3.4.1 The influence of farmer capacity on the use of cyber extension

The results in Table 4 show that farmer capacity has a positive (coefficient value of 0.730) and significant (p value of 0.000 or t statistic of 7.401) effect on the use of Cyber Extension. This means that the higher and better the capacity of farmers, the better the level of Cyber Extension utilization in supporting farming activities. Farmer capacity is a key factor in improving managerial, social, and technical abilities in understanding and accessing information and managing existing resources effectively using information and communication technology media. Farmer capacity will increase through the learning content available on the Cyber Extension system, which farmers can access and learn independently. In addition, it can also serve as a communication medium for farmers to ask questions or consult with extension workers and researchers regarding the problems they face. Yuan and Sun (2024) revealed that increasing farmer capacity significantly encourages the adoption of digital technologies such as the Cyber Extension system. Zhang and Fan (2024) state that farmers with good technological literacy will find it easier to adapt to technological developments and agricultural innovations. One such digital technology is Cyber Extension, which is capable of providing information in the agricultural sector quickly and accurately. Baul et al. (2024) state that the role of multimedia assistance and training for farmers can improve the process of adopting digital services.

3.4.2 The influence of farmer capacity on rural community empowerment

The results of the study in Table 4 show that farmer capacity has a positive (coefficient value of 0.531) and significant (p value of 0.000 or t statistic of 7.401) effect on rural community empowerment. These results mean that improving farmer capacity will lead to better rural community empowerment. High capacity will encourage farmers to think critically about their farming activities, enabling them to make the right decisions independently and manage agricultural resources efficiently. Community empowerment activities are always aimed at achieving independence for the community itself, especially in achieving prosperity. Farmers with good capacity in managing and running their farms will obtain better results than farmers with low capacity. Capacity itself is closely related to an individual's ability to utilize their strengths and weaknesses in farming to achieve the best results. Dushkova and Ivlieva (2024) emphasize that a person's capacity is the main asset in community empowerment activities. Marinus et al. (2021) reveal that farmers with high capacity tend to be more innovative and adaptable to changes in their farming activities and are able to play an active role in improving economic and social networks in rural communities. Han et al. (2022) add that social capacity (trust, networks, and group participation) is an important aspect in encouraging farmers to adopt new technologies. Farmers' capacity, supported by social networks, will increase opportunities for collaboration between innovation and the economy, which can improve the success of community empowerment activities in rural areas.

3.4.3 The influence of cyber extension utilization on rural community empowerment

The results in Table 4 show that the use of Cyber Extension has a positive (coefficient value of 0.380) and significant (p value of 0.000 or t statistic of 4.941) effect on rural community empowerment. This result means that the more effectively farmers utilize the Cyber Extension system, the greater the impact on community empowerment activities, which are felt both directly and indirectly by farmers. Cyber Extension serves as a learning medium for farmers and a medium for accessing information, agricultural innovations, and a medium of communication between farmers and extension workers (Akinboye et al., 2024). Revell and Dinnie (2020) state that community empowerment is essentially the process of enabling individuals to achieve prosperity without depending on others. To achieve independence in agricultural development, it is necessary to improve

TABLE 4 The influence of farmer capacity and cyber extension utilization on rural community empowerment.

Construct	Original sample (O)	Sample mean (M)	t statistics (O/STDEV)	p -values
Farmer capacity (X1)→cyber extension utilization (X2)	0.730	0.730	21.075	0.000
Farmer capacity (X1)→rural community empowerment (Y)	0.531	0.543	7.401	0.000
Cyber extension utilization (X2)→rural community empowerment (Y)	0.380	0.370	4.941	0.000
Farmer capacity (X1)→cyber extension utilization (X2)→rural community empowerment (Y)	0.277	0.271	4.358	0.000

