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Development Model of an Agriculture-Based Smart Village: Case Study of Cibodas Village, West Java

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ABSTRACT

Background and Objective: The study explores the development of an agriculture-based smart village in Cibodas, West Java, which focuses on integrating agrotourism and sustainable practices. It highlights the importance of community participation and innovation infrastructure in fostering economic growth and environmental sustainability. The study proposes an innovative model for smart villages centered around agriculture. **Materials and Methods:** It explores key elements such as commodity selection, cultivation techniques and technologies, supply chains, and institutional frameworks. Insights were gathered from various agricultural stakeholders in Cibodas Village, West Java, utilizing a qualitative case study approach. Data collection involved observations, interviews, documentation, and audiovisual materials from January to May 2023. The analysis combined inductive and deductive methods, initially forming patterns and categories from abstract data units, then integrating data and facts to reinforce each theme. **Results:** The findings revealed that an agriculture-based intelligent village model enhances high-value commodities through digital transformation. This transformation incorporates Agricultural Technology 4.0, efficient supply chain management, and an institutional framework integrating farmers into a cohesive production and marketing platform. Such an approach not only enhances the agricultural production value chain but also addresses various village challenges sustainably. **Conclusion:** The study proposes an innovative agriculture-based smart village model in Cibodas, West Java, integrating agrotourism and sustainable practices. It emphasizes community participation and innovation infrastructure for economic growth and environmental sustainability. The study contributes to the field by offering a sustainable smart village model that integrates agrotourism and digital transformation, though it is limited by its focus on a single village. Future research could explore scalability and application in diverse agricultural contexts.

Keywords: smart village, supply chain, sustainable agriculture, high-value commodities, digital transformation, inductive and deductive methods

INTRODUCTION

The sustainable smart village model integrates agrotourism and digital transformation, addressing both economic growth and environmental sustainability in rural areas. The sustainable smart village model integrates agrotourism and digital transformation, addressing both economic growth and environmental sustainability in rural areas. The concept of smart villages has emerged as a response to the increasing digital divide between urban and rural areas, coupled with challenges in sustainability and food security. The innovative approach leverages technology to empower rural communities, improve their quality of life, and enhance economic opportunities. By providing digital infrastructure and training, intelligent villages aim to bridge the technology gap, promoting sustainable agriculture, renewable energy, and eco-friendly practices to ensure the long-term viability of rural livelihoods. Furthermore, intelligent villages focus on improving food security through technology-driven agricultural productivity, reducing food waste, and enhancing distribution systems. Integrating high-speed internet connectivity, e-governance, smart agriculture, telemedicine, online education, and renewable energy, intelligent villages create resilient and prosperous communities, fostering social innovation, cultural preservation, and community empowerment for a more equitable and sustainable future.

The basic concept of an intelligent village is to consolidate the efforts and strengths of individuals from various fields and integrate them with information technology to benefit rural communities [1]. This concept aims to transform digital technology to enhance the quality of essential services and village development based on inclusive and sustainable community empowerment [2]. Although the development of smart villages in Indonesia is significantly influenced by intelligent city development, intelligent villages must be constructed differently[2]. It should also preserve the local wisdom of the village people as much as possible[3]

From various studies conducted previously, there are at least three main issues that are the background to the emergence of intelligent village programs, namely the issue of technology gaps, sustainability, and food security. Many smart city platforms and solutions exist, while investment in small rural areas is relatively small. This situation can increase urban problems by increasing population movement to cities and deepening the digital divide among citizens. Although the development of smart villages in Indonesia is significantly influenced by intelligent city development, intelligent villages must be constructed differently[2]. It should also preserve the local wisdom of the village people as much as possible[3]. A study looks at village programs that can provide welfare to rural communities with an integrated design and strategy[4]. Regarding sustainability, climate change and variability are significant environmental and food security challenges worldwide. Climate-smart agriculture strategies are the keys to responding to this challenge variability in West Africa: Challenges and lessons learnt.

Sustainable growth and management is not limited to cities but extends to rural areas. The study expects a balance of three components that become indicators in the development of intelligent villages: economic, environmental, and social components[5]. The examined relationship between climate change issues, carbon emissions, economic impacts, and energy governance[6].

The emphasize the importance of technology, paying attention to community and sustainability. believes that the concept of intelligent villages answers the search for ways to apply the concept of sustainable development. The issue of food availability is also closely related to the development of digital villages because most villages in Indonesia are agricultural. In low- and middle-yielding countries, most of the population is rural, with more than 70% being scale farmers[7].

In developing countries, there is generally limited agricultural land, population development is difficult to control, and the scale of agricultural business is narrowing. The agricultural sector is significant in our economy and is crucial in supporting society. The 2018 Inter-Census Agricultural Survey results show that approximately 33 million more Indonesians work as farmers, or equivalent to more than 27 million households are small-scale farmers. However, it contributes nearly 14% of gross domestic income[8].

There is about 75 % of them only control land under 1 ha. Rural poverty is widely associated with the marginalization of the agricultural sector. Intelligent villages aim to leverage technology to empower rural communities, address the digital divide, and promote sustainable development. By integrating digital infrastructure, e-governance, smart agriculture, healthcare, education, renewable energy, and community development, these initiatives seek to improve the quality of life in rural areas, enhance economic opportunities, and preserve cultural heritage. Through the adoption of innovative technologies and sustainable practices, intelligent villages strive to create resilient and prosperous communities that can thrive in the 21st century.

The lack of investment and development in small rural areas, exacerbates the digital divide and urban migration, while also addressing sustainability and food security challenges. The study aimed to explore several critical aspects of modern agriculture, including how the adoption of hydroponic and digital farming technologies influences productivity, pest control, cost-efficiency, and labor requirements for farmers in Cibodas Village. Additionally, the study investigates the impact of selecting and regionalizing high-value commodities, such as beef tomatoes, on the economic stability, production continuity, and market competitiveness of farmers in the Lembang Agritani Association. Furthermore, it examines how the role of agricultural associations in providing resources, technical assistance, and market management affects the economic stability, production efficiency, and market competitiveness of member farmers. The research also delves into the effects of associations' provision of production facilities and agricultural capital on member farmers' economic stability and production efficiency. Lastly, it explores the impact of establishing a Digital Farmer Education and Tourism Center by the Lembang Agrotani Association on knowledge dissemination, agricultural practices, and economic opportunities for local and international stakeholders.

