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Digital Extension Strategies for Empowering Rice Farmers in West Bangka Regency Admid The Agricultural of Era 4.0 Transformation

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Abstract: Agricultural extension plays a strategic role in empowering farmers through non-formal education, particularly in the era of the Agricultural 4.0 transformation, characterized by rapid developments in information technology and digital innovation. This study aims to analyze digital extension strategies in empowering rice farmers in West Bangka Regency, especially in Tebing Village, Kelapa Sub-district. The research employed a qualitative descriptive method using questionnaires distributed to 30 rice farmers selected purposively. The study focuses on farmer characteristics and the role of agricultural extension workers in strengthening farmer empowerment through digital-based communication and information systems. The findings reveal that the characteristics of farmers, including age, formal education, non-formal education, farming experience, and land ownership status, are generally categorized as moderate (40%) in influencing empowerment levels. Meanwhile, the role of extension workers was considered highly significant (80%) in supporting farmer empowerment. In the context of the digital era, extension workers increasingly function not only as facilitators and motivators but also as digital mediators who introduce farmers to information technology, online agricultural marketing, weather and price information systems, and social media-based communication platforms. The integration of digital tools enables farmers to access agricultural knowledge more efficiently, improve decision-making processes, and strengthen market connectivity. This study concludes that digital extension strategies are essential in enhancing the capacity and independence of rice farmers amid the Agricultural 4.0 transformation. The utilization of information technology and digital communication can strengthen agricultural productivity, expand farmers' access to information, and support sustainable rural agricultural development in West Bangka Regency.

Keywords: Agricultural; Digital; Empowering; Rice

Introduction

According to data from the Indonesian Central Bureau of Statistics (BPS) in 2023, the total rice field area in Indonesia reached approximately 8.2 million hectares. Rice fields constitute agricultural land cultivated on wet soil systems that require irrigation water to support farming activities (Komarudin, 2010). The primary commodity cultivated in these areas is lowland rice, which remains one of the most strategic food crops in Indonesia (Yulia et al., 2025).

As an agrarian country, Indonesia continues to rely heavily on the agricultural sector not only for food security but also for employment generation, rural economic development, and social welfare improvement. In the contemporary era, agricultural development is increasingly interconnected with digitalization, information technology, and

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computational innovation as part of the Agricultural 4.0 transformation.

Agriculture, as defined in Law No. 16 of 2006 concerning the Agricultural, Fisheries, and Forestry Extension System (SP3K), encompasses all activities related to upstream agribusiness, farming operations, agroindustry, marketing, and supporting services involving the sustainable management of biological natural resources within agroecosystems. These activities are supported by technology, capital, labor, and management systems to maximize community welfare (Indahyani & Maga, 2023).

According to Vintarno et al. (2019), the development of agricultural extension institutions in Indonesia has experienced dynamic fluctuations over time. A significant milestone occurred with the enactment of Law No. 16 of 2006 concerning the Agricultural, Fisheries, and Forestry Extension System (SP3K), which strengthened extension institutions at provincial and district levels (Syahyuti, 2016). The law emphasized the importance of institutionalizing agricultural extension services to improve farmers' social and economic conditions. However, the implementation of Regional Autonomy policies and the issuance of Law No. 23 of 2014 concerning Regional Government created institutional uncertainties regarding extension systems. The regulation did not clearly accommodate the existence of extension institutions at the regional level, causing concerns about weakened extension services and reduced coordination between central and local governments (Syahyuti, 2016).

Precision agriculture, Internet of Things (IoT)-based irrigation systems, satellite mapping, digital weather forecasting, online agricultural marketplaces, and mobile farming applications are becoming integral components of modern agricultural practices. Consequently, extension workers are now required to function as digital facilitators who help farmers adapt to technological changes and utilize digital platforms for agricultural productivity improvement.

To address institutional challenges, the Indonesian government issued the Regulation of the Minister of Agriculture No. 03 of 2018 concerning Guidelines for Agricultural Extension Implementation. This regulation aims to strengthen agricultural extension institutions and ensure the integrated implementation of agricultural development programs from central to village levels. The policy also encourages the incorporation of digital technology into extension systems to improve farmer empowerment and agricultural sustainability. Through digital-based extension approaches, farmers can access agricultural information more rapidly, communicate directly with experts, monitor market prices online, and utilize computational tools for farm management and production planning.

Agricultural extension fundamentally serves as a farmer empowerment system designed to help farmers improve their agricultural knowledge, technical skills, and decision-making capacities. Sadono (2008) explained that agricultural extension aims to assist farmers in solving their problems independently and effectively, thereby improving their quality of life. In the Agricultural 4.0 context, empowerment increasingly involves digital competencies, including the ability to access online information, use agricultural applications, and participate in digital marketing systems. Extension services are no longer limited to face-to-face communication but also involve digital platforms such as social media, mobile applications, virtual training, and e-learning systems. These innovations significantly enhance the effectiveness and reach of agricultural extension programs.

