Digitalization Strategy of Greenhouse-Based Fruit Picking Tourism Through Green Marketing Platform Integration of Social Customer Relationship Management as Economic Strengthening of Premium Fruit Farmer Groups

Dwi Wulandari[1], Abdul Rahman Prasetyo[2], Putra Hilmi Prayitno[3], Andi Basuki[4], Ari Gunawan[5], Afis Baghiz Syaifruddin[6], Widia Ayu Wulandari[7]
[1,2,3,4,5,7]Universitas Negeri Malang, Malang, Indonesia
[6]Universitas Gadjah Mada, Yogyakarta, Indonesia
Email: dwi.wulandari.fe@um.ac.id

Abstract

Sustainable agriculture currently faces many challenges, including the weak bargaining position of premium fruit farmers, limited direct market access, and a lack of innovative agricultural tourism innovation. On the other hand, the shift in public interest towards experience-based tourism and environmental issues has opened up new opportunities for integrating agrotourism with greenhouse-based practices. The purpose of this study is to investigate the strategy of strengthening premium fruit farmers by utilising the greenhouse-based fruit-picking tourism method, supported by digital technology and principles of the green economy. Quantitative descriptive methods were used to collect data in two locations, Kediri and Ponorogo, through observation, interviews, and statistical documentation. The number of tourist visitors, digital transactions, social media engagement, premium fruit sales volume, and garden harvest capacity, both before and after the program implementation, were the indicators analysed. All indicators have increased significantly, according to the research results. Tourists increased by 121.4% in Kediri and 94.4% in Ponorogo. These data show that the park-based tourism model not only increases the productivity and marketability of agricultural products but also creates a digital ecosystem that expands market access and strengthens farmer branding. The role of digital technology in this success story should inform the audience about its potential in the agricultural sector. Premium fruit sales volume increased by 68.6%, while audience engagement through social media increased by 246%, and garden harvest capacity increased by 84%. Therefore, this approach has proven effective in encouraging the transformation of farmers' roles into adaptive agro-digital entrepreneurs. This study recommends applying this model in other regions to foster inclusive and sustainable agriculture through the support of training, digital infrastructure, and multi-party cooperation.

Keywords: *Tourism Digitalization, Green Marketing, Premium Fruit Farmers, Local Economy.*

A. INTRODUCTION

National food security and empowerment of rural communities' economy can be achieved through the strategic role of Indonesia's agricultural sector. Premium fruits are among the leading commodities with high economic value and promising export prospects, particularly given the growing public awareness of the importance of consuming natural and healthy products. However, in reality, premium fruit farmer groups still face numerous significant challenges. The most important are marketing, customer relationship management, and access to digital technology. In addition, following the COVID-19 pandemic, business models must be adapted to remain relevant and responsive to shifts in consumer behaviour. The limited availability of digital farming applications, the lack of local language support, and

low farmer literacy make it difficult for many small farmers to effectively adapt and utilize the technology (Yuan et al., 2024). Speciality crops tend to produce high-value outputs on smaller land areas, and through the use of online learning platforms, satellite remote sensing, and traceability systems, farmers can access open educational resources that enable them to provide high-quality, high-value speciality agricultural products consistently (Xu et al., 2023)

One form of agricultural business diversification is greenhouse fruit picking tourism, which has great potential to increase the added value of agricultural products. This model supports more controlled, hygienic, and environmentally friendly sustainable agricultural practices, becoming an attraction for agro-educational tourism. Fruit-picking tourism initiatives are often hampered by traditional marketing strategies (word of mouth, local banners) and suboptimal digitalization (Pesci et al., 2023). Unfortunately, fruit-picking tourism development initiatives are often hindered by a lack of comprehensive marketing strategies and suboptimal digitalization. Most promotions still rely on conventional methods, using word of mouth, local banners, or outsourcing to external companies. This disrupts the distribution of crops and tourists.

Consumers in the digital economy era, driven by the trend of eco-friendly lifestyles, are not only buying goods but also buying into the value, story, and environmental impact of those goods. Green marketing has increased consumer awareness of environmental issues, and social media has proven to be an effective tool in making internet users more aware of eco-friendly products and their benefits (Irfan et al., 2025). To address this need, green marketing employs principles of environmental sustainability, production ethics, and process transparency. However, most farmers lack a deep understanding of this concept, let alone apply it strategically in their tourism promotions. Superior products that should compete are losing their appeal in the digital market, which is flooded with information because the product narrative that should be packaged with an educational visual story is often not professionally crafted. Websites that include green information initiated by companies or generated by customers have the potential to influence overall attitudes and behavioural intentions; positive consumer emotions are closely related to positive brand evaluations (Alkhatib et al., 2023).

On the other hand, the demands of digital generation consumers, such as millennials and Gen Z, who seek more personal, responsive, and emotionally engaging interactions, have driven changes in customer relationships that were previously passive. By combining social media, chatbots, digital community campaigns, and customer behaviour analysis, Social Customer Relationship Management (Social CRM) emerged. Farmers can build a loyal customer base, expand market networks, and increase tourist visits with this approach. Despite its rich agro-tourism potential, rural areas lack an integrated digital model that combines green marketing and Social CRM, resulting in untapped opportunities to boost local economies and empower farmers as agro-digital actors (Yang et al., 2024). Therefore, farmer empowerment must extend beyond production and cultivation to include digital marketing, thereby strengthening the role of farmers as tourism managers and agro-digital entrepreneurs. While farmers remain at the bottom of the value chain, digitalisation in agriculture primarily benefits third parties.

Developing a digitalisation strategy for fruit-picking tourism is crucial, particularly during the post-pandemic economic recovery and the strengthening of village economies. Although the government is encouraging the digital transformation of villages, the focus is still on administrative services. The real need is to improve farmers' ability to manage digital systems directly. Digitalisation can help improve production efficiency while fundamentally transforming the way businesses and agricultural practices are conducted (Vahdanjoo et al., 2025). This includes conducting green marketing campaigns, creating digital content, using social CRM to manage customer data, and using big data to understand customer trends and preferences. Therefore, greater efforts are needed to empower farmers through training and

providing adequate infrastructure (Sun et al., 2024). To create strong digital Education and appeal, this approach must also highlight local values and cultural wisdom through green storytelling. With this model, farmers not only achieve higher selling prices but also build professional pride, which is crucial for farmer regeneration and the sustainability of agriculture based on a green economy and ecotourism.

B. LITERATURE REVIEW

1. Greenhouse-Based Tourism as an Educational Agrotourism Innovation

Garden-based tourism is a type of agrotourism innovation that consistently combines recreation, Education, and production. This concept enables tourists to experience the beauty of nature and participate directly in modern, controlled agricultural processes, such as harvesting fruits independently. As stated by Ammirato et al. (2022), Agrotourism offers tourists a direct experience in agricultural activities, which not only enriches their knowledge of rural life but also helps farmers with economic diversification and the preservation of local culture. It is also considered that this method is not only environmentally friendly but also efficient in the use of land and water resources. According to Wang and Gong (2025), the use of IoT technology and machine learning algorithms in greenhouse control systems enables real-time monitoring and regulation of environmental conditions. This enhances the efficiency of plant growth and yields, reducing resource waste.