the skills and knowledge of the community, particularly regarding their ability to access useful information for improving their businesses and productivity. When farmers have easy and direct access to agricultural information sources that can be opened and connected at any time, it will indirectly make farmers aware and understand developments in the agricultural sector. With this awareness, farmers will tend to be encouraged to keep up with developments by adapting and even applying the information they obtain through the Cyber Extension system. Thus, a well-utilized Cyber Extension system will not only be a platform for information diffusion (Yuan and Sun, 2024), but will also have many benefits for farmers and agricultural actors (Li et al., 2024), especially in rural community empowerment activities. Mao et al. (2024) emphasize that the use of Cyber Extension can improve the innovation adoption process, increase farming efficiency, and enable effective decision-making. Information and communication technology is an important factor in the transformation of rural communities into urban communities that are more productive and adaptive to digital developments. Ding et al. (2022) mention that the combination of digital services and field assistants provides more effective results, especially in supporting sustainable empowerment activities.

3.4.4 The influence of farmer capacity on rural community empowerment through the use of cyber extension

The results of the study in Table 4 show that the indirect effect of farmer capacity on rural community empowerment through the use of Cyber Extension shows positive results (coefficient value of 0.277) and is significant (p value of 0.000 or t statistic of 4.358). These results indicate that the use of Cyber Extension serves as a strategic connecting mechanism that amplifies the role of farmer capacity in promoting the process of rural community empowerment. Rice farmers with high capacity levels will be able to utilize the Cyber Extension system to support and increase the productivity of their farms, which will in turn have an impact on the level of empowerment of the community itself. The use of Cyber Extension is like accessing information and technological innovations as well as better crop cultivation techniques than conventional or traditional methods. In addition, this system is also used as a means of accessing market information, especially related to the selling price of agricultural products (Coggins et al., 2022).

Capacity is an indication of how well a farmer runs his farm (Czyżewski et al., 2021). Changes in the agricultural sector are constantly occurring and transforming in line with the times. Baiyegunhi (2024) states that the capacity of individuals and groups that is constantly being developed contributes to the productivity and efficiency of farming. Farmers who are unable to keep up with these changes will inevitably suffer losses in their farming businesses. Therefore, farmers must also continue to develop themselves, either through self-study or by involving other parties. In today's digital era, with the rapid development of information and communication technology, there are opportunities to be exploited to increase the capacity of farmers. Cyber Extension serves as a bridge in increasing the capacity of farmers in community empowerment activities in rural areas (Ding et al., 2022; Kansime et al., 2019). With the various benefits provided by Cyber Extension to farmers, especially as an intermediary in accessing various agricultural information, this system plays a crucial role in empowerment activities. Maximizing the

use of Cyber Extension will increase farmers' capacity so that the community becomes empowered and agricultural development goals are achieved. Thomas et al. (2017); Eyeyien et al. (2024) state that the combination of human resource capacity and the use of information technology is an effective approach and strategy in strengthening community empowerment. This is especially true in rural areas that need to improve the quality and capacity of their human resources. Sen et al. (2025) emphasize that in order to achieve community empowerment, an approach through interactive digital services and local capacity building activities is needed.

3.5 Model for rural community empowerment through capacity building for farmers based on the use of cyber extension

In formulating a model for rural community empowerment through farmer capacity building based on the use of Cyber Extension, the SmartPLS 3.0 program was used. The Partial Least Squares–Structural Equation Modeling (PLS–SEM) approach was used to analyze the research data. This analysis is a technique used to predict or refine an existing theory (Garson, 2016). The approach using this analysis consists of four stages, namely the formulation of a theory for the research model, testing the outer model, testing the inner model, and testing the hypothesis (Hair et al., 2014).