Yulia et al. (2025); Yuniarti et al. (2017) emphasized that extension workers are essential in farmer group empowerment. Their roles as educators, leaders, advisors, facilitators, and motivators are highly important in helping farmers identify and solve agricultural problems. Extension workers also encourage farmers to adopt innovative farming methods and technological advancements that can improve productivity and economic welfare. In the era of digitalization and computational agriculture, extension workers additionally function as mediators between farmers and technological innovation. They assist farmers in understanding digital farming systems, utilizing precision agriculture tools, accessing online marketplaces, and adopting data-based farming management. This digital transformation contributes significantly to improving agricultural efficiency, productivity, and sustainability.

According to Munir & Cahyati (2018), farmer welfare is one of the core indicators of successful agricultural development. Farmer empowerment is therefore essential in improving the socio-economic conditions of rural communities. Competent agricultural extension workers are needed to support this empowerment process effectively. Doli (2012) further argued that agricultural extension is necessary to transform farmers' mindsets, attitudes, and behaviors in order to create sustainable agricultural livelihoods. Until today, agricultural extension workers remain the primary source of agricultural information for farmers. However, the rapid development of digital technology and the changing institutional landscape require extension workers to adapt continuously to new technological environments.

In the Agricultural 4.0 era, the integration of digitalization and computational systems into agricultural extension has become increasingly important. Farmers are expected to utilize digital information systems, mobile-based agricultural applications, climate prediction technologies, and digital financial services to improve agricultural productivity and market competitiveness. Therefore, this study aims to analyze the characteristics of farmers and examine the role of agricultural extension workers in empowering rice farmers in Tebing Village, Kelapa Sub-district, West Bangka Regency, particularly in the context of digital transformation and computational agriculture in the era of Industry 4.0.

Method

The research design employed in this study was a quantitative approach supported by qualitative data. The quantitative approach was used to answer questions regarding the role of agricultural extension workers in empowering rice farmers (Kurniawan, 2016). Before the questionnaire was implemented in the field and the data collection process began, validity and reliability tests were conducted on the research instruments used. These tests were administered to ten farmers who possessed characteristics similar to the respondents, namely rice farmers who were members of farmer groups and participated in agricultural extension activities at least once a month. Qualitative data were used to support the quantitative findings (Sugiyono, 2022). In this study, qualitative data were collected through in-depth interviews with selected respondents and informants using a purposive sampling technique. The interviews were guided by structured questions related to the research topic and problems under investigation.

This research concerning the role of agricultural extension workers in empowering rice farmers was conducted in Tebing Village, Kelapa Sub-district, West Bangka Regency. The research location was selected purposively because Tebing Village is frequently used as a field practice site for agricultural extension activities in West Bangka Regency. Data collection was carried out over approximately two months, from May 2025 to June 2025.

The subjects of this study consisted of respondents and informants. The population included rice farmers who were members of farmer groups and actively participated in agricultural extension activities at least once a month. A simple random sampling technique was applied because the respondents shared homogeneous characteristics, namely rice farmers belonging to farmer groups in Tebing Village and actively participating in extension activities. The sample consisted of 30 respondents.

The selection of informants was conducted purposively, and the number of informants was not predetermined. Informants were identified using a snowball sampling technique involving agricultural extension workers and farmer group leaders in Tebing Village who possessed clear knowledge regarding the role of extension workers in empowering rice farmers.

The data processing stage in this study involved several analytical techniques, including frequency tables and qualitative descriptive analysis. The variables analyzed and tested included farmer characteristics (age, formal education, non-formal education, farming experience, and land ownership status) and the role of extension workers (facilitator, marketing partner, farmer assistant, and motivator). Farmer characteristics refer to individual attributes attached to each farmer that distinguish one farmer from another. In this study, farmer characteristics included age, formal education, non-formal education, farming experience, and land ownership status.

The role of agricultural extension workers refers to the functions and positions of extension officers assigned to improve farmers' technical farming skills, knowledge, positive attitudes, agricultural innovation adoption, and independence in managing agricultural land (Sudarmansyah et al., 2021). Accordingly, agricultural extension workers perform four major roles: facilitator, marketing partner, farmer assistant, and motivator. In this study, the role of extension workers was measured based on the perceptions of rice farmers who were members of farmer groups in Tebing Village and actively participated in agricultural extension activities at least once a month.