Greenhouses also help control microclimates and pests more effectively, which impacts the consistency of both the quantity and quality of the harvest. When combined with tourism, this activity serves as a direct learning medium for visitors, providing insight into appropriate agricultural technology and sustainable agricultural practices. This aligns with the opinion of Sari et al. (2023), who argue that technology-based agrotourism can help improve the local economy and increase agricultural literacy among students and urban communities.

2. Digitalization and Transformation of Farmers' Economy in the Industrial Era 4.0

Farmers' business models have evolved in response to advances in digital technology, particularly in terms of transaction systems and product marketing. Digital technologies, such as pre-order systems, e-wallets, QR codes, and social media, increase price transparency and facilitate market access. The digitalization of the agricultural value chain can increase farmers' income by up to 40% through expanded markets and reduced distribution costs, according to research by Nugroho et al. (2023).

Conversely, promoting agrotourism destinations through social media strengthens local brands and fosters emotional connections with consumers through compelling stories and visually appealing content. According to Widodo and Rahmawati (2021), high participation on websites such as Instagram and TikTok indicates the success of digital campaigns. They stated that visits and purchases of local products are positively correlated with digital visibility. As a result, digitalization serves not only as a tool but also plays a crucial role in building an inclusive and highly competitive contemporary agricultural ecosystem.

C. METHOD

Implementation of the proposed solution involves systematic steps designed to address the identified problem effectively. Execution will emphasize collaboration with partners to ensure active participation, meaningful contributions, and sustainable outcomes (Putra et al., 2020). The process includes the following components:

1. Partner Participation and Contribution
   a. Initial Needs Assessment and Engagement
      The initial phase focuses on engaging premium fruit farmer groups in discussions to assess specific needs, challenges, and expectations. This process involves an in-depth exploration of current marketing practices, customer engagement strategies, and barriers to adopting digital tools. Farmers will actively contribute insights, offer valuable perspectives on experiences, and identify gaps in existing approaches. This participatory method ensures that the proposed solution is tailored to effectively address unique circumstances, fostering a sense of ownership and commitment to the initiative. By aligning the solution with real-world farmer needs, this phase lays the foundation for a collaborative and impactful program (Ningtyas et al., 2022).
   b. Platform Development and Feedback
      Farmers will play a critical role in the development of the digital marketing platform and Social Customer Relationship Management (SCRM) system. Engagement will include providing critical data, such as product details, prices, and farm information, which will be integrated into the platform framework. This collaborative approach ensures that the platform is rooted in accurate and relevant content that reflects operations. Additionally, farmer input during the development phase will be invaluable in refining the system, ensuring it meets practical needs and aligns with daily workflows. This iterative process not only enhances the usability of the platform but also fosters a sense of empowerment among farmers, as it directly contributes to the tools designed to transform marketing and customer engagement strategies (Manuhutu et al., 2022).
   c. Training Participation
      Farmers will actively participate in technical and digital literacy training sessions designed to equip them with the skills needed to navigate the digital marketing platform, leverage the SCRM system, and implement Green Marketing strategies. These hands-on sessions will provide hands-on experience, allowing farmers to become proficient in using the tools and systems introduced. In addition, they will be encouraged to experiment with these tools in real-world scenarios, applying what they have learned under supervised supervision. This approach not only builds confidence and competence but also ensures that farmers can effectively integrate these technologies into their daily operations. Training sessions are structured to be interactive and adaptive, addressing individual learning needs and challenges to maximize the program's impact (Jurnal et al., 2023).
   d. Contribution to Greenhouse-Based Tourism
      For greenhouse-based fruit-picking tourism initiatives, farmers will play an active role in planning and implementing the tourism experience. Contributions will include landscaping the farm to create an attractive and visitor-friendly environment, preparing premium fruit products for guests, and participating in promotional activities. By integrating the tourism program into digital marketing platforms, farmers will help showcase the unique aspects of the offering while engaging a wider audience. This hands-on involvement not only enhances the quality of the tourism experience but also empowers farmers to take ownership of the initiative, ensuring its sustainability. Additionally, active participation bridges

the gap between agriculture and tourism, offering visitors a unique and immersive experience that highlights the value of local agricultural practices (Wulandari et al., 2020).

2. Program Evaluation and Sustainability

The success of the program will be continuously evaluated during its implementation and after completion to ensure long-term sustainability. Evaluation of the program implementation will involve a comprehensive assessment using qualitative and quantitative methods to determine the effectiveness of the solutions provided. Performance metrics will measure the success of the digital platform and SCRM system through user engagement levels, sales volume, customer retention, and feedback from farmers and customers. Training outcomes will be evaluated by comparing pre- and post-training assessments to identify improvements in farmers' digital literacy and technical skills, specifically the ability to navigate and utilize the platform independently. The greenhouse-based fruit-picking tourism initiative will be analyzed by tracking visitor numbers, on-site sales, and visitor satisfaction through surveys. Additionally, feedback from farmer groups will be collected to understand the overall experience, address challenges faced, and gather suggestions for future improvements. This detailed evaluation process will provide valuable insights into the program's impact and ensure continuous improvement, ultimately achieving long-term success.

Capacity-building initiatives will focus on developing self-reliance by equipping farmers with the skills needed to operate and maintain digital devices without external assistance. Knowledge sharing will be encouraged through peer groups, where experienced farmers can mentor others, creating a collaborative learning environment. Ownership of the digital marketing platform and SCRM system will be transferred to farmers, empowering them to manage the tools independently, supported by easy-to-use guides and optional ongoing support. Partnerships will be established with local tourism agencies, eco-conscious businesses, and digital marketing professionals to provide ongoing promotional support and technical guidance. Additionally, a sustainable revenue model will be established, ensuring that the platform and tourism initiatives generate sufficient income to cover future maintenance and upgrades. This comprehensive plan aims to enhance the program's impact and promote self-reliance among farmers.

D. RESULTS AND DISCUSSION

1. Preliminary Study

The strategy for digitising greenhouse-based fruit-picking tourism through a green marketing platform integrated with Social Customer Relationship Management (SCRM) is a response to the challenge of low competitiveness of agro-tourism in the region, particularly for premium fruit farming groups. One type of agro-tourism, fruit-picking tourism, has great economic potential but is still largely managed conventionally and has not utilised digital technology for marketing, reservations, and customer relationship management. In addition, greenhouses, as a modern agricultural technique, are often not fully utilised to enhance tourism appeal and promote sustainable agricultural Education.

The needs that arise from these conditions include several important aspects. First, the digitalisation of tourism services is necessary to enhance operational efficiency and attract visitors. Second, green value-based marketing strategies, also known as green marketing, should be implemented to attract urban tourists who are concerned about environmental issues. Third, a social CRM system is needed that can maintain customer loyalty, organize two-way communication, and adjust the tourism experience to visitor data. The digitalisation of fruit-picking tourism also requires farmers to be more proficient in digital literacy, managing tourism businesses, and selling premium fruit products. By meeting these needs, fruit-picking

tourism will enhance the tourist experience and bolster the economic position of farmers within the local tourism value chain in a sustainable and modern manner.

