EXAMINING THE LINKAGES BETWEEN TECHNOLOGY ADOPTION AND COMPONENTS OF CORN AGRIBUSINESS

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EXAMINING THE LINKAGES BETWEEN TECHNOLOGY ADOPTION AND COMPONENTS OF CORN AGRIBUSINESS

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ABSTRACT

This research delves into the complex relationship between technology adoption and the various components of corn agribusiness, with a focus on Indonesia's South Oba District. Corn, a key national commodity, faces challenges in meeting production targets set by the Ministry of Agriculture. This study investigates how technology adoption influences corn agribusiness aspects, including productivity, economic integration, and social and environmental impacts. Utilizing a quantitative approach, the research involves purposive sampling of 70 corn farmers and assesses agribusiness and cultivation technology through indicators like seed usage, soil processing, and agro-input systems. Findings reveal that despite high technology adoption, certain subsystems, notably agro-marketing and agro-industry, require improvement. The study underscores the interdependence between technology adoption and subsystems, emphasizing the need for targeted development in agro-marketing, agro-supporting services, agro-industry, agro-input, and agro-production. Recommendations include enhancing marketing strategies, improving support services, developing the agroindustry value chain, ensuring quality agro-inputs, and implementing sustainable farming practices. This interdisciplinary research aims to provide insights for policymakers, agribusiness practitioners, and researchers to navigate challenges and harness opportunities in the modernization of corn agribusiness.

Keywords: technology adoption, agro-marketing, agro-supporting services, agro-industry, agro-input, agro-production.

INTRODUCTION

As the backbone of the global economy, the agricultural sector continues to undergo significant transformations over time, closely tied to the impact of technology as a primary catalyst in reshaping the agribusiness landscape. This research aims to specifically investigate the intricate relationship between technology adoption and the components of corn agribusiness. Corn, being a national flagship commodity and one of the self-sufficiency targets alongside rice, soybeans, sugarcane, and beef, experiences substantial effects from the technological revolution (Hamilton-Hart, 2019; Neilson & Arifin, 2013). Corn production in Indonesia still falls below the targets set by the Ministry of Agriculture, reaching 17.66 million tons of dry cobs in 2009 (Suhardi et al., 2019). Kemtan (2010) set the corn production target for 2010 at 19.8 million tons, with the hope of achieving 29 million tons of dry cobs by 2014 or achieving self-sufficiency in corn. However, formidable challenges arise from both internal and external factors.

The productivity of corn crops remains low, below 1.9 tons (Rachmad, 1997), primarily due to the majority of the national corn harvest coming from rainfed land cultivation with subsistence farming practices. The increasingly complex international, regional, and local strategic environment also impacts corn production nationally. The significance of corn as a source of food, animal feed, and industrial raw material makes it a focal point for agribusiness practitioners and researchers (Barnard et al., 2020; Gunderson et al., 2014; Nkukwana, 2018). With advancing technology, the implementation of innovations in corn production becomes increasingly crucial to ensure food security, production efficiency, and environmental sustainability. Therefore, this research aims to dissect and deeply understand how technology adoption in the context of corn agribusiness can influence various aspects, ranging from production to distribution.

One key aspect to be analyzed is the impact of technology adoption on enhancing agricultural productivity. The use of modern technology, such as agricultural information systems, soil sensors, and automated equipment, can play a vital role in improving resource utilization efficiency and optimizing agricultural yields (Alahmad et al., 2023; Khan et al., 2021; Monteiro et al., 2021; Sishodia et al., 2020). This research will explore the extent to which technology adoption has influenced corn production outcomes and how the use of more advanced technology can positively impact farmer well-being. This study will also delve into the interconnection between technology adoption and the economic aspects of corn agribusiness. In this era of globalization, agribusiness stakeholders must be able to integrate technology into their business management to compete effectively in an increasingly complex market. This analysis will provide insights into how technology integration can affect the corn agribusiness supply chain, including distribution, marketing, and product value addition.