MATERIALS AND METHOD

Study Area

This research was conducted in Cibodas Village, Lembang Regency, West Java Province. This location was chosen as the research object because West Java province is included in the Digital Village Program by the Ministry of Communication and Information and the Horticultural Village program of the Ministry of Agriculture. It is also a region that has already implemented agricultural technology and digitalization activities. The research will be conducted from February to June 2023.

Analysis Methods

The qualitative method using a case study approach and the described analysis techniques are suitable for addressing the research questions provided.

1. Category Collection: By collecting data examples related to hydroponic and digital farming technologies, high-value commodity selection, and the role of associations, researchers can identify relevant patterns and themes that address the impact on agricultural productivity, economic stability, and market competitiveness.
2. Direct Interpretation: Examining specific examples of farmers' experiences, associations' practices, and the implementation of educational programs allows for a deeper understanding of the individual and collective impacts on the farming community. This technique helps to draw meaningful insights without the need for multiple examples.
3. Forming a Pattern: Seeking equivalence between categories such as technology adoption, resource provision, and educational initiatives helps to identify broader patterns and relationships that can explain the overall effects on economic and production outcomes.

The development of innovative agricultural systems can be divided into several stages, as depicted in highlights the evolution from manual mechanical methods to advanced digital technologies. Each stage builds upon the previous one to enhance productivity, sustainability, and efficiency in farming practices.

The Beef Tomato Association Lembang Agrotani in Cibodas Village, West Java, has a significant impact on local agriculture and community. The association focuses on the cultivation and marketing of beef tomatoes, providing support and resources to local farmers.

The process from production to marketing in agricultural supply chains is visually represented in a flow chart. This flow chart highlights the key stages involved, from initial production to final marketing and distribution. It provides a clear overview of the steps and interactions within the supply chain, emphasizing the importance of efficient management and coordination throughout the process.

The flow chart outlines the functions and interactions of these institutions, emphasizing their roles in supporting agricultural development and community well-being.

The combination of inductive and deductive methods ensures a comprehensive analysis. Initially building patterns and themes from the data (inductive) and then validating these with existing theories or frameworks (deductive) provides a robust approach to understanding the complex dynamics at play. This method aligns well with the research questions' focus on technological adoption, commodity selection, association roles, resource provision, and educational impacts.

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RESULTS AND DISCUSSION

Cultivation System and Technology

Several farmers in Cibodas Village have adopted a cultivation system with greenhouse (GH) bamboo facilities and a transparent plastic cover roof. They use a hydroponic system, with postbags facilities and planting media made of manure, burnt husks, and cocoa. Some farmers use a drip irrigation system, whereas others use a drip watering system with an ordinary hose. Of the 21 member farmers currently available, two garden units have fully practiced the innovative farming model, using sensor equipment to control watering and fertilization and measure soil moisture, air, and fertilizer solubility.

Farmers faced many challenges before adopting the hydroponic polybag system, including pest infestations and plant diseases. With this system, it is easier for farmers to control pests such as Fusarium pests, which are typical diseases of tomato plants. Fusarium pests are soil bacteria that often appear in moist soil media. With hydroponic systems and drip irrigation, humidity is easier to regulate, plants are sterile, and they do not spread to other plants because each postbag is isolated and the origin of the growing medium has no bacteria.

The hydroponic system uses a destination system, which involves fertilizing and watering with a drip hose. Nutrient provision for plants is carried out daily, whereas the application in the soil can be done weekly. Digitalized gardens can fertilize easily; fertilizers are stored separately in tanks, and sensor equipment mixes itself and drains to plants as needed. The presence of this equipment is very beneficial to farmers because it allows them to work and control the garden remotely.

Farmers can make energy, time, and cost-efficient with the cultivation system and innovative farming technology they apply. Work that manually must be done in half a day with digitization only takes 10 minutes. Based on experience, with a total GH size of 1,000 square meters, it is only controlled by one person even then controlled only once a week. The garden does not need to be maintained because it can be monitored through CCTV. Farmers can do other jobs, whether in other gardens or office work. Thus, farmers can make significant cost savings.

The sensor equipment can be purchased or rented with a harvest season rental system, and technology companies can obtain assistance. For example, the rental of fertilizer mixing control equipment is Rp.300,000 per season, excluding mechanical equipment. Mechanical equipment, such as drip hoses, can be purchased separately. The drip hose can be run with an electrical system only but cannot be controlled remotely.

The difference between mechanical and digital systems is that mechanical systems must work in the garden daily, whereas digital systems can be controlled via mobile phones. Farmers can make their own decisions about whether to digitize or stick to the mechanical manual system. Farmers with a workforce and less equipment investment can survive with mechanical systems. Meanwhile, farmers with less time and energy but sufficient capital can implement a digital system.

Several components are required before it is fully digitized: GH garden model, polybag system, hydroponic system, drip irrigation system, fertilization system, Etc. Not all system components are implemented simultaneously, but they can be applied gradually until all are digitized later. Material can be obtained from the surrounding environment, such as bamboo, which is not too expensive compared to steel materials. For example, sensors are needed to overcome labor shortages and save time. Meanwhile, those still have plenty of time to delay the fertilization and irrigation digitization system.

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Components are required before complete digitization can be achieved. These include the GH garden model, polybag system, hydroponic system, drip irrigation system, and fertilization system. Not all system components are implemented simultaneously, but they can be applied gradually until all are digitized. Materials such as bamboo can be obtained from the surrounding environment, which is less expensive than steel materials.

For example, sensors are needed to overcome labor shortages and save time. Meanwhile, those who still have plenty of time can delay the digitization of fertilization and irrigation. However, those who do not have a workforce and only have a little time can immediately digitize.