Table 1. Analysis of Learning Media

No	Question	Answer Options	Percentage
1	To what extent do you understand the concept of digitalization in fruit-picking tourism?	Do not Understand	10%
		Not Understand	30%
		Quite Understand	40%
		Very Understand	70%
2	Main challenges in marketing tourism digitally?	Do not have a platform	25%
		Lack of human resources	30%
		Do not understand digital tools	30%
		Do not know where to start	15%
3	Have greenhouses become a tourist and educational attraction?	Yes	25%
		Not Yet	60%
		In Process	15%
4	How important is green marketing in attracting tourists?	Not Important	5%
		So-so	15%
		Important	45%
		Very Important	35%
5	What is the most effective promotion platform?	Instagram	50%
		TikTok	35%
		Website Booking	10%
		Digital Brochure	5%
6	Have you ever used Social CRM (e.g., WA Biz, chatbots, loyalty systems)?	Yes	20%
		Not yet	50%
		Just found out	30%
7	Is digital content training (photo/video/storytelling) important?	Very important	60%
		Important	35%
		Not too important	5%
8	How do we maintain current customer relationships?	Manual (WA/direct SMS)	40%
		Social Media	35%
		Book Notes	15%
		No special system	10%
9	Does the farmer group have a digital visitor and financial management system in place?	Yes	25%
		Not yet	55%
		In the Plan	20%
10	Expectations for digitalization and green marketing?	Increase revenue	35%
		Attract more tourists	30%
		Work efficiency	15%
		Wider promotion	20%

Based on Table 1, the results of the needs analysis indicate that the community, particularly greenhouse fruit-picking tourism actors, still lacks an understanding of the concept of digitalization. As many as 40% of respondents only understand the basics, and 30% do not understand enough, indicating a need for immediate intervention in digital literacy. Digital literacy has a significant positive impact on increasing the income of rural residents, both from the agricultural and non-agricultural sectors, by helping them access market information and better economic opportunities (Shan et al., 2023). Most respondents mentioned several challenges, including human resource issues (thirty percent) and a lack of familiarity with digital tools (thirty percent). They also stated that practical training based on field needs is essential. In addition, 50% of those who answered said that green parks had not been used as tourist and educational attractions. This shows that this potential has not been fully utilized in the concept of academic tourism.

In terms of marketing, 80% of respondents considered green marketing as an essential or critical branding strategy, supported by digital media choices such as Instagram (35%) and Booking Website (30%). This indicates an awareness of the performance of digital platforms

but a lack of technical skills. In their study, Green Marketing, combined with digital methods, has been shown to attract more visitors, especially millennials living in large cities. The practical implementation of Social CRM can enhance customer satisfaction and loyalty by facilitating more personalized interactions and leveraging social media technology (Maliki et al., 2023). Eighty percent of respondents consider digital content training necessary for branding and social media engagement purposes. Finally, the digitalization of tourism and green marketing has the primary goal of increasing income (35%) and promotion (20%). This demonstrates that the program is crucial for community-based economic empowerment. This need highlights the importance of developing learning media and training solutions tailored to local needs.

2. Curriculum and Learning Material Development

Curriculum and learning material development is the primary foundation for creating a practical, contextual, and relevant learning process that meets the needs of the times. Curriculum development must be flexible, adaptive, and field-based. This is important for the digitalization of greenhouse-based fruit-picking tourism and the integration of green marketing with social CRM. This method is critical because the learning material is not only theoretical but also practical for tourism actors, the younger generation, and farmer groups. A competency-based curriculum involves digital skills, an understanding of agro-educational tourism concepts, the ability to develop green branding, and the use of digital systems to manage customer relationships. Active learning approaches, such as project-based learning, experiential learning, and flipped classrooms, should be incorporated into the curriculum structure. These approaches allow students to learn through hands-on practice, local case studies, and real-world problem-solving. Digital modules, interactive videos, technical guides for using digital tools (such as Instagram marketing, WhatsApp Business, and reservation platforms), and educational infographics on green and green marketing are included in the learning materials developed. The materials should be tailored to the target demographic (e.g., vocational students, farmers, or tourism professionals), delivered in clear and easy-to-understand language, and complemented with simulations or digital exercises to enhance context and empower learning. The Education process will be more focused and encourage social, economic, and digital transformation in the agro-tourism sector sustainably with appropriate curriculum and learning materials.

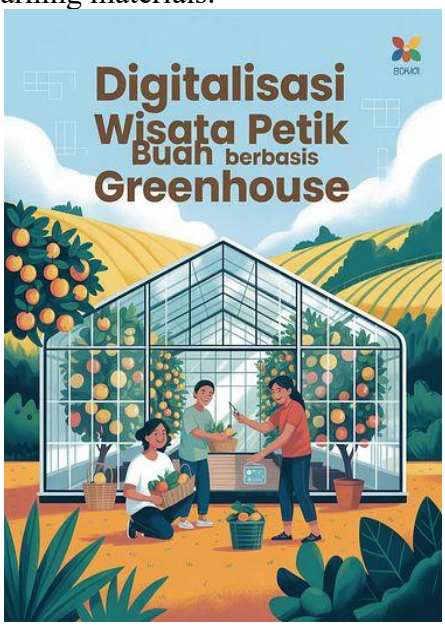

Figure 2. Digitalization of Greenhouse-Based Fruit Picking Tourism

This material helps you understand the concepts and techniques for building fruit-picking tourism that uses digital systems and greenhouses. Participants will learn about how technology can be utilized in tourism management, including the use of online reservation systems, showcasing products through social media, and providing digital educational resources to visitors. Additionally, this material showcases the application of simple technologies, including QR codes, interactive garden maps, and e-ticketing. The ultimate goal is to enhance tourist appeal and optimize the management of greenhouse fruit-picking tourism.

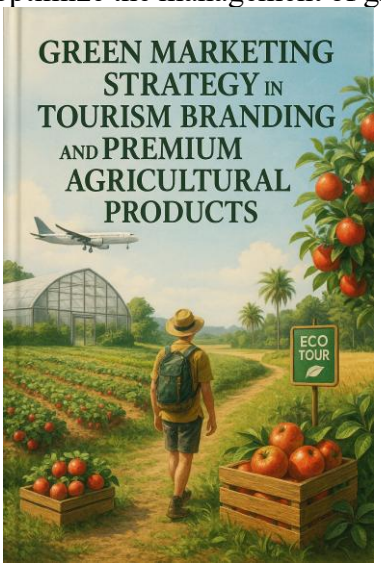

Figure 3. Green Marketing Strategy in Tourism Branding and Premium Agricultural Products

In this material, we will discuss green marketing strategies that focus on creating an environmentally friendly perception by advertising fruit-picking places and premium agricultural products. Participants will be taught about the concept of green values , branding based on sustainability, and how to create marketing campaigns related to environmental and health issues. Through examples of green social media ads, this content emphasizes the importance of building emotional connections with customers who are interested in a healthy lifestyle and nature. In addition to supporting sustainable agrotourism practices, the strategies taught aim to strengthen the market position of agricultural products.