Result and Discussion

Farmer Characteristics

The farmer characteristics in this study include age, formal education, non-formal education, farming experience, and land ownership status. These characteristics are distinctive features of each farmer.

Farmer Age

Age refers to a person's lifespan, which in this study is calculated as the farmer's age at the time the research was conducted. A person's age influences their way of thinking, problem-solving, acceptance of new technologies, and physical capabilities.

Table 1. Percentage of respondents by age

Age Group	Percentage (%)
Old (>55 years)	33.33
Adults (36–55 years)	50.00
Young (17–35 years)	16.67
Total	100.00

Table 1 shows that the largest percentage of respondents fell within the 36–55 age range, comprising 15 respondents (50%) who were categorized as adults. Age influences how a person responds to new situations, even if they lack extensive experience. This is consistent with Wildani et al. (2018) assertion that the productive age range is between 15 and 50 years. Given that the farmers are of productive age, it is hoped that they will be able to manage and develop their farming businesses to increase production and income.

Formal Education

Formal education refers to the length of schooling completed by the respondents. Educational attainment influences the ability to think critically and analyze problems (Yulia et al., 2024). Individuals with a higher level of education tend to be open to new ideas and willing to try them out. Educational attainment can influence farmers' responses to innovation.

Table 2. Percentage of respondents by level of formal education

Education Level	Percentage (%)
Low (did not complete primary school and completed primary school or equivalent)	60
Medium (completed lower secondary school and upper secondary school or equivalent)	30
High (completed a diploma or bachelor's degree)	10
Total	100

Table 2 shows that the largest percentage of respondents' formal education levels was those who had not completed primary school and those who had completed primary school or equivalent, totalling 18 respondents (60%). From this data, it can be concluded that the farmers' formal education levels are moderate to low. This is because the farmers in the sample came from lower-middle-class families, meaning they were unable to continue their education to a higher level. The farmers' still-low level of formal education also influences how they manage their farming businesses. Nevertheless, farmers are diligent in seeking the latest agricultural information to develop their farming businesses, whether obtained from farmers' groups, agricultural extension officers, or the internet.

The findings of Utama et al. (2007) indicate that the low educational level of respondents may be a factor in farmers' limited ability to manage their agricultural enterprises, which can act as a barrier to increasing rice production and achieving sustainable agricultural management. Furthermore, farmers with higher levels of education also demonstrate greater motivation in developing their agricultural enterprises.

Non-formal Education

In this study, non-formal education refers to training activities related to farming that respondents have participated in over the past year. Non-formal education is an organised educational activity that takes place outside the formal education system. Table 3 shows that the respondents' level of non-formal education is relatively high. This indicates that farmers in Tebing Village remain actively engaged in activities related to agricultural extension, meaning the majority of farmers have gained new knowledge and experience through these training activities. Training sessions are typically held both within the village and outside Tebing Village.

Table 3. Percentage of respondents by level of non-formal education.

Non Formal Education	Percentage (%)
Rarely	53.33
Moderately	30.00
Frequently	16.67
Total	100.00

The training sessions held within Tebing Village took place in the village office hall, whilst those held outside Tebing Village were held at the Kelapa Sub-district Agricultural Extension Centre in West Bangka Regency. The training is one of the extension activities aimed at empowering farmers, specifically to improve the knowledge, attitudes and skills of farmers as the target group of agricultural extension. It is hoped that this training will improve farmers' knowledge, attitudes and skills in managing their farming businesses, thereby making them more empowered.

Farming Experience

Farming experience tends to influence the decisions farmers make regarding their future farming activities. Farmers who have been farming for a long time find it easier to adopt innovations than novice farmers; this is because they have more experience and are therefore able to make comparisons when making decisions.

Table 4. Percentage of respondents based on farming experience

Experience	Percentage (%)
Low (1–15 years)	30.00
Medium (16–30 years)	46.67
High (>30 years)	23.33
Total	100.00

Table 4 shows that the respondents' farming experience is relatively moderate. Farming experience can influence a farmer's skills. The longer a farmer's experience, the more skilled they become in managing their farm, thereby increasing their productivity and income. Most farmers in the study area who did not continue their education to a higher level decided to become farmers at a young age to help their parents and to earn an income.

The findings of Nurdina et al. (2015) indicate that a lack of experience among farmers leads to a decline in their motivation to manage their farms. Experience is crucial to developing a farming enterprise; the longer a farmer works in the field, the more proficient they become at running their business.

Land Ownership Status

Land is a key production resource that plays a vital role in determining the productivity of farming operations. The land ownership status in Tebing Village comprises 40% owned by the farmers themselves, 60% owned by the farmers themselves plus a share of the harvest, or leased.