Figure 1: Stages of innovative agriculture system development, from manual mechanical to digital (Adapted from Gualandri, E. (2008)[9])

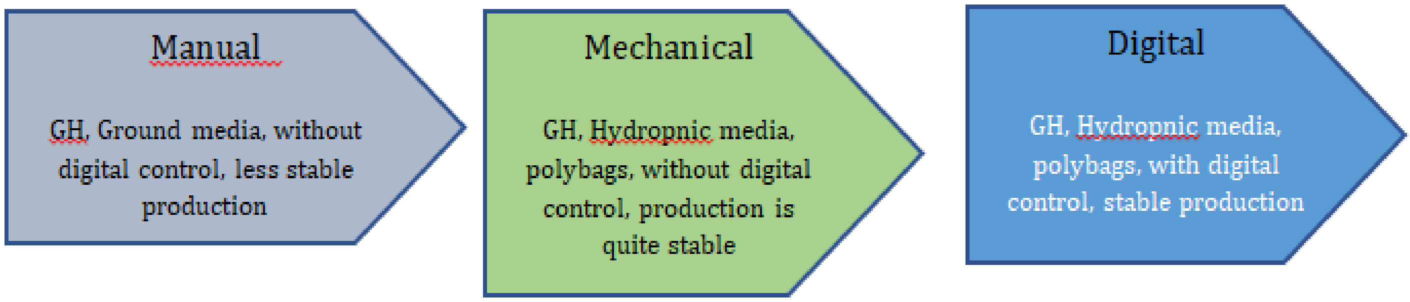

Figure 1: Stages of Innovative Agriculture System Development typically outlines the progression of agricultural practices through different stages. These stages often include:

1. Manual Labor: Initial reliance on human and animal labor.
2. Mechanization: Introduction of machinery to enhance farming efficiency.
3. Automation: Implementation of automated processes to reduce manual intervention.
4. Digitalization: Integration of digital technologies, such as data analytics and precision farming tools.

The digitization process can be carried out gradually, but the development direction should be planned from the beginning, starting from manual, mechanical, and digital cultivation techniques. For example, beef tomato farmers still use technology both manually and mechanically. Some still water manually or mechanically but already use hydroponic planting media with polybags. To transform the system digitally, add a drip irrigation system component, with IoT lubricants for sensors, to control the irrigation system, fertilization, and pest control.

Selection of Featured Commodities

The key to the success of farmers who are members of the Lembang Agritani Association is the selection of the main commodity, beef tomatoes, which have high economic value. The beef tomato commodity has advantages because the price of beef tomatoes is quite good and stable at the consumer level compared to vegetables in general. Vegetables are generally prone to price fluctuations, sometimes high, but suddenly can go down even at low prices. Other commodities, such as peppers, melons, and radiation, are competitive. Everything can be cultivated through intelligent farming. Suitable peppers and melons can be grown in GH, whereas radius is grown in open gardens using mulch, drip hoses (flattened), and soil moisture control.

One of the requirements for becoming a member of the association is the willingness to grow the same commodity and make one-stop sales through the association. The association provides seeds and production facilities as required. The association also provides technical assistance in production and marketing. Farmers follow the instructions of the association. The purchase price of the association to farmers is currently set at

Rp—15,000 per kg. The market demand that can be served is around 25%, while export demand has yet to be served. Production from all members of the new association is approximately 700 kg daily.

This pattern of mapping and selecting commodities is quite effective in regulating the harvest amount, maintaining continuity, preserving the quality and quantity of production, and stabilizing prices. If not managed properly, farmers can experience losses at any time. For instance, a farmer named HU (57) once had a harvest of around Rp.1 billion in one harvest season, but in the next planting season, suffered a significant loss because the crop price fell to 500 rupiah per kilogram. As a result, the tomato fruits were not harvested and left to rot.

The pattern of commodity sorting is crucial for avoiding such problems. These patterns can be developed on a broader scale, either by the type of commodity or by area. Commodity regionalization can be performed per village, sub-district, or district through farmer institutional arrangements.

The mapping and selecting commodities strategy has proven effective in regulating harvest volumes, ensuring production continuity, maintaining product quality and quantity, and stabilizing prices. Mismanagement can lead to significant losses for farmers. For instance, a farmer named HU (57) once yielded approximately Rp.1 billion in a single harvest season. However, in the subsequent planting season, he suffered substantial losses because of a drop in crop prices to 500 rupiah per kilogram, resulting in unharvested tomatoes that were left to decay. To prevent such scenarios, the implementation of commodity sorting is crucial. This strategy can be expanded in terms of commodity type or geographical area. Regionalization of commodities can be organized at various levels - village, sub-district, or district - through institutional arrangements among farmers.

The association plays a crucial role by acting as a channel for communication for joint marketing, with the proceeds benefiting both the operational funding and capital of the association and serving the common interest. The association does not function as a trader. In this context, the association merely represents farmer management, with the margin agreed upon by the members and utilized for their benefit. The margin taken by the association is partially used for operational costs, grading costs, and sorting until delivery. Some of it is used for the association's capital reserves. It subsidizes farmers' risk from production that is not in demand in the market, namely Grade D tomatoes, which are produced when tomato prices are low and cannot be sold on the public market.

The association's success in managing supply chains the system's strength lies in its ability to match the requirements of individuals or organizations with the available resources to achieve a desired outcome. Farmers and markets ensure continuity of production. The archived by conducting a strict planting and harvest schedule, with discipline applied to all association members. The objective is to adjust to market demand, avoiding accumulation or shortage. Therefore, market demand must be calculated first, followed by regulating production from member farmers. The schedule is communicated through the group's WhatsApp, making it accessible to all members.

In ensuring a smooth supply chain, the association continuously calculates production capabilities so that not all off-taker and consumer requests can be served. Currently, the association's production is still around seven quintals per day, and only about 25% of the demand can be served, not including export demand. The association prioritizes the local market because of sufficient production and higher local prices than export prices.

To fulfill all of these market requirements., associations are challenged to develop new gardens through intelligent farming. In the future, to increase the volume of the beef tomato supply chain, the association plans to increase its business scale by increasing the area of GH-based farms through several patterns, including adding new farmer members. This expansion also involves and empowers local farmers.

Institutional Role of Farmers' Associations

Before implementing the intelligent farming system, several farmers in Cibodas were conventional cultivators of various vegetable horticultural crops. A few individuals then developed greenhouse (GH) facilities to cultivate beef tomato commodities. In 2018, only about seven farmers utilized GH for tomato cultivation. They encountered numerous obstacles, such as technical issues in cultivation, capital, and marketing, which hindered their development. Consequently, in 2020, they established an association named " the Lembang Agrotani Beef Tomato Association."