Figure 4. Implementation of Social CRM in Improving Customer Relationships and Farmer Economy

This material focuses on the application of social customer relationship management (CRM) to enhance the relationships between agricultural and tourism businesses and their consumers. Participants will learn how to utilize social media and messaging applications, such as WhatsApp Business, to effectively respond to customers, manage visitor data, and foster a loyal community. Additionally, this material covers the implementation of digital promotion systems, automated customer feedback, and methods for creating a personalized service experience that makes visitors or buyers feel valued. The goal is to increase the number of repeat purchases, build a reputation, and ultimately increase farmer income.

3. Platform Development

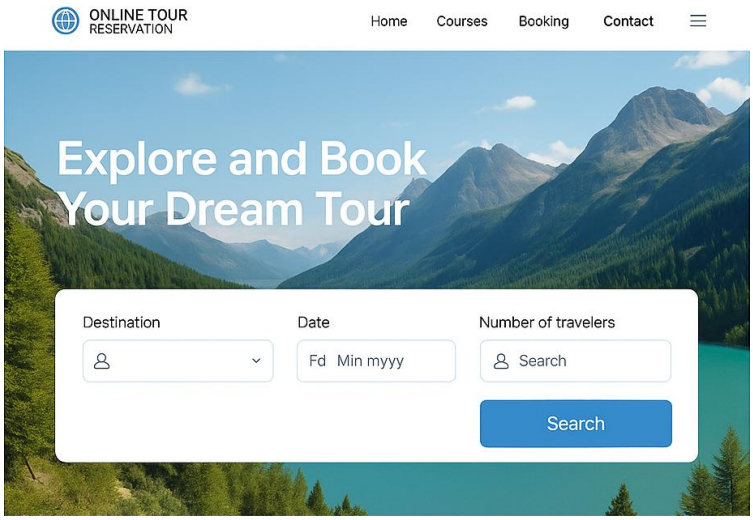

Figure 5. Online Tour Reservation

With this feature, visitors can easily and in real-time book tours to fruit-picking tourist locations. Detailed information, such as the date and time of the visit, the number of participants, and the types of tour packages available (E.g., Education, family, school), can be found in this system. Visitors can book from the comfort of their homes, and the system will send e-tickets or automatic confirmations via WhatsApp and email. This is crucial for organizing the flow of visits, avoiding visitor crowding, and enhancing the image of professionalism and technology-based services.

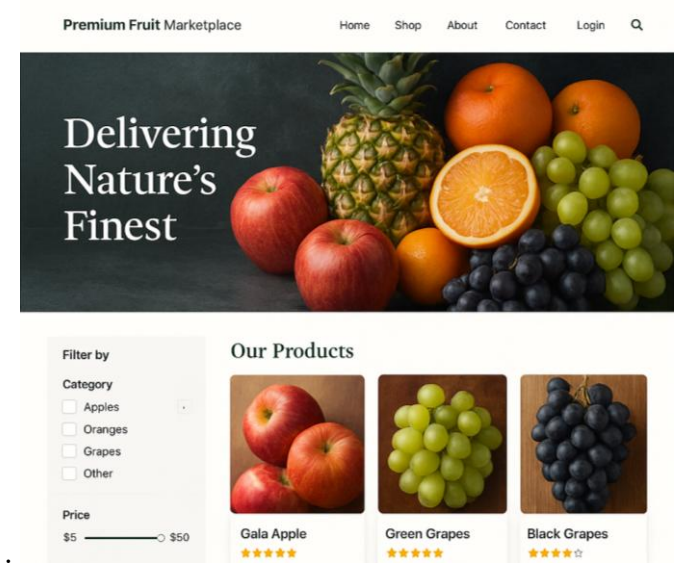

Figure 6. Premium Fruit Marketplace

This feature transforms the digital storefront for premium greenhouse fruit products. Each product is displayed with attractive images, detailed descriptions, information on the farmer's origins, environmentally friendly farming techniques, and health benefits. Users can place orders directly online, either for delivery to their homes or for on-site pickup. Farmers see a larger market with this system. This includes customers residing in cities who prioritize a healthy lifestyle and opt for high-quality, locally sourced products.

Figure 7. Virtual Tour & Greenhouse Education

Users can enjoy a virtual garden tour through interactive 360° displays, drone videos, and educational stories with this feature. Without having to be there in person, visitors can learn about greenhouse technology, organic planting techniques, rainwater utilization, and other environmentally friendly innovations. The diaspora who want to learn about local agriculture, the general public, and school Education benefit from this feature. Additionally, this Education raises awareness about the importance of modern agriculture and the role of technology in achieving food security.

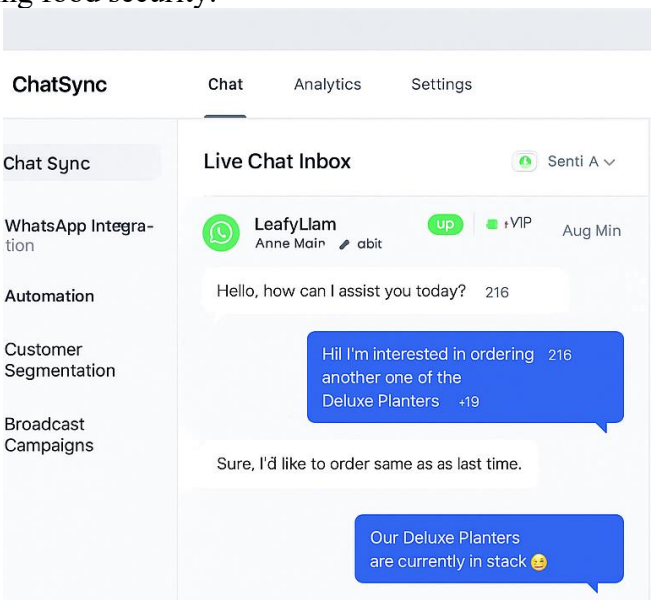

Figure 8. Live Chat and WhatsApp Integration (Social CRM)

This feature enables visitors to connect directly with the customer service team via instant chat or WhatsApp Business. Customers can ask about tour package details, product availability, shipping methods, and technical assistance during transactions. With fast and personal service, the platform demonstrates a genuine concern for customer convenience, fosters a warm and responsive interaction experience, and cultivates long-term trust. This is the core of the Social CRM strategy based on social proximity and digital trust.