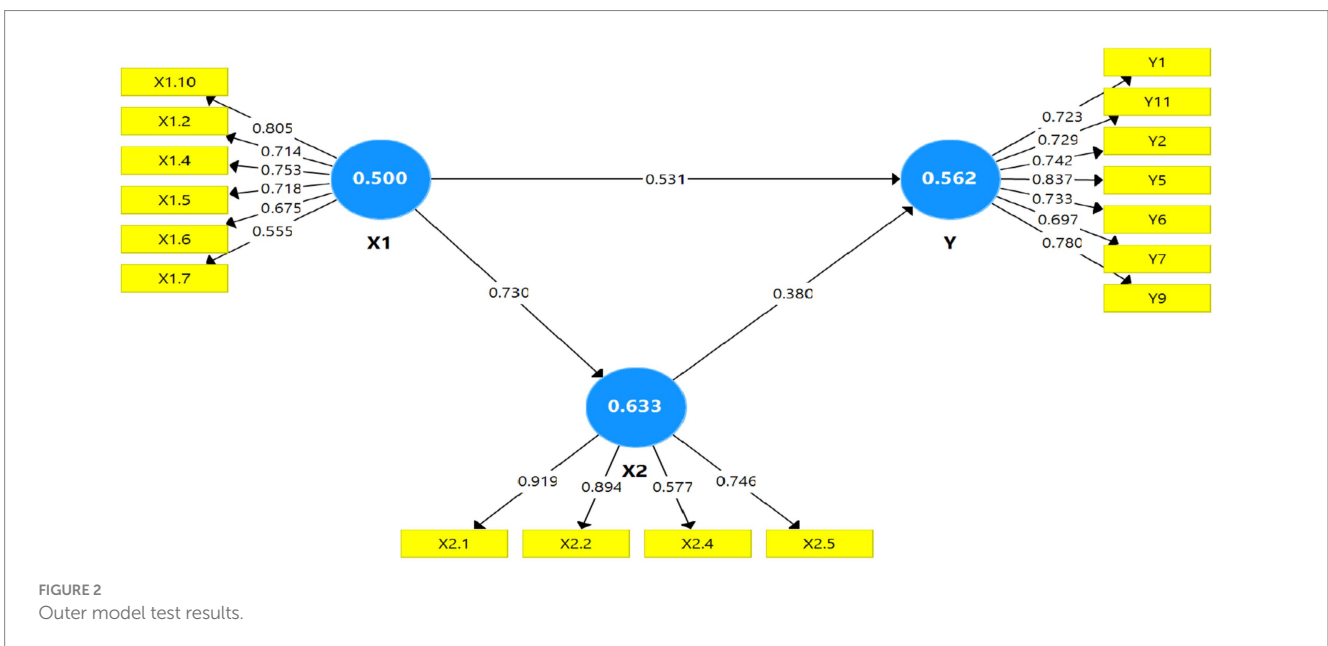
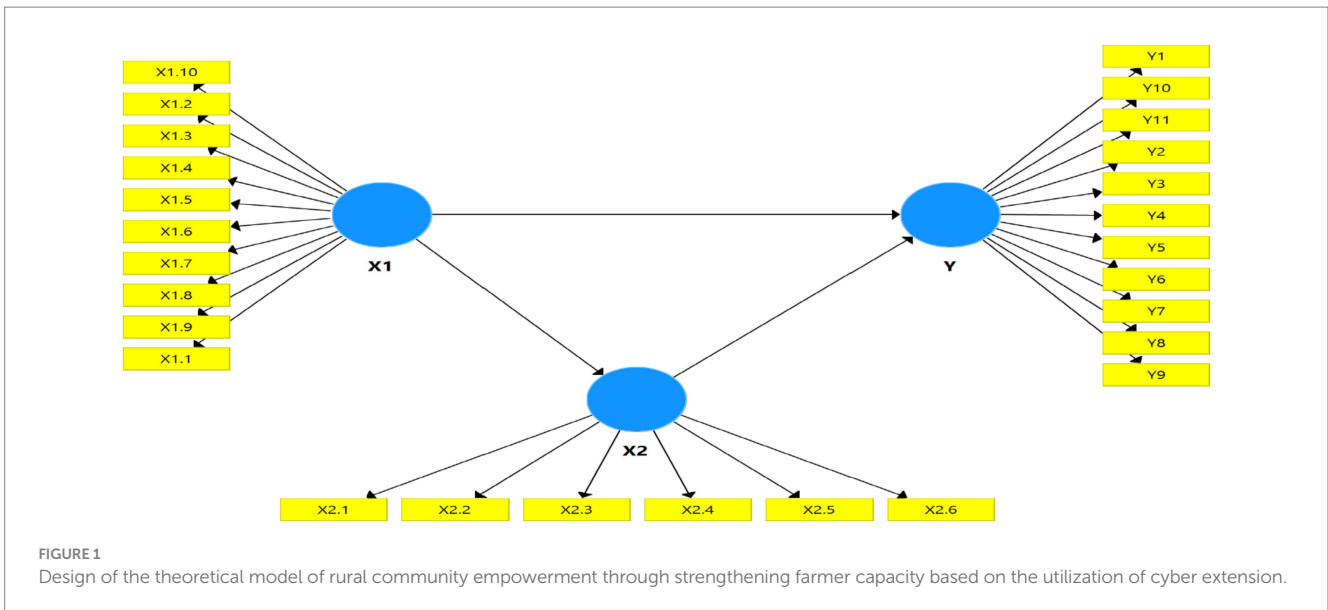
3.5.1 Formulation of structural model theory