The association has since grown to include 21 member farmers in two villages: Cibodas Village, with 17 units, and Sunten Jaya, with four. The total area of gardens within the association is approximately 7,000 m^2, with individual garden units ranging from 100 to 500 m^2 .

This growth was facilitated by the association's ability to enhance its bargaining position in the market. In order to improve both the production capabilities and market reach., all member activities are coordinated through the association, encompassing technical cultivation, marketing, and financing. Farmers agreed to sell their produce exclusively through an association platform at a pre-agreed price and production volume.

The association ensures supply continuity, influenced by quantity, production schedule, and stable quality. The market seeks other suppliers to connect supply if production is not continuous. When an old supplier struggles to resupply, it offers a lower price to re-enter the market. Unfair competition and price inconsistencies may result from these events. To tackle this issue., a one-stop supply system was agreed upon to ensure continuity, healthy competitive prices, and increased unity. With this system, the price of beef tomatoes from the association maintains high bargaining power and stability.

The choice of association institutions as a forum for farmers was deliberate to avoid the mindset that cooperatives only belong to management. In this association, membership is limited to farmers cultivating the same commodity. Unlike cooperative institutions, associations do not recognize deposits or dues; instead, they provide loan assistance to farmers.

Members must sell through one door and adhere to the organization's work system, such as planting and picking schedules while meeting set quality standards. Farmers feel secure joining because they receive immediate assistance, and new members can be added without fear of competition.

Apart from being a joint marketing forum, the association also serves as an education center for beef tomato farmers because members can share their experiences. It is easily accessible to government programs and provides investors with easier access to information because of its transparency and trustworthiness.

To raise reserve funds, the association charges a fee of approximately 5% of the wholesale price for selling saprody goods to farmers. While selling seeds themselves, the association does not make a profit; members are only required to sell their harvests to the association. The association takes a margin of about Rp2,000-3000 per kg with purchases from members at Rp15,000 per kg while selling them in the market at Rp. 17 000- 18 000 per kg.

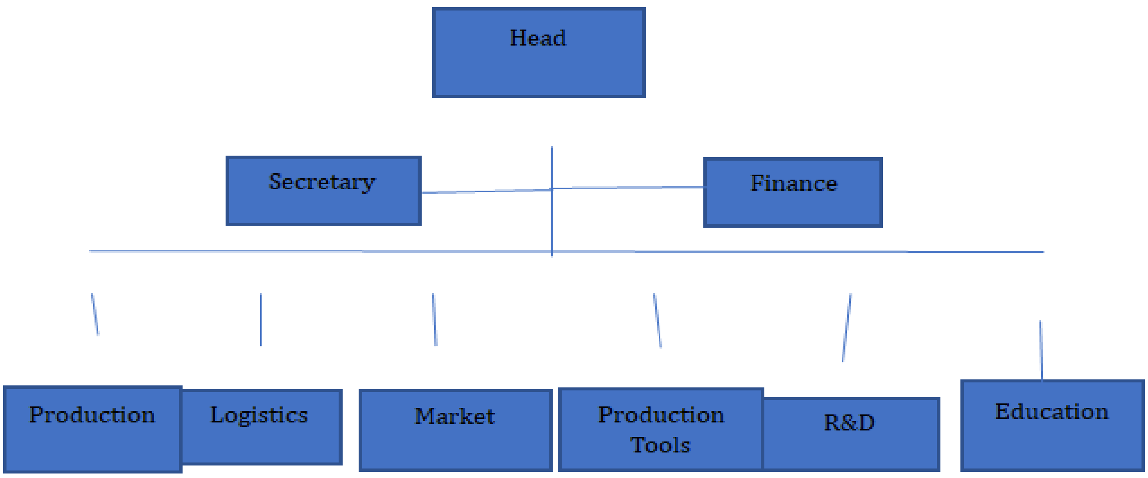

Figure 2: The association operates through a well-organized structure, with clear roles and responsibilities for its members. It aims to promote sustainable farming practices and innovative techniques to increase productivity. This structured approach has contributed to the success and growth of the association[10].

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Co-Marketing Management

The harvest of beef tomatoes produced by association members is marketed collectively through the association. All products from members are consolidated in warehouses, processed, and then dispatched to buyers. The workflow involves the marketing department receiving orders from the market and forwarding these orders to the production department. The buyer's request data are utilized by the production department to formulate production plans, encompassing planting scheduling, harvest scheduling, and delivery.

The incoming crop undergoes grading, weighing, and packaging and is then sent to the off-taker or market. The farmers' crops received by the associations of warehouse are paid for via transfers to the farmers' accounts. This process is conducted daily.

The association's success hinges on its ability to establish modern market access, including online. Some agricultural product e-commerce platforms that are primary customers of this association include Sayur Boks, Segari, Tani Hub, and Fresh Box. Modern markets such as Yan's Fruit, Sukarasa Farm, Dewa Family, Rumah Sayur, and some individual buyers from Bali also form part of their customer base.

The association purchases from farmers for Rp. 15,000 per kg while selling to off-takers at Rp. 18,000-26,000. The price difference constitutes the association's profit. The price of beef tomatoes at the consumer level through online purchases varies among all off-takers and ranges from Rp—50,000 per kg.

Deliveries to online sales platforms such as Sayur Boks are scheduled daily with a payment system of three times per week. Modern markets have a delivery schedule of three times weekly, with payments made every two weeks.

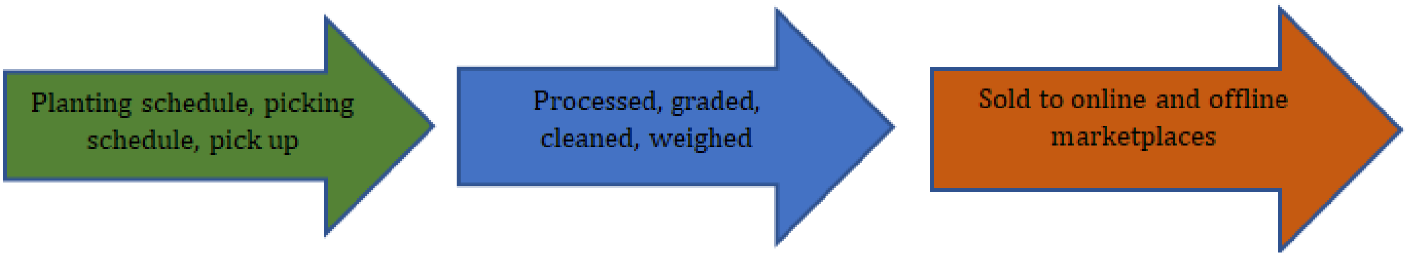

Figure 3: Flow chart; Structure and function of the Beef Tomato Association Lembang Agrotani Cibodas Village, West Java [11].