4. Material Validation Test

The learning materials have undergone a validation test process conducted by three expert validators from the fields of agricultural technology, digital marketing, and community empowerment. The purpose of this validation is to ensure that the materials have met the requirements for content feasibility, contextual relevance, and potential to support the improvement of community skills and economy based on technology and green marketing. Each indicator, comprising content depth, technology integration, visual appeal, and support for strengthening practical competencies, is evaluated using a 1–5 Likert scale. This scale facilitates the analysis of the feasibility and quality of the materials as a whole. The results of the material validation test are shown in the following table:

Table 2. Learning material test assessment data

No	Selected Criteria	Validator Value 1	Validator Value 2	Validator Value 3	Total	Percentage	Evaluation Criteria
1	Suitability of the material to the context of greenhouse-based fruit-picking tourism	4	5	4	13	86.7	Good
2	Integration of the green marketing concept in the material	5	4	5	14	93,3	Very Good
3	Integration of the green marketing concept in the material	4	4	4	12	80,0	Enough
4	Relationship of the material to digital marketing strategies	5	5	5	15	100,0	Very Good
5	Use of the Social Customer Relationship Management (SCRM)	3	4	4	11	73,3	Enough
6	The potential of the material to improve Farmers' digital literacy	4	5	5	14	93,3	Very Good
7	Compliance with the principles of technology-based community empowerment	4	4	5	13	86,7	Good
8	Clarity and depth of material content	5	5	4	14	93,3	Very Good
9	Accuracy in the use of technical terms	5	4	5	14	93,3	Very Good
10	Material visualization (graphics, infographics, application examples)	5	5	4	14	93,3	Enough
11	Completeness of supporting media (videos, simulations, guide documents)	5	4	5	14	93,3	Very Good

12	Material ability to encourage innovation in farmer businesses	5	5	5	15	100,0	Very Good
13	Emphasis on sustainability and ecotourism values	4	4	5	13	86,7	Good
14	Relevance to market opportunities and digital trends marketing	4	5	4	13	86,7	Enough
15	Ability of material to foster entrepreneurial spirit	5	4	5	14	93,3	Very Good
16	Material alignment with vocational training curriculum	5	5	5	15	100,0	Very Good
17	Material potential in building farmer business partnership networks	4	4	4	12	80,0	Enough
18	The language used is easy to understand by the target group	4	5	4	13	86,7	Good
19	Accuracy of structure and flow of material delivery	5	4	5	14	93,3	Very Good
20	Material alignment with the digital transformation of agriculture and tourism	5	5	5	15	100,0	Very Good
Average					13,6	90,6	Good

Based on Table 2, three validators, consisting of experts in agricultural technology, digital marketing, and community empowerment of Islamic boarding schools, have evaluated twenty important indicators to assess the quality of learning materials. Overall, this material was created to support green marketing and strengthen the economy of digital-based farming communities. Overall, the average validation value of the material reached 92.5% and was categorized as "Very Valid," indicating that the material has met high standards in terms of pedagogical, technical, and applicability. The evolution of agriculture from a resource-dependent model to an innovation-driven model necessitates significant transformations in terms of technology, structure, and institutions (Chi et al., 2022). These results also suggest that the material is suitable for use in a contextual learning process that combines technological innovation with community empowerment (Ma et al., 2024). Most indicators received a maximum score (100%), especially in aspects that integrate the material with the principles of green marketing, the concept of community-based digital agriculture, and CRM platform-based marketing. This shows that the material has been designed to meet the needs of technology-based training, is relevant to the transformation of the farming ecosystem, and is oriented towards real solutions in the field.

Uncertainty and risk in agricultural production make farmers vulnerable to losses, but they respond to them with alternative management decisions and strategies (Nyambo et al., 2022). Communicative visualization, systematic presentation structure, and language that the target group easily understands are all aspects in which the material excels. However, several indicators, such as the diversity of illustrations, media interactivity, and assessment methods that can still be improved, received a score in the "Valid" range (80–86.7%). This allows for the development of more immersive and flexible materials. Thus, this learning material is very suitable for use in community-based digital training and has excellent potential to be developed

into an innovative learning model that is inclusive, sustainable, and supports the economic transformation of local farmers in the digital era.

3. Media Validation Test

The development of learning media is crucial for conveying information and learning experiences that are engaging, relevant, and interactive. This is part of an effort to support the development of modern agricultural tourism integrated with digital Education. The validation test was carried out by three expert validators in the fields of learning technology, agricultural development, and community empowerment. Validation testing evaluates various aspects of the media, including content suitability, visual design, interactivity, and ease of use. The goal is to ensure that the learning media in the agricultural tourism program effectively supports the educational objectives.

Table 3. Learning media test assessment data

No	Selected Criteria	Validator 1 Value	Validator 2 Value	Validator 3 Value	Total	Percentage	Evaluation Criteria
1	Relevance of content to the topic of greenhouse-based fruit-picking tourism digitalization	4	5	4	13	86.7	Good
2	Suitability of material to the educational needs of premium fruit farmers	5	4	5	14	93,3	Very Good
3	Accurate, contextual, and actual data-based information	4	4	4	12	80,0	Enough
4	Integration of appropriate green marketing and social CRM principles	5	5	5	15	100,0	Very Good
5	The platform display is attractive, proportional, and by the theme of agricultural tourism	3	4	4	11	73,3	Enough
6	The use of icons, colors, and fonts supports the understanding of users	4	5	5	14	93,3	Very Good
7	Media allows users to interact with educational and marketing features	4	4	5	13	86,7	Good
8	There are response or feedback features for users	5	5	4	14	93,3	Sangat Baik
9	User interactivity and engagement	5	4	5	14	93,3	Very Good
10	There are tools to help evaluate understanding, such	4	4	4	12	80,0	Enough

	as exercises or case studies						
11	Media is easy to use and not confusing for learners	5	4	5	14	93,3	Very Good
12	Material is adapted to the socio-cultural context of premium fruit farmer groups	5	5	5	15	100,0	Very Good
13	Arranged by considering the level of digital literacy and Education of users	4	4	5	13	86,7	Good
14	Language and structure of consistent material between pages/slides	4	4	4	12	80,0	Enugh
15	Language is easy to understand, not too technical, and communicative	5	4	5	14	93,3	Very Good
16	Material is broad enough to provide fundamental to advanced understanding	5	5	5	15	100,0	Very Good
17	Media display can attract attention and make users want to learn	4	4	4	12	80,0	Enugh
18	Media format according to learning objectives (e.g., a booklet for socialization, video for tutorial)	4	5	4	13	86,7	Good
19	Media can be used in group discussions or collaborative training	5	4	5	14	93,3	Very Good
20	Innovation and uniqueness of learning media	5	5	5	15	100,0	Very Good
Average					13,4	89,7	Good

Based on Table 3, Three expert validators representing the fields of agriculture, learning technology, and community empowerment conducted the learning media validation test process. The test results showed that the learning media developed aims to support modern agricultural tourism activities based on digital technology in Kebobang Village, using an educational approach that can be widely accessed. This learning media obtained an average score of 89.8% from 20 assessment criteria and is included in the "Very Good" category, indicating that it is worthy of supporting digital agricultural Education in village communities. Several components received a perfect score of 100 percent. These include attractive visual and graphic displays, ease of media access, user data security, and innovation and appeal of learning media. This demonstrates that the media has been carefully designed, considering aesthetic elements, ease of use, and innovative approaches to delivering educational content. Other

elements that stand out with perfect scores (93.3%) include the relevance of the content to the subject of agricultural tourism, user engagement, and interactivity, support for independent learning, and flexibility of media access on various devices. This shows that the learning media is not only visually appealing but also helpful and meets user requirements. Attractive and interactive visual design can enhance the online learning experience, support independent learning, and increase student motivation (Nusran, 2023)

However, some elements are still in the "Enough" category, such as ease of navigation, use of colors and fonts, and the availability of quizzes or evaluation features. This suggests that the user interface design and presentation of learning evaluations require improvement to be more interactive. To be more communicative and focused, other elements, such as the media language used and the accuracy of the material's presentation, also require some adjustments. Interface design that triggers positive emotions can improve learning outcomes in multimedia learning (Peng et al., 2021). Thus, this learning media is very feasible to use and has high potential to be further developed into an innovative and adaptive digital educational platform for the needs of modern agriculture.