Meanwhile, social and environmental aspects will also be the focus of this research. Technology adoption in corn agribusiness not only shapes production and distribution patterns but also has repercussions on farmer communities and the surrounding environment. By analyzing the social and environmental impacts of technology adoption, this research will provide a comprehensive overview of the consequences of technological changes in corn agribusiness. By detailing the relationship between technology adoption and various components of corn agribusiness, this research is expected to offer a holistic and in-depth perspective. The findings from this study are anticipated to provide a better understanding of the complex dynamics in addressing challenges and opportunities arising from technological developments in corn agribusiness. Through an interdisciplinary approach, this article aims to open up space for new thinking, innovative strategies, and sustainable policies to advance the corn agribusiness sector in the era of modern technology.

LITERATURE REVIEW

Adoption of agricultural technology

The adoption of agricultural technology is a crucial process in which farmers receive and implement various agricultural innovations. The types of technology that can be adopted include superior varieties, reliable seeds, modern fertilizers and pesticides, agricultural machinery and equipment (farm machinery), as well as information and communication technology or ICT (Dadi, 1998; Das et al., 2023; Raj et al., 2021). Agricultural technology brings several important benefits. Firstly, technology adoption can enhance agricultural productivity by leveraging innovations that optimize crop yields. Additionally, the efficiency of agricultural production can be improved, resulting in a more sustainable agricultural system. Furthermore, technology adoption can elevate the quality of agricultural products and strengthen competitiveness in the global market. Lastly, by harnessing technology, a country's food resilience can be enhanced.

Farmers can adopt technology either individually or in groups, obtaining technology from various sources, including the government, private sector, or agricultural research institutions. Various factors influence farmers' decisions in adopting technology. Farmer characteristics such as age, education level, experience, and income play a crucial role, as do technology characteristics such as complexity, cost, and expected benefits (Akudugu et al., 2012; Muchangi, 2016; Tey & Brindal, 2012). Environmental factors such as climate conditions, the availability of facilities and infrastructure, and government support also contribute to the technology adoption process.

The Indonesian government has made significant efforts to promote the adoption of agricultural technology. These measures include increasing agricultural extension services, providing assistance in agricultural facilities and infrastructure, and implementing policies that support agricultural technology adoption (Davis et al., 2010; Kassie et al., 2013; Shiferaw et al., 2009; Zegeye et al., 2022). Agricultural technology adoption is a key element in efforts to enhance agricultural productivity and food resilience in Indonesia. Therefore, more intensive efforts are needed to encourage farmers to adopt agricultural technology. Several examples of successful agricultural technologies adopted by farmers in Indonesia involve superior varieties such as IR64 for rice, hybrid corn seeds, the use of NPK fertilizer, modern pesticides, farm machinery like tractors, pesticide spraying equipment, and the utilization of ICT for weather and price monitoring (Guntoro, 2011; Kushartanti et al., 2012). The adoption of these technologies has proven their ability to increase agricultural productivity in Indonesia.

Agribusiness subsystem

The agribusiness subsystem plays an integral role within the interconnected and interdependent framework of the agribusiness system (Anandajayasekeram & Gebremedhin, 2009; Paez, 2021; Tefft et al., 2017). Each subsystem holds specific functions of importance, and its existence significantly impacts the overall sustainability of the agribusiness system. This subsystem encompasses various elements, including production, distribution, marketing, and consumption of agricultural products, working synergistically to achieve sustainability and maximum efficiency (Liu et al., 2020; Therond et al., 2017). For instance, the production subsystem is associated with planting, crop care, and the use of agricultural technology. Meanwhile, the distribution subsystem involves transportation and logistics to flow products from producers to consumers. The interconnection among these subsystems creates a complex and mutually supportive agribusiness ecosystem.

In general, the agribusiness subsystem can be divided into four main interconnected components (Anandajayasekeram & Gebremedhin, 2009; Pavlovic et al., 2008; Phrommany & Philavong, 2021). Firstly, the procurement and distribution of production facilities and infrastructure involve industries and trade that produce essential agricultural production tools, such as fertilizers, medicines, seeds, and agricultural machinery. Secondly, the primary production subsystem or on-farm enterprises encompasses economic activities that utilize farming production facilities to generate primary agricultural products. Meanwhile, the third subsystem is processing or agro-industry, which engages in industries transforming primary agricultural products into processed ones, collaborating with trade and consumers. Fourthly, the support

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services subsystem includes activities that provide various support services for agribusiness, including banking, infrastructure (physical and non-physical), research and development, education, consultancy, and transportation.