Table 5. Percentage of respondents by land ownership status

Land Ownership Status	Percentage (%)
Low	26.67
Medium	40.00
High	33.33
Total	100.00

Table 5 shows that the respondents' land ownership status falls into the 'moderate to high' category. This is because farmers acquire land through inheritance from their parents and through the division of land by parents amongst their children. Land ownership is linked to an individual's innovativeness. Farmers who own large tracts of land tend to be more receptive to innovation and are highly motivated to engage in farming. Farmers can develop their farming businesses by creating new innovations suited to the land they own, thereby increasing their income.

Overall Farmer Characteristics

Farmer characteristics are unique and differ from one farmer to another. These characteristics are distinctive to each farmer.

Table 6. Percentage of respondents based on farmer characteristics.

Character	Percentage (%)
Low	33.33
Medium	40.00
High	26.67
Total	100.00

Table 6 shows that the largest percentage of farmers' overall characteristics falls into the 'moderate' category, at 40%. The overall characteristics of farmers referred to comprise age, formal education, non-formal education, farming experience, and land ownership status. Farmers' characteristics can vary within a village or region. This reflects the social and economic conditions and needs to be understood in order to identify the characteristics of the majority of farmers practising agriculture in the area (Altieri, 2002; Edwards-Jones, 2006). Furthermore, farmer characteristics can to some extent reflect the level of farmers' ability to manage their farming operations; this implies that the higher the overall farmer characteristics, the better their ability to manage their farming operations.

The Role of Agricultural Extension Officers

The role of an agricultural extension officer involves a person tasked with providing extension services to enhance technical farming skills, knowledge, foster more positive attitudes, promote agricultural innovation, and build self-reliance in managing their agricultural land. The role of agricultural extension workers is measured based on their ability to act as facilitators, marketing partners, environmental analysts, farmer mentors, and motivators. These five roles of agricultural extension workers are an elaboration of roles based on an approach that has become a recommended model for the diffusion of innovation.

Table 7. Number and percentage of respondents by extension worker role, according to paddy farmers in Tebing Village in 2025

Role	Category	Percentage (%)
Facilitator	Low	33.33
	Medium	40.00
	High	26.67
Total		100.00
Marketing Partner	Low	30.00
	Medium	50.00
	High	20.00
Total		100.00

Role	Category	Percentage (%)
Farmer Advisor	Low	6.67
	Medium	73.33
	High	20.00
Total		100.00
Farmer Motivator	Low	6.67
	Medium	66.67
	High	26.67
Total		100.00
Roles	Low	6.67
	Medium	80.00
	High	13.33
Total		100.00

Table 7 shows that the largest percentage of extension workers' overall role falls within the 'active' category, comprising 24 respondents (80%). This indicates that agricultural extension workers in the study area have successfully fulfilled their role in improving farmers' technical skills and knowledge, fostering more positive attitudes, developing agricultural innovations, and building self-reliance in managing their farmland.

Agricultural extension workers who actively carry out their roles in assisting and supporting farmers are essential for improving farmers' welfare (Eryanto et al., 2023; Feder et al., 2001). This is supported by the statement by Mulyani & Elviana (2017), who state that extension workers play a crucial role in improving farmers' welfare. The role of extension workers is vital in changing farmers' behaviour towards agribusiness-oriented farming. Agricultural extension is an effort to change the behaviour of farmers and their families so that they are exposed to information, have the willingness to work hard, and can solve their own problems in order to improve their farm output and standard of living (Marbun et al., 2019). Agricultural extension workers who perform their roles effectively can have a significant impact on the progress of farming enterprises. Extension workers possess a wide range of knowledge and information that can be shared with farmers. They connect farmers with the latest sources of information and technology (Naika et al., 2021; Singh et al., 2024).

The role of agricultural extension workers is to assist farmers in increasing agricultural production and making sound decisions by communicating with them and providing information tailored to their needs. The primary role of an extension worker is to facilitate a process whereby farmers make their own decisions by offering advice on alternative options and helping farmers develop an understanding of the consequences of those choices (Lusiana et al., 2018). Interaction between farmers and extension workers can take place both during extension sessions and outside of such activities. The more frequent the interaction between farmers and extension workers, the more information farmers can obtain.

Conclusion

This profile of farmers in Tebing Village, involving 30 respondents, shows that the farmers' characteristics as a whole fall into the 'moderate' category (40%), comprising age, formal education, non-formal education, farming experience, and land ownership status, alongside the farmers' level of empowerment. Furthermore, extension workers play a significant role (80%), and farmers have recognised the impact of extension workers in their roles as facilitators, marketing partners, farmer mentors, and motivators in farmer empowerment; this means that extension workers are able to help farmers obtain assistance from the agricultural department.

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