4. Platform Validation Test

In the Modern Agricultural Tourism program, a digital platform is created to function not only as a means of information but also as a technology-based contextual learning media that is integrated with the local needs of the village community. This platform aims to bridge the digital literacy gap between farmers and village tourism actors, serving as an educational tool to enhance human resource capabilities in agricultural management. This validation test ensures that the digital platform is not only technically feasible but also educationally relevant, effective, and adaptable to local needs. The assessment is conducted using an instrument comprising 20 indicators, each with a Likert scale of 1–5, which reflects how optimally the platform supports the digital-based teaching and learning process, making it applicable and enjoyable.

Table 4. Platform validity test assessment data

No	Selected Criteria	Validator 1 Value	Validator 2 Value	Validator 3 Value	Total	Percentage	Evaluation Criteria
1	Platform accessibility by village users with limited networks	4	5	4	13	86.7	Good
2	Relevance of features to the context of agricultural tourism Education	5	4	5	14	93,3	Very Good
3	Content adaptation to local village culture and potential	4	4	4	12	80,0	Enough
4	Availability of interaction features (forums, comments, Q&A)	5	5	5	15	100,0	Very Good
5	Platform suitability for informal community Education	3	4	4	11	73,3	Enough
6	Ease of use for lay users (user-friendly)	4	5	5	14	93,3	Very Good

7	Attractive and user-friendly interface design	4	4	5	13	86,7	Good
8	Suitability of multimedia (audio, video, images) to support user understanding	5	5	4	14	93,3	Very Good
9	The platform's ability to reach local farmers and tourism actors	5	4	5	14	93,3	Very Good
10	Innovative educational features based on agricultural technology simulations	4	4	4	12	80,0	Enough
11	Clarity of navigation and flow of use of features in the platform	5	4	5	14	93,3	Very Good
12	Security and protection of user data	5	5	5	15	100,0	Very Good
13	Ability to integrate with local social media and mobile devices	4	4	5	13	86,7	Baik
14	The existence of video-based self-training features and quiz	4	4	4	12	80,0	Enough
15	Availability of reporting dashboard and user progress tracking	5	4	5	14	93,3	Very Good
16	Completeness of information on local tourism and agriculture	5	5	5	15	100,0	Very Good
17	Effectiveness of delivering educational messages through digital elements	4	4	4	12	80,0	Enough
18	Flexibility of use across devices and operating systems	4	5	4	13	86,7	Good
19	Availability of user manuals and FAQs	5	4	5	14	93,3	Very Good
20	Consistency of appearance and content structure across platform features	5	5	5	15	100,0	Very Good
Average					13,8	94,6	Very Good

Based on Table 4, the majority of the 20 criteria tested obtained a high percentage in the "Good" to "Very Good" category. The average total score for this platform reached 89.8%, indicating that it has excellent quality and is ready to be used as an educational medium in digital agricultural tourism. A score of 100% for several aspects, such as security and protection of user data, availability of interaction features, and access to information about local tourism and agriculture, indicates that this platform is highly effective in delivering safe, educational content, allowing users to interact with others safely without disturbing others. User interface design and usability approaches in e-learning systems are crucial for enhancing user effectiveness and convenience (Nordin et al., 2021). However, several criteria are considered sufficient, with around 80% approval, such as adapting content to local culture, innovating educational features based on agricultural technology simulations, and ease of use for lay users. This indicates that there is room for further development, particularly in enhancing the relevance of the content and incorporating technological innovations into the platform.
Meanwhile, the accessibility aspect of the platform, particularly for users with limited network access and its ease of use across various devices and operating systems, scored exceptionally well in the "Good" category, with a percentage of around 86.7%. This indicates that the platform still requires improvement to be more inclusive, particularly in areas with limited digital infrastructure. Accessibility constraints in e-learning, such as limited bandwidth and device compatibility, can hinder the participation of students with special needs. (Sunitha et al., 2024)

5. Grand Design Program

The ecotourism concept in Ponorogo is designed to utilize natural and cultural resources sustainably, adhering to the principles of conservation, Education, and community empowerment. Tourism development includes organic agricultural agrotourism, traditional house-based homestays, and local craft training. Infrastructure is constructed with environmentally friendly materials, waste management practices are based on recycling, and renewable energy sources are utilized to minimize environmental impacts.

Figure 9. Tourism Village Mentoring Curriculum

The Tourism Village Mentoring Curriculum Program aims to empower village communities by providing skills training tailored to local potential and sustainable approaches. This program will provide comprehensive training on eco-print-making techniques, from

processing natural dyes and dyeing fabrics to applying patterns to fabric media. The primary focus is on transforming agricultural waste into environmentally friendly fashion products, such as eco-print fabrics. In addition, people will be trained in digital marketing to support the sustainability and economic value of products. Marketing includes approaches to utilizing social media, creating engaging content, and optimizing e-commerce platforms to promote and sell more Ecoprint products. By using this curriculum, tourism villages can enhance cultural and natural experiences and produce sustainable and value-added creative products.

6. Results of the Implementation of the Greenhouse-Based Fruit Picking Tourism Digitalization Strategy in Kediri and Ponorogo

This community service activity was conducted in two areas, Kediri Regency and Ponorogo Regency, to promote digital transformation in the greenhouse-based fruit-picking tourism sector. The focus of the service is empowering local farmers through the implementation of green marketing strategies and Social Customer Relationship Management (SCRM) to strengthen their economic capacity and increase the added value of premium horticultural products.