The interaction among these four subsystems constructs a comprehensive framework to illustrate the dynamics of agribusiness as a whole. Each subsystem within the agribusiness system has a specific role that supports its overall function (Andriushchenko et al., 2019; Jones et al., 2017; Pavlovic et al., 2008). The procurement and distribution of production facilities and infrastructure subsystem are crucial in providing the necessary infrastructure for the primary production subsystem. The primary production subsystem, or on-farm enterprises, plays a key role by producing primary agricultural products that serve as vital raw materials for downstream subsystems (De Boer & van Ittersum, 2018; Dijkman et al., 2018). The processing or agro-industry subsystem makes a significant contribution by adding value to primary agricultural products through processing into economically valuable processed products. Meanwhile, the support services subsystem provides support through banking, infrastructure, research and development, education, consultancy, and transportation services.

The success of agribusiness heavily relies on effective collaboration among its subsystems. Therefore, close coordination and collaboration among agribusiness subsystems are crucial to produce high-quality agricultural products with a competitive edge. Good integration among these subsystems will ensure operational efficiency and effectiveness, contributing to the overall progress of the agribusiness system.

METHODS

The research methodology applied in this study is quantitative, employing purposive sampling in the South Oba District. The population selected as samples comprises corn farmers with the largest corn cultivation areas. Respondents are divided into three groups based on the highest corn cultivation areas, namely the first, second, and third groups. Each group is randomly selected with a total of 70 respondents.

The research variables and indicators encompass the agribusiness system and cultivation technology (refer to Table 1). In the effort to develop corn agribusiness, an evaluation of its subsystems is conducted, involving agro-input agroproduction, agro-industry, agro-marketing, and agro-support services. Each item is assessed by assigning scores: Excellent = 4, Good = 3, Not Good = 2, and Not Excellent = 1.

Table 1. Research Variables and Indicators

No	Variable	Indicator
1.	Technology in crop cultivation	1. Seed usage; 2. Soil processing; 3. Planting; 4. Weeding; 5. Fertilization; 6. Crop management; 7. Harvesting and post-harvesting.
2.	Agribusiness	1. Agro-input; 2. Agro-production; 3. Agro-industry; 4. Agro-marketing; 5. Supporting service.

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Primary data are obtained through questionnaire completion by respondents under the guidance of enumerators, while secondary data are sourced from BP3K and relevant institutions. The questionnaire's validity is tested using the Pearson correlation coefficient, and reliability is assessed using Cronbach's alpha coefficient (α) (S. Sangadji et al., 2022).

The data recapitulation results categorize the development of the agribusiness subsystems as Excellent (score 4), Good (score 3), Less Good (score 2), and Not Good (score 1). Meanwhile, the corn cultivation technology adopted by farmers is classified as Very High (score 4), High (score 3), Low (score 2), and Very Low (score 1). Analysis of the relationship between the adoption of corn cultivation technology as the independent variable (Y) and other agribusiness subsystems as dependent variables (X) is conducted using Kendall's W correlation test. To examine the level of consensus among respondents in determining agribusiness development priorities, an analysis is performed using the concordance or concordance test with Kendall's W.

RESULTS AND DISCUSSION

Characteristics of Respondents

The respondents' educational background reveals a diverse distribution, with 30.5% having completed elementary school, 18.7% having finished junior high school, 12.7% having graduated from senior high school, and the remaining 38.1% falling under the category of "Others." In terms of age distribution among farmers, a significant majority (61.9%) falls within the 25-30 years age range, while the remaining 38.1% belong to other age groups. Furthermore, the data indicates that maize farming is conducted on an average land area of 6624.85 m2, with a specific percentage of 21.12%. This information provides valuable insights into the educational and demographic characteristics of the respondents, as well as their practices related to maize farming.