This study, it consists of three main variables, namely farmer capacity (X1) which includes 10 indicators, namely X1.1–X1.10, utilization of Cyber Extension (X2) which includes 6 indicators, namely X2.1–X2.6, and rural community empowerment (Y), which includes 11 indicators, namely Y1–Y11. The theoretical model of rural community empowerment through strengthening farmer capacity based on the use of Cyber Extension in Konda District, South Konawe Regency, can be seen in Figure 1.

3.5.2 Outer model testing

This test evaluates indicators and latent variables related to the validity and discriminant of the model constructed in the Partial Least Squares–Structural Equation Modeling (PLS–SEM) approach. Validity values can be seen by analyzing the results of Composite Reliability and Cronbach's Alpha. The Average Variance Extracted (AVE) and Heterotrait–Monotrait Ratio (HTMT) results indicate the level of discriminant validity of the proposed model. Then, a collinearity test using the Variance Inflation Factor (VIF) was conducted to measure the validity of the interpretation of the relationship between variables in the research model. The results of the outer model analysis on rural community empowerment through capacity building of farmers based on the use of Cyber Extension can be seen in Figure 2.

Figure 2 shows that several indicators were removed because they did not meet the standards or were invalid (outer loading value <0.5). The indicators removed from the farmer capacity variable (X1) are X1.1 (0.425), X1.3 (0.326), X1.8 (−0.009), and X1.9 (0.328). The indicators removed from the Cyber Extension utilization variable (X2) are X2.3 (0.315) and X2.6 (0.300). As for the rural community empowerment variable, the indicators that were removed were Y3 (0.341), Y4 (0.260), Y8 (0.217), and Y10 (0.206).



In this study, the discriminant validity threshold was set at 0.5. The parameter used was the Average Variance Extracted (AVE) value, which was recommended to be ≥ 0.5 . In addition, reliability was tested based on the composite reliability value (>0.6) and Cronbach's alpha (≥ 0.6) (Sarstedt et al., 2021). The values of Cronbach's alpha, composite reliability, and Average Variance Extracted (AVE) for the rural community empowerment model through the use of farmer capacity based on the utilization of Cyber Extension are presented in Table 5.

Another indicator that needs to be considered in testing discriminant validity is the Heterotrait-Monotrait Ratio (HTMT) value. The recommended Heterotrait-Monotrait Ratio (HTMT) value is $HTMT < 0.90$. The Heterotrait-Monotrait Ratio (HTMT) results in this model can be seen in Table 6.