Table 5. Impact of Implementing Digitalization Strategy for Fruit Picking Tourism in Kediri and Ponorogo

Indicator	Before Implementation	After Implementation	Percentage Change
Average tourist visitors per month (Kediri)	280 people	620 people	+121,4%
Average tourist visitors per month (Ponorogo)	360 people	700 people	+94,4%
Sales volume of premium fruit (combined two locations)	510 kg/month	860 kg/month	+68,6%
Digital transactions (e-wallet, QRIS, pre-order)	38 transactions/month	170 transactions/month	+347%
Social media engagement	1,5%	5,2%	+246%
Greenhouse harvest capacity per harvest	65–80 kg	100–120 kg	+60–84%

The results of implementing the greenhouse-based fruit-picking tourism digitalization strategy showed a significant increase in various performance indicators. In Kediri, the number of visitors increased by 121.4% from 280 to 620 per month, representing a 94.4% increase. In Ponorogo, the number of visitors increased by 94.4% from 360 to 700 per month. This increase reflects growing public interest in environmentally friendly agricultural tourism, as well as the success of digital marketing strategies and content-based destination management. Digital marketing through social media and tourist attractions simultaneously has a positive influence on tourist interest (Aliyah et al., 2024). The economic aspect also benefits from this approach. Sales of premium fruit from two locations increased by 68.6% each month from 510 kg to 860 kg. In addition, the adoption of digital technology in transactions has increased rapidly, rising from 38 digital transactions per month to 170 transactions, a 347% increase. Effective digital marketing strategies, including digital payment infrastructure such as mobile banking and payment applications, contribute to enhancing the tourist experience and improving transaction efficiency (Sharafuddin et al., 2023). This indicates the growing trend of people using digital payment systems, such as e-wallets, QR codes, and pre-order services. This speeds up the flow

of transactions and makes financial management easier for farmers. In terms of digital engagement, green story strategies and social media campaigns have been successful in increasing audience engagement. Engagement on Instagram and TikTok increased by 246% from 1.5% to 5.2%, strengthening the brand position of the tourism village and building a loyal digital community. Communication through social media can enhance consumer knowledge about environmentally friendly products, thereby strengthening positive attitudes towards the brand and driving increased sales (Lu et al., 2022).

Additionally, the harvest capacity of green crops increased from 65–80 kg per harvest to 100–120 kg per harvest. This demonstrates an increase in efficiency of 60–84% due to the use of technology and data-driven planting management. Internet of Things (IoT) technology and machine learning algorithms provide intelligent solutions in greenhouse farming by providing a greenhouse control system that can significantly improve the efficiency and sustainability of agricultural production (Wang et al., 2025). Overall, these findings suggest that digitalization, combined with green marketing strategies and social CRM, can lead to fundamental changes in the local economy and empower premium fruit farmers.

7. Greenhouse Effectiveness and Capacity Improvement

Measurements were conducted to evaluate the effectiveness of various technical and operational aspects of greenhouse-based fruit-picking tourism. The focus of the evaluation was on agricultural productivity, the efficiency of the cultivation system, the quality of the harvest, and visitor engagement in educational events during the tour. The results showed significant improvements in land use, harvest yields, production frequency, and the number of visitors who turned into active buyers. The following table provides an overview of the comparison of conditions before and after the implementation of the strategy:

Table 6. Results of Greenhouse Performance Evaluation Post-Digitization at Partner Locations

Measured Aspects	Before Implementation	After Implementation	Changes / Effectiveness
Average harvest yield per cycle	65–80 kg	100–120 kg	increased by 60%–84%
Harvest frequency per month	1 time	1.5–2 times	increased to 100% (in optimal season)
Harvest failure rate	±20%	±8%	reduced by 60%
Fruit quality (visual & taste assessment)	Local standard (less uniform)	Premium (more uniform & sweet)	increased quality class
Number of greenhouse Education visitors	±100 people/month	±280–350 people/month	increased by 180%–250%
Conversion of tourism to fruit purchases	±30%	±68%	increased by 126%
Utilization ratio greenhouse land	±65% active production	±90% active & systematic	land efficiency increased by 25%
Income from picking & tourism	±Rp 4 million/month	±Rp 10 million–12 million/month	increased by 150%–200%

Based on Table 6, the implementation of the agrotourism and agricultural development program in the Kediri and Ponorogo areas has had a significant impact on several key performance indicators. One of the most notable impacts is the increase in the average number

of tourists visiting each month. Agrotourism is crucial for agricultural areas because it attracts numerous visitors seeking new experiences and generates alternative income for rural communities (Gartner, 2024). In Kediri, the number of visitors increased from 280 to 620 people after implementation, representing a 121.4% increase. In Ponorogo, the number of visitors increased from 360 to 700 people per month, representing a 94.4% increase. This shows that the attractiveness of tourist destinations in both areas is increasing. The two locations increased the number of visitors and sold high-quality fruit. Sales of premium fruit were recorded at 510 kg per month prior to the program's initiation. However, after the program started, sales increased to 860 kg per month, representing a 68.6% increase. This is the result of a more comprehensive marketing and production strategy for premium fruit. The integration of digital payments improves consumer behavior and market performance, with consumers preferring the convenience and security of credit cards over cash (Ly et al., 2024).

In terms of digitalization, a significant increase in the number of digital transactions was recorded through pre-order systems, QRIS, and e-wallets. Digital transactions had only reached 38 transactions per month before implementation but then increased to 170 transactions, representing a 347% increase. This indicates that people and visitors are increasingly adopting modern payment methods that are more practical and efficient. In addition, social media engagement such as Instagram and TikTok) showed an increase in terms of digital promotion and interaction. The engagement rate increased from 1.5% to 5.2%; this 246% increase demonstrates the effectiveness of the digital branding and promotion approach through social media platforms. The sharing and engagement features on TikTok amplify brand exposure, and effective marketing strategies on this platform can significantly increase user engagement (Agrawal et al., 2023). Lastly, the greenhouse capacity has increased drastically. Before the program began, the harvest capacity ranged between 65 and 80 kilograms per harvest or an increase of 60 to 84 percent. This increase demonstrates the effectiveness of agricultural technology employed in the plantation system and the success of the program in directly enhancing productivity.

E. CONCLUSION

This community service activity has successfully demonstrated that integrating greenhouse-based fruit-picking tourism digitalization strategies with a green marketing approach and social customer relationship management (Social CRM) has had a tangible impact on strengthening the economy of premium fruit farmers in the Kediri and Ponorogo areas. Through a mentoring process that includes digital marketing training, social media utilization, customer relationship management, and the development of sustainability-based promotional content, farmers have successfully increased their market reach, the quality of tourism services, and fruit sales volume. Quantitatively, there was a significant increase in the average number of tourists by more than 100%, a 347% increase in digital transactions, and a rise in harvest yields from 65–80 kg to 100–120 kg per cycle. The 60% decrease in crop failure rate also reflects the effectiveness of increasing greenhouse production capacity. Meanwhile, from a qualitative perspective, there has been a positive shift in the mindset of farmers in understanding the importance of experience-based marketing and sustainability, as well as in strengthening their self-confidence in navigating a broader digital market. Greenhouses that previously served only as production spaces have now evolved into family-friendly, healthy, and experiential educational and tourism spaces, thereby creating new sustainable economic value. This service model can be replicated in other areas with similar characteristics to encourage the transformation of the agricultural sector towards digital-based educational tourism and sustainability. Thus, the digitalization strategy based on green marketing and Social CRM has proven to be not only a promotional tool but also a strategic approach to

building a more adaptive, inclusive, and competitive local economic ecosystem in the era of digital transformation and the green economy.

ACKNOWLEDGEMENT

We would like to thank the Institute for Research and Community Service, State University of Malang, for providing service funds in the Community Service scheme of the Community Partnership Program (PKM) with contract number 24.2.1139/UN32.14.1/PM/2025

REFERENCES

Agrawal, E. (2023). *Going viral: An analysis of advertising of technology products on TikTok*. arXiv. https://doi.org/10.48550/arXiv.2402.00010

Aliyah, K., Kisworo, B., Miraj, S., & Gupta, S. (2024). The effect of digital marketing through social media and tourism attractiveness on visitor interest. *Jurnal Pengabdian kepada Masyarakat (Indonesian Journal of Community Engagement), 11*(1), 47–54.