Preparation of Production Facilities and Agricultural Capital

In addition to managing marketing, the association ensures the availability of something crucial depending on the role played by something or someone, facilities, and infrastructure for member farmers. Seeds, fertilizers, fungicides, planting media, container equipment, transportation, cooling rooms, and capital. Each farmer receives a supply of seeds, planting media, and fertilizers from the association on credit, with manageable repayments deducted gradually at harvest. Procurement services for seeds and planting media benefit members as they can access lower prices than the public market with faster and more practical procurement. Furthermore, the association assists members with plastic crates for harvesting without purchasing.

The association assigns special officers who travel to conduct service activities for members to facilitate these services. This mechanism makes the association's presence highly effective and service-oriented for members.

The association plans to construct facilities that members can utilize collectively, such as greenhouse (GH), for research and development and market research activities. Through the Ministry of Agriculture Program, the government has assisted this association through the Lembang Agrotani Farmer group with a mobile cooling container device with a capacity of 5 tons. This container tool is quite effective in maintaining the freshness of tomatoes before they are shipped to consumers and significantly aids associations in improving their supply and production value chain.

The association plays a crucial role as a channel for communication; The association plays a crucial role as a channel for communication, with the proceeds benefiting both the operational funding and capital of the association and serving the common interest. Thus, the association does not function as a trader. In this context, the association merely represents farmer management, with the margin agreed upon by the members and utilized for their benefit. The margin taken by the association is partially used for operational costs, grading costs, and sorting until delivery. Some of it is used for the association's capital reserves. It subsidizes farmers' risk from production that is not in demand in the market, namely Grade D tomatoes, which are produced when tomato prices are low and cannot be sold on the public market.

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In ensuring a smooth supply chain, the association continuously calculates production capabilities so that not all off-taker and consumer requests can be served. Currently, the association's production is still around seven quintals per day, and only about 25% of the demand can be served, not including export demand. The association still prioritizes the local market because of insufficient production and higher local prices than export prices.

In order to meet all of the requirements in the market, associations are challenged to develop new gardens through intelligent farming. In the future, to increase the volume of the beef tomato supply chain, the association plans to increase its business scale by increasing the area of GH-based farms through several patterns, including adding new farmer members. This expansion also involves and empowers local farmers.

Digital Farmer Education and Tourism Center

With the increasing demand for information and Knowledge about digital agriculture, the Lembang Agrotani Association has begun hosting numerous visitors interested in farming practices. Notable guests include a group of Field Extension Officers from Bangka Province, who sought to learn about the institutional association to apply to the onion association they were forming. Additionally, higher education institutions such as ITB conducted a study on water resources and irrigation systems with approximately 40 participants. The association has also welcomed international guests from Turkey and Taiwan, who expressed interest in seed cooperation and crop schedule studies, respectively.

Recognizing this opportunity, the association plans to offer hydroponics agricultural training services and agricultural digitalization as a source of income. Potential markets for these educational services include extension workers and educational institutions, particularly vocational education. These groups have expressed interest in learning from the experiences of farmers and associations.

The association plans to introduce itself to the public through profiles to promote this educational program. The aim is to attract individuals interested in learning about cultivation technology, supply chain management, and institutions. Through these educational activities, associations can secure new sources of incentives.

Economic Prospects and Potential for Beef Tomato Business Development

The market opportunity for beef tomato remains extensive. According to demand data collected by the association, only approximately 25% of the local market demand is currently being met. Furthermore, export market demand still needs to be met. Regarding profitability, beef tomatoes present a favorable prospect compared to conventional vegetable crops because of their stable prices and markets, which do not fluctuate as much as general vegetables. This stability motivates farmers who are members of the Lembang Agritani Group to continue developing their businesses and increasing membership numbers.

One of the critical roles of the association is to act as a channel or medium marketing, with the proceeds benefiting both the operational funding and capital of the association and serving the common interest. Thus, in essence, the association does not function as a trader. In this context, the association merely represents farmer management, with the margin agreed upon by the members and utilized for their benefit. The margin taken by the association is partially used for operational costs, grading costs, and sorting until delivery. Some of it is used for the association's capital reserves. It subsidizes farmers' risk from production not in demand, namely Grade D tomatoes, which cannot be sold on the public market when prices are low.

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Preparation of Production Facilities and Agricultural Capital

The association plays a significant role in supporting the availability of facilities and infrastructure for member farmers, including seeds, fertilizers, fungicides, planting media, container equipment, transportation, cooling rooms, and capital. Each farmer receives a supply of seeds, planting media, and fertilizers from the association on credit, with manageable repayments deducted gradually at harvest. These procurement services benefit members by accessing lower prices than the public market with faster and more practical procurement. Furthermore, the association assists members with plastic crates for harvesting without purchasing.

To facilitate these services, the association assigns special officers who travel to conduct service activities for members. This mechanism makes the association's presence highly effective and service-oriented for members.

In the future, the association plans to construct facilities that can be utilized collectively by members, such as Green Houses (GH), for research and development and market research activities. Through the Ministry of Agriculture Program, the government has assisted this association through the Lembang Agrotani Farmer group with a mobile cooling container device with a capacity of 5 tons. This container tool is quite effective in maintaining the freshness of tomatoes before they are shipped to consumers and significantly aids associations in improving their supply chain and production value chain.

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Economic Prospects and Potential for Beef Tomato Business Development

The market opportunity for the Beef Tomato commodity remains extensive. According to demand data collected by the association, only about 25% of the local market demand is currently being met. Furthermore, the export market demand has yet to be served. In terms of profitability, Beef Tomatoes present a favorable prospect compared to conventional vegetable crops due to their stable prices and markets, which do not fluctuate as much as general vegetables. This stability motivates farmers who are members of the Lembang Agritani Group to continue developing their businesses and increasing membership numbers.