The results of the discriminant validity test using the HTMT criteria in Table 6 show that all HTMT values between constructs are

in the range of 0.830 to 0.892 and are below the threshold of 0.90. Thus, it can be concluded that each construct in the research model has adequate discriminant validity and does not show any overlap in concepts between latent variables.

Then, to maintain the validity of the interpretation of the relationship between variables, a collinearity test was conducted using the Variance Inflation Factor (VIF). The Variance Inflation Factor (VIF) value must be < 5.0 for the model to be considered free from collinearity problems. The results of the collinearity test in this model can be seen in Table 7.

The collinearity test results in Table 7 show that all VIF values are in the range of 1.000 to 2.139, which is well below the recommended limit of 5.0. Thus, it can be concluded that there is no multicollinearity problem between variables in the structural model, so that the relationship between constructs can be interpreted reliably and validly.

TABLE 5 Results of testing the outer model of rural community empowerment through strengthening farmer capacity based on the use of cyber extension.

Variable	Indicator	Outer loading	Composite reliability	Cronbach's alpha	AVE
Farmer capacity (X1)	X1.2	0.714	0.856	0.803	0.500
	X1.4	0.753			
	X1.5	0.718			
	X1.6	0.675			
	X1.7	0.555			
	X1.10	0.805			
Cyber extension utilization (X2)	X2.1	0.919	0.870	0.799	0.633
	X2.2	0.894			
	X2.4	0.577			
	X2.5	0.746			
Rural community empowerment (Y)	Y1	0.723	0.900	0.871	0.562
	Y2	0.742			
	Y5	0.837			
	Y6	0.733			
	Y7	0.697			
	Y9	0.780			
	Y11	0.723			

TABLE 6 Heterotrait-monotrait ratio (HTM) output.

Construct	Farmer capacity (X1)	Cyber extension utilization (X2)	Rural community empowerment (Y)
Farmer capacity (X1)	—	—	—
Cyber extension utilization (X2)	0.830	—	—
Rural community empowerment (Y)	0.892	0.862	—

TABLE 7 Results of collinearity test using variance inflation factor (VIF).

Exogenous variable	Endogenous variable	VIF value	Assessment
Farmer capacity (X1)	Cyber extension utilization (X2)	1.000	Acceptable
Farmer capacity (X1)	Rural community empowerment (Y)	2.139	Acceptable
Cyber extension utilization (X2)	Rural community empowerment (Y)	2.139	Acceptable

3.5.3 Inner model testing

Inner model or structural model testing is conducted by examining four measurements, namely Path Coefficients, R-square (R^2), Goodness of Fit (GoF), and Q-square (Q^2). The results of inner

model testing on the rural community empowerment model through capacity building of farmers based on the use of Cyber Extension are presented in Figure 3.

3.5.3.1 Path coefficients

The direction of influence exerted by exogenous variables on endogenous variables is measured through Path Coefficients values. Path Coefficients can be positive or negative. A positive value means that the exogenous and endogenous variables have a similar effect, and vice versa for a negative value. The results of testing the Path Coefficients in the rural community empowerment model through strengthening farmer capacity based on the use of Cyber Extension are presented in Table 8.

Table 8 shows that the Path Coefficients value between farmer capacity and rural community empowerment is positive at 0.531. Then, the Path Coefficients value between Cyber Extension utilization and rural community empowerment is positive at 0.380. In general, the Path Coefficients value of the rural community empowerment model through strengthening farmer capacity based on Cyber Extension utilization is positive. This result means that if there is an increase in farmer capacity and the use of Cyber Extension, rural community empowerment will increase even more strongly.

3.5.3.2 R-square (R^2)

The R^2 (R-square) test analyzes the extent to which the independent variables in the model explain the dependent variable. The closer the R-square value is to 1, the greater the influence of the independent variable on the dependent variable. The results of the R-square (R^2) test of the model for rural community empowerment through capacity building for farmers based on the use of Cyber Extension are presented in Table 9.