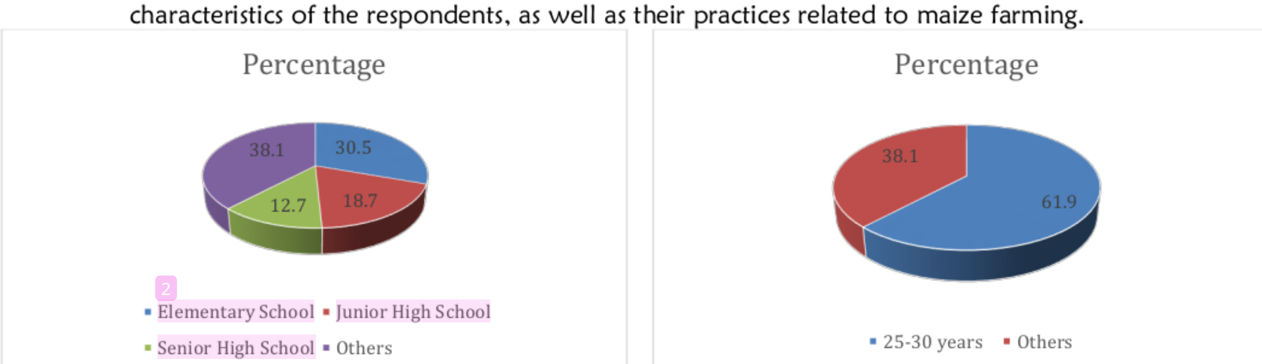

Figure 1. Characteristics of respondents

Validity and Reliability Test

The study assessed the validity and reliability of two variables: "Technology in crop cultivation" and "Agribusiness." For the variable "Technology in crop cultivation," seven indicators were considered, including seed usage, soil processing, planting, weeding, fertilization, crop management, and harvesting/post-harvesting, with respective correlations ranging from 0.727 to 0.986. All indicators demonstrated validity, and the overall reliability, indicated by the Cronbach's alpha coefficient of 0.837, exceeded the

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acceptable threshold of 0.600, signifying a reliable measure. Similarly, the variable "Agribusiness" was evaluated using five indicators: agro-input, agro-production, agro-industry, agro-marketing, and supporting service, with correlations ranging from 0.761 to 0.994. All indicators exhibited validity, and the overall reliability, with a Cronbach's alpha coefficient of 0.958, surpassed the acceptable threshold of 0.600, affirming the reliability of the measure. These findings suggest that both variables are valid and reliable constructs in assessing the respective domains of technology in crop cultivation and agribusiness.

Table 2. Validity & reliability test results

Variable	Indicators	Correlation	Remarks	Reliability
Technology in crop cultivation	1. Seed usage;	0,727	Valid	0,837 > 0,600 = reliable
	2. Soil processing;	0,852	Valid	
	3. Planting;	0,732	Valid	
	4. Weeding;	0,986	Valid	
	5. Fertilization;	0,826	Valid	
	6. Crop management;	0,736	Valid	
	7. Harvesting and post-harvesting.	0,831	Valid	
Agribusiness	*1. Agro-input;*	0,876	Valid	*0,958* > 0,600 = reliable
	2. Agro-production;	0,897	Valid	
	3. Agro-industry;	0,761	Valid	
	4. Agro-marketing;	0,994	Valid	
	5. Supporting service.	0,746	Valid	

Source: data analysis 2024

Corn Agribusiness

The agro-input subsystem in South Oba District is currently in good condition, with the highest score recorded in the seed quality indicator and the lowest in the pesticide distribution process indicator (Figure 2).

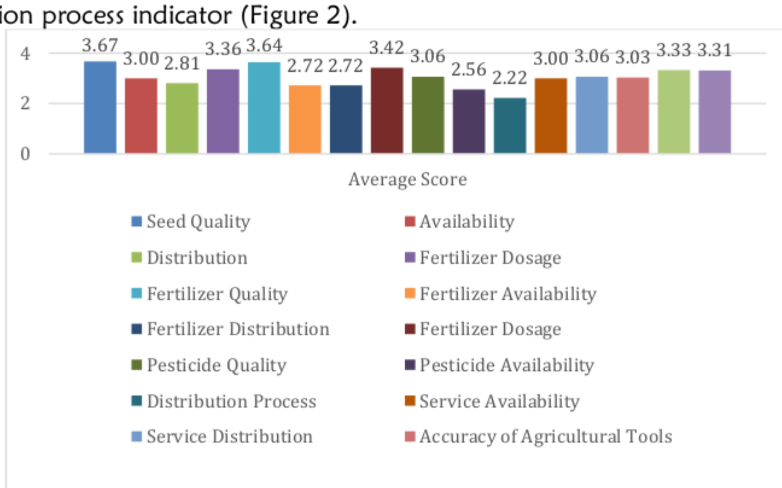

Figure 2. Agro-input Subsystem.