Please provide the table based on this concept, The Table1 illustrates the profitability of the beef tomato cultivation business within a 5-year investment plan. With an initial capital of approximately Rp.300 million for an area of 100 tumbak (1 tumbak = 14 square meters) housing 3,000 trees, yields can reach 5 kg per tree over an 8-month fruiting period, with a selling price of Rp.15,000 per kg. The initial capital can be recouped within two years, allowing for-profit accumulation from the third to fifth year. Significant capital expenditure occurs only in the first season, while the return of working capital can be achieved after the second season. This design is based on empirical experience gathered by farmers who are members of the Lembang Agritani association.

Table 1. Ilustrating the profitability of the beef tomato cultivation business within a 5-year investment plan based on the provided concept:

Year	**Initial Capital (Rp)**	**Number of Trees**	**Yield per Tree (kg)**	**Total Yield (kg)**	**Selling Price (Rp per kg)**	**Revenue (Rp)**	**Cumulative Revenue (Rp)**	**Net Profit (Rp)**
1	300,000,000	3,000	5	15,000	15,000	225,000,000	225,000,000	-75,000,000
2	-	3,000	5	15,000	15,000	225,000,000	450,000,000	225,000,000
3	-	3,000	5	15,000	15,000	225,000,000	675,000,000	225,000,000
4	-	3,000	5	15,000	15,000	225,000,000	900,000,000	225,000,000
5	-	3,000	5	15,000	15,000	225,000,000	1,125,000,000	225,000,000

The Table 1, illustrates the profitability of the beef tomato cultivation business within a 5-year investment plan. With an initial capital of approximately Rp.300 million for an area of 100 tumbak (1 tumbak = 14 square meters) housing 3,000 trees, yields can reach 5 kg per tree over an 8-month fruiting period, with a selling price of Rp.15,000 per kg. The initial capital can be recouped within two years, allowing for-profit accumulation from the third to fifth year. Significant capital expenditure occurs only in the first season, while the return of working capital can be achieved after the second season. This design is based on empirical experience gathered by farmers who are members of the Lembang Agritani association.

The planting system employs hydroponic and controlled irrigation and pest control systems, ensuring stable and continuous production. The association's work system guarantees the supply chain system, supported by member discipline and member welfare assurance, resulting in a smooth supply chain trusted by off-takers. The price set collectively strengthens farmer solidarity. All members, in the form of facilities and infrastructure, can enjoy the benefits of the association. This agricultural model presents advantages over

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conventional farming models, which tend to need more certainty about results due to their heavy reliance on natural conditions and intuition.

Another advantage is that decent results can be achieved without requiring large land areas, aligning with the current difficulty in obtaining agricultural land. GH construction does not necessitate expensive steel but can utilize bamboo material purchased from the local community.

Despite its profitability, several obstacles and considerations deter many farmers from transitioning to intelligent farming systems. These include not only capital and land but also knowledge or literacy. Another factor is that some farmers still rely on their land area without guaranteeing that large land areas can yield profitable results due to weather factors, pest factors, price fluctuations, and markets.

The potential for intelligent agriculture development is vast, primarily because there is still significant market demand. In the future, the market can be created and developed as post-harvest processed products. Innovative agriculture programs can also address the dwindling land and workforce issues, attracting millennial farmers to work in the agricultural sector.

The agriculture-based smart village model significantly enhances high-value commodities through digital transformation. This transformation incorporates Agricultural Technology 4.0, efficient supply chain management, and an institutional framework that integrates farmers into a cohesive production and marketing platform.The farmer institutional model developed in Cibodas Village is an example of rural agricultural management. The institutional model of the association functions as an aggregator that can consolidate various interests in the agricultural business. Farmers in Cibodas Village have successfully made institutional innovations. The selection of the association model is an intelligent effort and can provide a collective solution for farmers.

Based on experience, the Lembang Agrotani Association has succeeded in becoming an aggregator in the supply chain of beef tomato agricultural products. From an institutional perspective, the association procures agricultural infrastructure and facilities such as seeds, fertilizers, production equipment, marketing, and financing. It carries out delivery system functions and product management, such as grading before they are sent to market; resource management through cultivation using GH-based hydroponics; and value chain improvement through joint marketing, online marketing, and post-harvest management.

In Norman Uphoff's (1986) thinking, farmers' associations can be included in the voluntary sector category because they primarily serve as a forum for gathering common interests. There are three types of institutions with similarities: Member Organizations, Cooperatives (Cooperatives), and Service Organizations. Within the framework of the Lembang Agrotani Beef Tomato Association, it can be placed between voluntary sector membership organizations and service organizations included in the private sector.

Figure 4: The continuum of local institutions by sector, as depicted in Figure 4, provides a detailed breakdown of various local institutions involved in different sectors. This flow chart outlines the functions and interactions of these institutions, emphasizing their roles in supporting agricultural development and community well-being[12].

PUBLIC SECTOR		VOLUNTARY SECTOR		PRIVATE SECTOR	
Local Administration (LA)	Local Government (LG)	Member Organizations (MOs)	Cooperatives (Co-ops)	Service Organizations (SOs)	Private Businesses (PBs)
Bureaucratic Institutions	Political Institutions	Local Organizations (based on the principle of membership direction and control; these can become institutions)			Profit Oriented Institutions

The success of an organization is contingent upon its "suitability" to its environment. Achieving this "fit" requires the organization to have a structure, strategy, and culture to adapt to its environment or find a

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favorable environment in which to operate. The utilization of local resources among rural communities can be achieved by integrating the values of the local knowledge base (Indigenous Knowledge) into everyday life[13].

Beef tomato farmers in Cibodas opt for associations over cooperatives for various reasons, including a) associations do not recognize formal binding rules, unlike cooperatives, which have known principal deposits and dues that often pose a problem and follow regulations on binding cooperatives; b) associations do not recognize the distance between members and administrators, thus avoiding all direct involvement, whereas in other organizations such as cooperatives, administrators are often more dominant; c) all members have the same profession and manage the same commodity i.e., Beef Tomatoes, while in other organizations, it is often mixed so that it is not focused. The association operates voluntarily on one hand but also has a common goal for members' business development.