Alkhatib, S., Kecskés, P., & Keller, V. (2023). Green marketing in the digital age: A systematic literature review. *Sustainability, 15*(16), 12369.

Ammirato, S., Felicetti, A. M., Raso, C., Pansera, B. A., & Violi, A. (2020). Agritourism and sustainability: What we can learn from a systematic literature review. *Sustainability*, *12*(22), 9575.

Chi, M., Guo, Q., Mi, L., Wang, G., & Song, W. (2022). Spatial distribution of agricultural eco-efficiency and agriculture high-quality development in China. *Land*, *11*(5), 722.

Gartner, A. (2024). Study explores what helps agritourism grow. *Journal of Rural Studies, 105*.

Irfan, A., & Bryła, P. (2025). Green marketing strategies for sustainable food and consumer behavior: A systematic literature review and future research agenda. *Journal of Cleaner Production, 486*, 144597.

Liu, B., & Zhou, J. (2023). Digital literacy, farmers' income increase and rural internal income gap. *Sustainability*, *15*(14), 11422.

Lu, Q. S., & Miller, R. (2022). How social media communications combine with customer loyalty management to boost green retail sales. *Journal of International Marketing, 46*(1).

Ly, R., & Ly, B. (2024). Digital payment systems in an emerging economy. *Computers in Human Behavior Reports, 16*, 100517. https://doi.org/10.1016/j.chbr.2024.100517

Ma, X., & Lv, L. (2024). Facilitating the high-quality agricultural development with digital economy: a panel data study of Jiangsu Province from 2013 to 2021. *Frontiers in Sustainable Food Systems*, *8*, 1424097.

Malki, D., Bellahcene, M., Latreche, H., Terbeche, M., & Chroqui, R. (2024). How social CRM and customer satisfaction affect customer loyalty. *Spanish journal of marketing-esic*, *28*(4), 465-480.

Manuhutu, E. A., Lengkong, M. R., & Paendong, S. M. (2022). Penerapan Inovasi Teknologi Pasca Panen Tanaman Wortel dalam Manajemen Agribisnis Berkelanjutan. *Jurnal LOCUS: Penelitian & Pengabdian–Vol*, *1*(4), 210.

Ningtyas, S., Asmono, R. T., Nurlaela, L., Kurniati, I., & Nasri, J. (2023). Pelatihan pengenalan digital marketing pemasaran produk pertanian di kelurahan kali abang tengah. *Swadimas: Jurnal Pengabdian Kepada Masyarakat*, *1*(01), 27-34.

Nordin, H., Singh, D., & Mansor, Z. (2021). Interface Design for E-Learning: Investigating Design Characteristics of Colour and Graphic Elements for Generation Z. *KSII Transactions on Internet and Information Systems*, 15(9), 3169–3185.

Nusran, N. F. M. (2023). Guidelines For Designing Engaging and Appealing Visual Content for Online Learning to Enhance Learner's Experience. *ResearchGate*.

Nyambo, P., Nyambo, P., Mavunganidze, Z., & Nyambo, V. (2022). Sub-Saharan Africa Smallholder Farmers Agricultural Productivity: Risks and Challenges. In *Food Security for African Smallholder Farmers* (pp. C1-C1). Singapore: Springer Nature Singapore.

Peng, X., Xu, Q., Chen, Y., Zhou, C., Ge, Y., & Li, N. (2021). An eye tracking study: positive emotional interface design facilitates learning outcomes in multimedia learning?. *International Journal of Educational Technology in Higher Education*, *18*(1), 40.

Pesci, S., Galt, R. E., Durant, J. L., Manser, G. M., Asprooth, L., & Pinzón, N. (2023). A digital divide in direct market farmers' online sales and marketing: Early pandemic evidence from California. *Journal of rural studies*, *101*, 103038.

Putra, D. T., Wahyudi, I., Megavitry, R., & Supriadi, A. (2023). Pemanfaatan E-Commerce dalam Pemasaran Hasil Pertanian: Kelebihan dan Tantangan di Era Digital. *Jurnal Multidisiplin West Science*, *2*(08), 684-696.

Sari, L. N., Nurhidayati, T., Shovitri, M., Zulaika, E., Kuswytasari, N. D., Luqman, A., ... & Priananda, C. W. (2023). Greenhouse Potential based on Ecotourism and Education for Sustainable Village Economic Resilience. *IPTEK Journal of Proceedings Series*, (1), 24-28.

Sharafuddin, M. A., Madhavan, M., & Wangtueai, S. (2024). Assessing the effectiveness of digital marketing in enhancing tourist experiences and satisfaction: A study of thailand's tourism services. *Administrative Sciences*, *14*(11), 273.

Sun, Y., Miao, Y., Xie, Z., & Wu, R. (2024). Drivers and barriers to digital transformation in agriculture: An evolutionary game analysis based on the experience of China. *Agricultural Systems*, *221*, 104136.

Sunitha, R., & Supreeth, D. (2024). E-Learning Accessibility: Barriers and solutions for inclusive online education. *Journal of Informatics Education and Research*, 4(3)

Tiara, L. C., Lestari, H. R., Kholifah, C. D. N., Zulfi, R. F. F., & Anshori, M. I. (2023). Pelatihan dan pengembangan berbasis digital: Implementasi pembelajaran daring, platform pelatihan interaktif, dan teknologi simulasi dalam pengembangan karyawan. *Wawasan: Jurnal Ilmu Manajemen, Ekonomi dan Kewirausahaan*, *1*(4), 359-379.

Vahdanjoo, M., Sørensen, C. G., & Nørremark, M. (2025). Digital transformation of the agri-food system. *Current Opinion in Food Science*, *63*, 101287.

Wang, C., & Gong, J. (2025). *Intelligent agricultural greenhouse control system based on Internet of Things and machine learning* (Version 2). arXiv.

Wulandari, D., Utomo, S. H., Narmaditya, B. S., Priambodo, M. P., & Prayitno, P. H. (2020). Digital farming and Local economy: a study on nudira, greenhouse Bandung. *International Journal of Scientific & Technology Research*, *9*(2), 5689-5694.

Xu, J., Wan, J., & Dai, Z. (2024). How does digital technology application empower specialty agricultural farmers? Evidence from Chinese litchi farmers. *Frontiers in Sustainable Food Systems*, *8*, 1444192.

Yang, C., Ji, X., Cheng, C., Liao, S., Obuobi, B., & Zhang, Y. (2024). Digital economy empowers sustainable agriculture: Implications for farmers' adoption of ecological agricultural technologies. *Ecological Indicators, 159*, 111723.

Yuan, Y., & Sun, Y. (2024). Practices, challenges, and future of digital transformation in smallholder agriculture: Insights from a literature review. *Agriculture, 14*(12), 2193.