The assessment of the agro-input subsystem reveals promising results, with the Superior Seeds category attaining the highest average score of 3.67, indicating excellent

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seed quality. The aspects of seed availability and distribution also received commendable scores of 3.00 and 2.81, respectively. In the Fertilizers category, fertilizer dosage and quality scored 3.36 and 3.64, respectively, showcasing a positive trend. However, there is room for improvement in fertilizer availability and distribution, with scores of 2.72 each. Pesticides exhibit decent performance, with pesticide quality scoring 3.06, while availability and distribution process received scores of 2.56 and the lowest at 2.22, respectively. Agricultural tools and machinery demonstrate overall sound functionality, with service availability, distribution, and the accuracy of tools scoring around 3.00. Capitalization metrics, including Return on Investment (ROI) and Asset Recording, exhibit satisfactory performance, with scores of 3.33 and 3.31, respectively. The total average score for all aspects is 48.91, resulting in an overall average of 3.06, indicating a good performance level. However, attention should be given to improving fertilizer availability, distribution, and the pesticide distribution process to further enhance the efficiency of the agro-input subsystem.

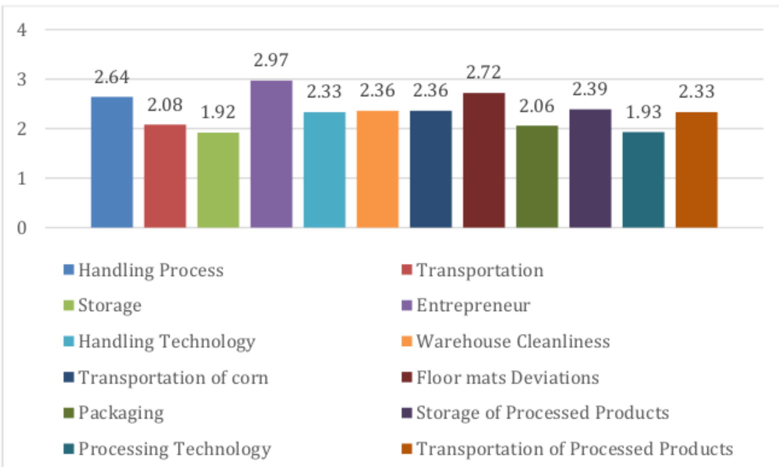

Figure 3. Agro-industry Subsystem.

The measurement data indicates various aspects of the agro-industrial subsystem, with an overall average score of 2.34, reflecting a suboptimal performance. Among the components assessed, handling processes received an average score of 2.64, with transportation and storage scoring 2.08 and 1.92, respectively. The entrepreneurial aspect recorded the highest score of 2.97, showcasing a relatively better performance. However, processing elements, including packaging, storage of processed products, and transportation of processed products, yielded scores ranging from 2.06 to 2.39. Notably, the processing technology aspect received the lowest score of 1.93. The cumulative average suggests that improvements are necessary to enhance the overall efficiency and structure of the agro-industrial subsystem. Specific attention may be required in addressing storage, processing technology, and packaging to elevate the subsystem's performance.