The utilization of intelligent farming systems, a part of agricultural technology 4.0, has made agribusiness ventures highly efficient and effective, as they can easily control plant diseases. Cultivation models that employ technology can serve as examples for farmers in other regions. An agricultural model based on digital transformation can guarantee production, thereby ensuring a robust supply chain. Stable production can guarantee a supply-to-market chain that requires continuity of production. A stable production system is crucial to ensure quality and continuity of production to the market. Technology 4.0 is a significant factor in ensuring the quality and quantity of production.

Digitalization of agriculture can increase productivity and quality with minimal use of labor, energy, and other resources[14]. Digitalization of agriculture can reduce the impact of problems on conventional agriculture. The concept of this technology is how plants are given food according to their portions. So environmental problems, narrow land, shortage of agricultural labor, and weather anomalies can be overcome with this agriculture 4.0 technology.

Comparison of intelligent farming with conventional agriculture, in simple terms, can be seen as follows:

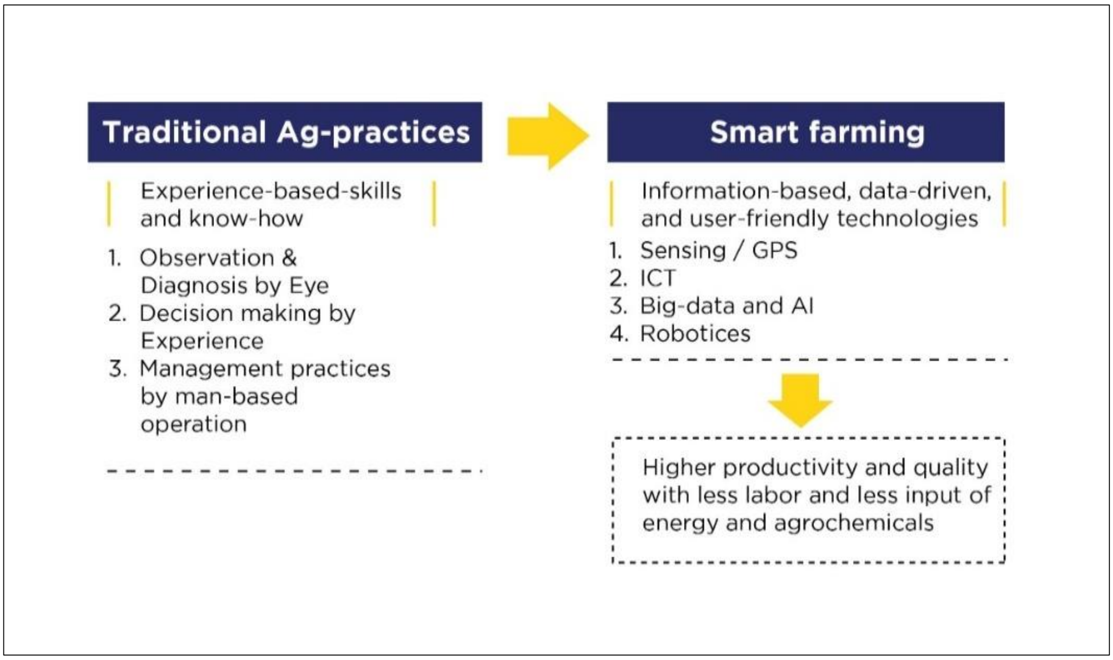

Figure 5. The process from traditional farming model to smart farming is illustrated in Figure 5. This flow chart shows the transition and transformation stages from conventional farming practices to advanced smart farming technologies. It highlights the integration of digital tools and data-driven approaches to optimize agricultural productivity and sustainability[16].

Aligned with the trend of the Fourth Industrial Revolution, digital transformation strategies now provide intelligent solutions to boost agricultural productivity. Agriculture 4.0 technology has demonstrated its ability to enhance agricultural output[17].

Digitalization of the agricultural sector can also address various challenges related to the impact of climate change, such as weather anomalies, crop diseases, low market prices, and so on. Climate change complicates farmers' ability to determine the appropriate growing season and control plant pests, often leading to crop failure. Through sensor technology, weather conditions can be continuously monitored, studied, and stored on cloud servers to become big data[20].

The application of agricultural innovation technology increases agricultural productivity.

Technology adoption is a mental process, and behavior change in the form of farmers' knowledge, attitudes, and skills from knowing to deciding to apply[21].

Technology 4.0 in the agricultural sector can be combined with the local wisdom of the community. The experience of beef tomato farmers in Cibodas village can be used as a lesson in the development of a greenhouse system made from bamboo, thereby reducing costs compared to conventional Green Houses that use iron or steel construction. The digitization process can also be done in stages. Based on the experience of farmers in Cibodas in carrying out the transformation process to digital, it can be done gradually, from manual mechanical to digital.

The technology adoption process can take place effectively if an adoption process provides relative benefits on an ongoing basis. Superior commodities can benefit from an economic perspective. Many commodities can be developed in other agribusiness sectors depending on the market analysis results. A rural area that wants to use a technology-intensive agricultural system such as agricultural digitalization must consider selecting commodities with good selling value[22].

Aspects of territoriality, technology, and commodity selection play an essential role in developing smart villages based on agriculture. The geographical aspect is crucial because it allows adjacent villages to be integrated into a supply chain approach. The selection of superior commodities with competitive prices and a guaranteed market is essential. Similarly, using technology to ensure quantity and quality is also essential.

Associations that function as aggregators involve stakeholders such as triple helix institutions, financing institutions, universities, technology companies, and cross-sector government agencies. Development based on commodity and technology clusters makes it easier for external stakeholders to provide support and cooperation. Innovative village development can be developed through various creativity and collaboration between sectors. Collaboration between sectors can originate or cooperate between institutions such as government, educational institutions, industry, and society[23].

Innovative village development requires determination and the capacity to harness local potential from all angles, including external influences. Villages can utilize external resources for technical support and advice.

The progress of an intelligent village depends on the determination and ability to manage local potential from all perspectives, including external factors. Villages can tap into outside resources for technical assistance, consultation, and other formal mechanisms through triple helix collaboration schemes involving universities, the government, and the private sector. Local governments must back every necessary policy, especially in infrastructure.

Village development schemes can work if village governments can be involved in developing agricultural strategies. Village development schemes can work if village governments can be involved in developing agricultural strategies. Village governments must map the types of superior commodities; then, the superior commodities are developed and digitized through farmer associations[24].