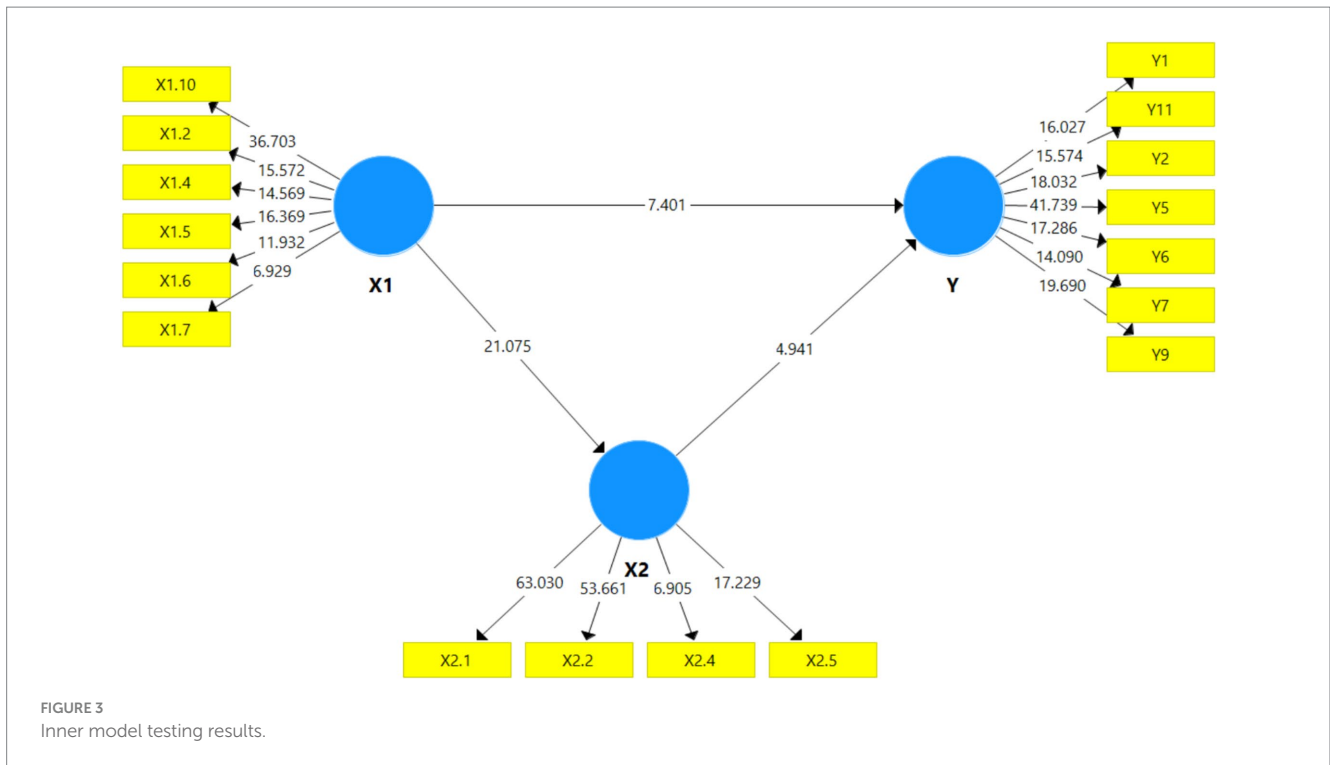


TABLE 8 Path coefficients values.

Empowering	Empowerment of rural communities (Y)
Farmer capacity (X1)	0.531
Cyber extension utilization (X2)	0.380

TABLE 9 R-square values.

Construct	R square	Adjusted R-square
Cyber extension utilization (X2)	0.532	0.529
Empowerment of rural communities (Y)	0.722	0.718

Table 9 explains that the R-square value between farmer capacity and the use of Cyber Extension is 0.532, which is classified as moderate. Furthermore, the R-square (R²) value between farmer capacity and the use of Cyber Extension on rural community empowerment is 0.722, which is classified as moderate. In general, the R-square value produced in the rural community empowerment model through strengthening farmer capacity based on the use of Cyber Extension is in the moderate category. Cheung et al. (2024) determined that a model is strong if R-square >0.75, moderate if R-square is between 0.50 and 0.75, and weak if R-square is between 0.25 and 0.50.