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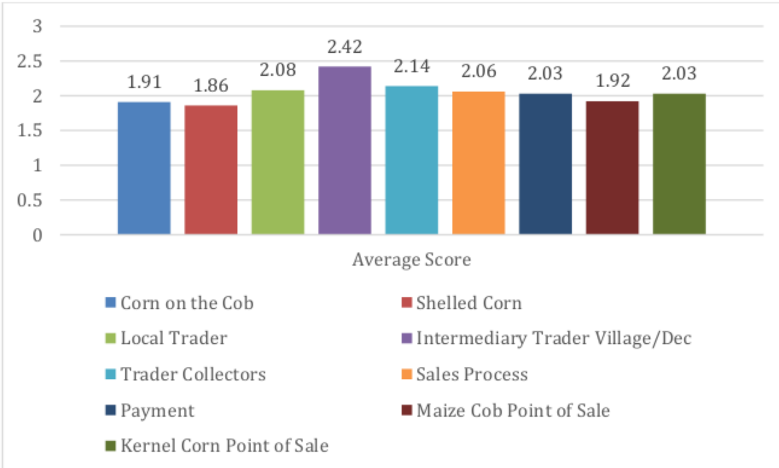

Figure 4. Agro-marketing Subsystem.

The measurement data for the agro marketing subsystem reveals varying scores across different aspects. The price aspect indicates that the Shelled Corn category has the lowest average score at 1.86, while the Local Trader in the Merchant category has a relatively higher score of 2.08. The Intermediary Trader in the Village/Dec category stands out with the highest score of 2.42. In terms of sales, both the Sales Process and Payment aspects have average scores of 2.06 and 2.03, respectively. The point of sale aspect shows that the Maize Cob Point of Sale has a lower score of 1.92 compared to the Kernel Corn Point of Sale, which has a score of 2.03. The overall total score is 18.45 with an average of 2.05, indicating that the current state of the agro marketing subsystem is not considered good. To enhance and structure the subsystem, attention should be directed towards addressing the lower scores in certain categories, particularly focusing on improving the price competitiveness of Shelled Corn and refining the Maize Cob Point of Sale.

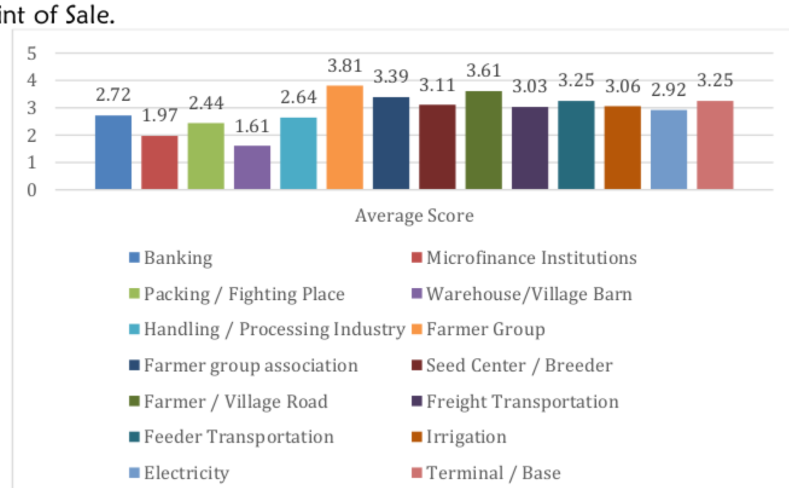

Figure 5. Agro-supporting services Subsystem.

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The measurement of the Agro-supporting services subsystem reveals varying scores across different aspects. In the economic domain, Banking and Handling/Processing Industry exhibit moderate scores of 2.72 and 2.64, respectively, while Microfinance Institutions and Packing/Fighting Place lag slightly behind with scores of 1.97 and 2.44. Notably, Warehouse/Village Barn receives the lowest score at 1.61, indicating a need for improvement in this area. On the other hand, the social counseling aspect demonstrates positive outcomes, with Farmer Group securing the highest score at 3.81, followed by Farmer/Village Road and Feeder Transportation at 3.61 and 3.25, respectively. These results highlight the effectiveness of social counseling services. Overall, the Agro-supporting services subsystem attains a commendable average score of 2.92, reflecting a good performance, with opportunities for enhancement in certain economic components.