A significant challenge in modeling farm-based smart villages is integrating with rural programs. What is the hierarchical and coordination model with the village government? In order to develop Smart Villages, the Ministry of Village PDTT has launched a new institution controlled by the village government, namely the Village Digital Community Space (RKDD). The Village Head appoints the management of RKDD, then strengthened by the Village Minister PDTT.

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Various ministry programs, such as the millennial farmer program, P4S, and agricultural digitalization, can be collaborated in the Smart Village program. Likewise, the village digitalization program by the Ministry of Communication and Information can also support the development of internet infrastructure and the required technological components. Corporate Social Responsibility (CSR) activities from SOEs can also foster digital village programs like those by Bank Indonesia PT. Telkom, etc. Patterns like this are already running and will positively impact the future.

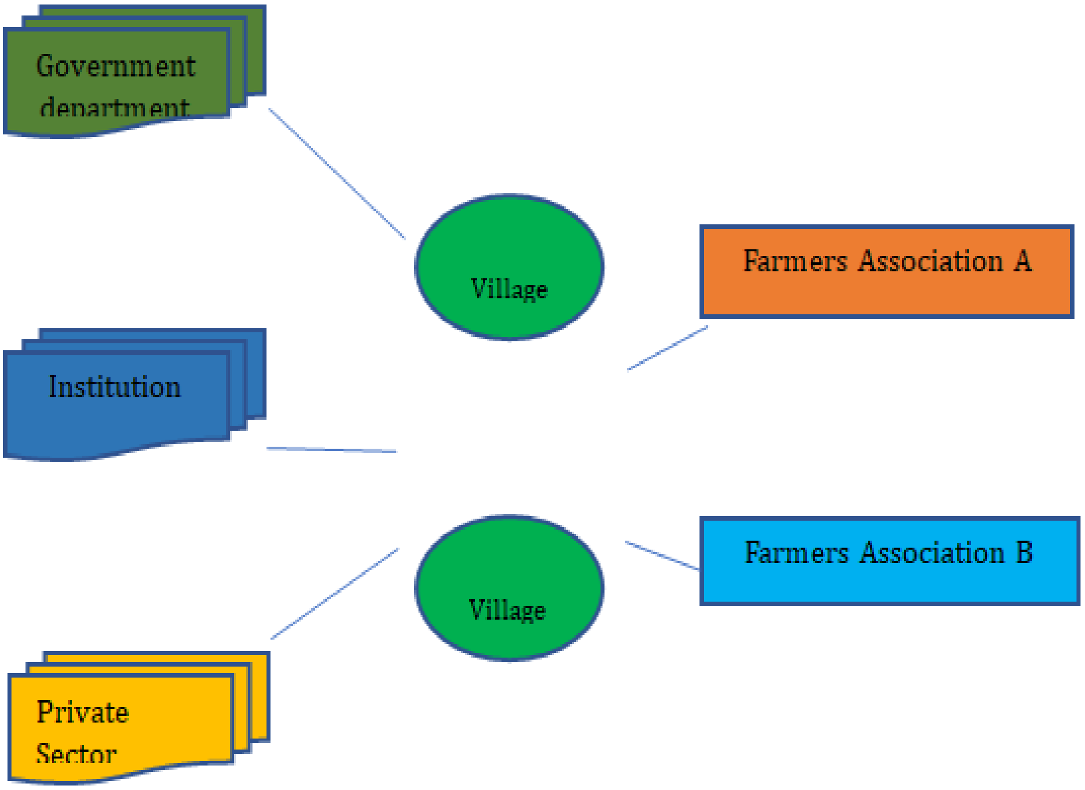

Figure 6: Cross-sectoral pattern of institutional support to support agriculture-based smart villages (created by Author).

In Cibodas Village, several forms of collaboration have been implemented;

1. The Ministry of Agriculture has assisted in procurement, providing one refrigerated container unit through the 1000 Horti Villages program at the Lembang Agri Farmer Group.
2. Two farmer members received equipment assistance and support in agricultural digital technology in the form of Internet of Things (IoT) devices for irrigation and fertilization and temperature and humidity sensors.
3. Assistance was also received from innovative farming technology companies.

The results of this collaboration have been encouraging. Farmers have been able to transition into digital-based intelligent farmers. This model has proven effective and holds potential for further development, volume increase, quality improvement, and scope expansion throughout Indonesia.

Future research should aim to expand the geographic scope by including a larger number of villages to gather comprehensive data and identify regional variations. Conducting longitudinal analyses would help capture the long-term impacts of digital transformation on agricultural practices and rural welfare. It is also important to assess how evolving policies affect the adoption and effectiveness of smart village models. Exploring the integration of agriculture with other sectors, such as education, healthcare, and tourism, can further enhance the overall development of rural areas. Additionally, investigating how new and emerging technologies can be adapted and integrated into the existing smart village framework will ensure continuous improvement. Building on these areas will provide deeper insights and more robust recommendations for developing agriculture-based intelligent villages.

CONCLUSION

The model of an intelligent village based on agriculture is characterized by villages that develop specific superior commodities through digital transformation in the agricultural sector. This transformation is facilitated by applying agricultural technology 4.0, based on efficient cultivation management with the support of Internet of Things (IoT) equipment and efficient supply chain management. This model is further bolstered by an institutional model that unites farmers for joint production and marketing platforms to enhance the value chain of agricultural production. Ultimately, this approach can address various challenges in the village, including improving the welfare of rural communities. This study was focused on a limited number of villages, suggesting that different facts may be uncovered in a broader study. Furthermore, this research was confined to January to May 2023, indicating that data changes could occur due to evolving policy dynamics. Therefore, this research should be considered a stepping stone for further investigations.

Significance statement: The study lies in its innovative approach to developing an agriculture-based smart village model in Cibodas, West Java, which integrates agrotourism and sustainable practices. By emphasizing community participation and innovation infrastructure, the model addresses economic growth and environmental sustainability, offering a scalable and adaptable solution for rural development in various agricultural contexts.

Conflict of interest: The authors declare no conflicts of interest relevant to this manuscript.

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Dr. Andi Ilham is a distinguished lecturer based in West Java, Indonesia. In 2023, he earned his Doctorate in Development Studies from Hasanuddin University (UNHAS), where he specialized in Development studies. His academic and professional contributions focus on research interests, providing valuable insights into regional development and policy advancements.

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