3.5.3.3 Goodness of fit (GoF)

Goodness of Fit (GoF) is conducted to validate the overall research model. This test begins by evaluating the measurement model

and structural model together. Goodness of Fit (GoF) is an analysis of the quality of the proposed research model by measuring how well the model represents the data (Cho et al., 2020). The formula is as follows.

$$GoF = \sqrt{AVE \times R^2}$$

$$GoF = \sqrt{0,1779 \times 0,3862}$$

$$GoF = \sqrt{0,0687}$$

$$GoF = 0,262$$

The Goodness of Fit (GoF) value for the model of rural community empowerment through capacity building of farmers based on the use of Cyber Extension was found to be 0.262. The resulting Goodness of Fit (GoF) value is in the moderate category. As stipulated, the GoF values are small = 0.10, medium = 0.25, and big = 0.38. These results explain that the research model constructed is valid.

3.5.3.4 Q-square (Q²)

Predictive relevance or Q-square (Q²) is an analysis that tests the predictive ability of a constructed model or structural model. A research model has good predictive relevance if it has a Q-square value >0. In SmartPLS software, the Q-square value can be seen from the blindfolding analysis output. The results of the Q-square analysis of the rural community empowerment model through capacity building for farmers based on the use of Cyber Extension are presented in Table 10.

The Q-square value (Q²) found in the Cyber Extension utilization construct is 0.328, which is classified as moderate (Table 10).

TABLE 10 Q-square values.

Construct	SSO	SSE	$Q^2 = (1 - SSE/SSO)$
Cyber extension utilization (X2)	560.000	376.511	0.328
Empowerment of rural communities (Y)	980.000	607.578	0.380

Meanwhile, the Q-square value (Q^2) in the rural community empowerment construct is 0.380, which is classified as high or strong. In general, the rural community empowerment model through strengthening the capacity of farmers based on the use of Cyber Extension is said to have good predictive relevance. The interpretation of the Q-square value is categorized into three, namely 0.02–0.15 (small), 0.16–0.35 (moderate), and >0.35 (large) (Hair et al., 2017). Sarstedt et al. (2021) state that a higher Q-square value indicates a higher level of fit between the structural model and the data and serves to assess the goodness of a constructed model.

4 Conclusion

The empowerment of rural communities in rice production canters in Konda District is largely determined by strengthening farmers' capacity and utilizing Cyber Extension as a digital extension tool. The capacity of farmers, which is at a moderate to good level, is still limited by low digital literacy and limited access to information technology. Cyber Extension serves as a digital learning space that connects farmers with sources of knowledge and extension, while encouraging more intensive interaction and more reflective decision-making in the management of rice farming. Structural relationship analysis shows that farmer capacity has a significant effect on the utilization of Cyber Extension and directly and indirectly increases the level of rural community empowerment. These findings confirm the role of Cyber Extension as a mediating variable that strengthens the transformation of farmer capacity into rural community empowerment. Conceptually, this study enriches the literature by offering a model of rural community empowerment based on strengthening farmer capacity and contextual digital extension in areas with digital literacy gaps. However, the limitations of the study area and the use of a cross sectional design limit the generalization of findings and understanding of long-term dynamics. In developing policies and empowerment programs, integrating Cyber Extension with a community-based participatory approach, strengthening the digital capacity of farmers and extension workers, and supporting local institutional strengthening are appropriate steps. Further research needs to be conducted longitudinally and across regions to deepen understanding of the

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role of digital extension in inclusive and sustainable rural agricultural development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

SA: Formal analysis, Writing – original draft, Methodology, Data curation, Visualization, Conceptualization. Bunyamin: Visualization, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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