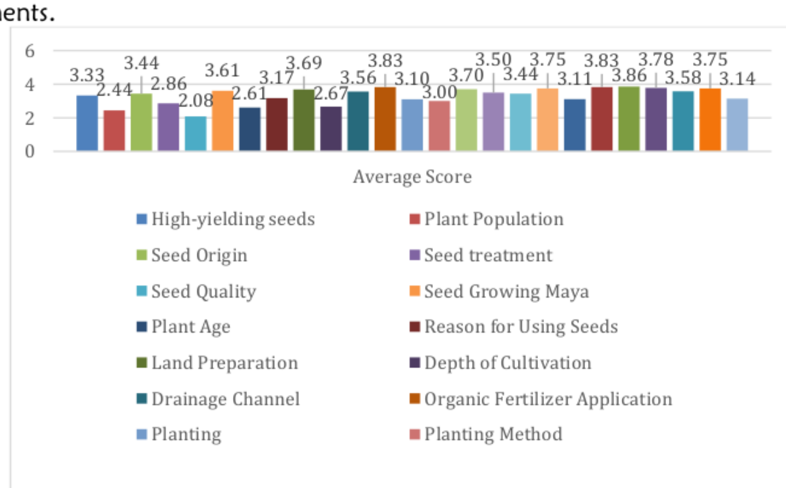

Figure 6. Agro-production Subsystem.

The Agro-production subsystem has been assessed across various aspects, revealing a structured and generally positive performance. Notably, aspects such as High-yielding seeds, Seed Origin, and Land Preparation scored above average, indicating a commendable foundation. Challenges are evident in Seed Quality, where improvement is needed. The utilization of Organic Fertilizer and efficient Weeding practices received high scores, contributing to the subsystem's overall success. Fertilization emerged as a standout aspect, achieving the highest score due to effective Urea fertilization and meticulous Pest and disease control. Harvesting and Yield Handling also demonstrated robust performance. With an aggregate score of 39.44 and an average of 3.59, the Agro-production subsystem showcases a good overall status, emphasizing the need for targeted enhancements in specific areas for optimal agricultural productivity.

Adoption of Corn Farming Technology

The adoption of technology in corn cultivation in the South Oba district can be classified as high overall, with an average score reaching 3.40, as depicted in Figure 7. The significant improvement in the implementation of this technology has had a positive impact on productivity and efficiency in the corn cultivation process in the region.

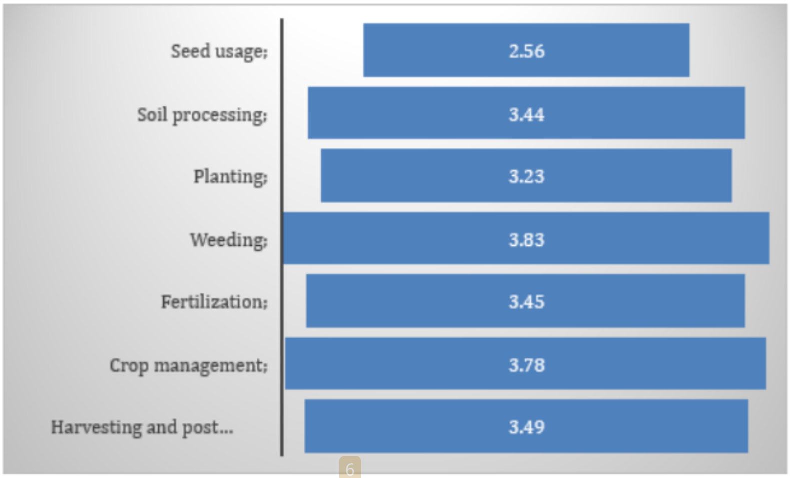

Figure 7. Adoption of Corn Farming Technology

The assessment of Adoption of Corn Farming Technology reveals varying scores across different aspects. Notably, planting and soil processing scored 3.23 and 3.44, respectively, indicating a moderate level of adoption. Weeding and crop management demonstrated higher scores at 3.83 and 3.78, suggesting a relatively robust incorporation of technology in these phases. Fertilization and harvesting/post-harvesting activities also received commendable scores of 3.45 and 3.49, indicating a moderate to high level of technology adoption. However, seed usage scored lower at 2.56, suggesting a potential area for improvement. On average, the overall adoption of corn farming technology is rated at 3.40, indicating a moderate level of implementation across the evaluated aspects. This analysis highlights specific areas, such as seed usage, where targeted interventions could enhance the overall adoption and efficiency of corn farming technology.

Discussion

The analysis results indicate a significant correlation between the agroproduction subsystem and the supporting services subsystem. This positive relationship is believed to be attributed to several factors, such as the effective farmer groups, Gapoktan's support for these groups, and the active role of BP3K in providing guidance through agricultural extension officers. The presence of cohesive farmer groups forms the basis for a strong synergy between the agroproduction subsystem and supporting services. The role of Gapoktan as a supporting institution for farmer groups also plays a crucial role in enhancing the interconnection between the two subsystems. Furthermore, BP3K's role as a guide and agricultural extension provider helps strengthen the positive relationship between the agroproduction subsystem and supporting services.

Additionally, the interconnection between the agroproduction subsystem and the Agro-input subsystem has proven to be significant. This positive correlation can be explained by factors such as farmers' good practices in using seeds, fertilizers, and pesticides. Moreover, the adequate availability of seeds, fertilizers, pesticides, and agricultural machinery and equipment services also contributes to this positive relationship. Efficient distribution and services of agroinputs further reinforce the interconnection between these two subsystems. Hence, a well-integrated approach between agroproduction and Agro-input serves as a crucial foundation for achieving optimal productivity. Meanwhile, the interconnection between the agroproduction subsystem and the marketing/Agro-trade subsystem shows a highly significant yet negatively characterized relationship. Factors such as unfavorable corn prices, lack of quality in local traders, inefficient sales processes, including payment issues, and unfavorable sales conditions all contribute to this negative interconnection. Therefore, efforts are needed to enhance the efficiency and effectiveness of the marketing subsystem to support positive growth within the agroproduction subsystem.

On the other hand, the interconnection between the agroproduction subsystem and the Agro-Industry subsystem reveals a less significant level of correlation. Although there are some positive aspects, such as inadequate handling and processing of corn products, this relationship does not achieve the expected significance level. Improvements in the handling, processing, transportation, storage, and warehouse-related aspects are necessary to enhance the interconnection between agroproduction and Agro-Industry. Enhancements in the management and quality of processed products should also be a focus to strengthen this connection. Overall, this research demonstrates that the agroproduction subsystem exhibits strong interconnections with several other subsystems, particularly supporting services, Agro-input, and marketing/Agro-trade. However, further enhancement in the interconnection with Agro-Industry is required to achieve optimal integration within the agricultural system. Improvement and enhancement measures in each subsystem are essential to enhance productivity, efficiency, and sustainability in the agricultural value chain.

CONCLUSIONS

The findings of this research indicate that farming in the South Oba District still faces several subsystems that need improvement to enhance overall performance. Despite the successful adoption of corn cultivation technology, the research results show that there are still suboptimal subsystems in farming activities in the area. Further analysis reveals a significant interdependence between corn cultivation technology and other subsystems, although the level of correlation tends to be low to moderate. In the context of enhancing corn agribusiness development in the South Oba District, this study recommends prioritizing several subsystems for further development. Firstly, the agro-marketing subsystem takes center stage, considering the importance of marketing in adding value to products. In this context, more effective and efficient marketing strategies can be implemented to expand market reach and improve the competitiveness of corn products. Additionally, the research highlights the need for development in the agro-supporting service subsystem. Better technical support and information for farmers can enhance their operational efficiency, including the selection of superior varieties, pest and disease management, and more innovative cultivation techniques. Therefore, investing in better support services in this field can increase productivity and the sustainability of corn farming in the region.

The development of the agroindustry subsystem is also a crucial step, especially in creating added value to corn products through processing. By strengthening the agroindustry value chain, farmers can access broader markets and achieve better profits from their harvests. Furthermore, special attention should be given to the agro-input subsystem, including the provision of quality and affordable agricultural inputs, as well as organizing training for farmers in using advanced agricultural technologies. Lastly, the agro-production subsystem also needs attention to ensure sustainable corn productivity improvement. By implementing innovative and sustainable farming practices, farmers can enhance their harvest yields without harming the surrounding environment. Overall, the development of these subsystems is expected to create a stronger and more sustainable corn farming ecosystem in the South Oba District, positively impacting the well-being of farmers and the local economy as a whole.

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