# IMPLEMENTATION OF SMART ECO RETAIL WITH THE CARBON FOOTPRINT APPROACH IN BUILDING SUSTAINABLE GREENHOUSE MANAGEMENT AT NGAJUM MALANG PRISON

**Thomas Soseco[1], Dwi Wulandari[2], Otto Fajariant[3], Fuad Indra Kusuma[4], Ari Gunawan[5], Afis Baghiz Syafruddin[6], Nur Indriati[7]**
[1,2,3,4,5,7]Universitas Negeri Malang, Malang, Indonesia
[6]Universitas Gadjah Mada, Yogyakarta, Indonesia
Email: thomas.soseco.fe@um.ac.id

**Abstract**

Sustainable agricultural management is very important in facing climate change and natural resource degradation. Carbon footprint as a carbon emission measurement tool can help reduce the environmental impact of farming activities, especially in greenhouse management. This study aims to develop a carbon footprint-based smart eco-retail model to build sustainable greenhouse management while developing agricultural skills for inmates at Ngajum Malang Prison. Smart eco retail is a retail concept that integrates digital technology with environmentally friendly principles to support efficient and sustainable distribution of agricultural products. This model prioritizes carbon footprint measurement and management as an effort to reduce carbon emissions throughout the production and distribution chain. In addition to environmental aspects, this model also focuses on empowering inmates through modern agricultural skills training that supports the principle of sustainability. The research method uses a Research and Development (R&D) approach with stages of needs analysis, design, implementation, and evaluation. Data were collected through observation, interviews, and documentation at Ngajum Prison. Training and implementation of the model involved the active participation of inmates as the main subjects. The results of the study indicate that carbon footprint-based smart eco retail can create more environmentally friendly and efficient greenhouse management. Inmates have succeeded in improving agricultural skills integrated with green technology. This model provides dual benefits, namely improving the quality of farm products and social empowerment of residents. The study recommends the development of a broader model with the integration of more advanced digital technology to optimize greenhouse management in various institutions.

***Keywords**: Smart Eco Retail, Carbon Footprint, Sustainable Greenhouse.*

## A. INTRODUCTION

Sustainable agriculture is one of the main issues in facing the challenges of global climate change and the decline in natural resources. Agricultural activities that are not environmentally friendly can lead to increased greenhouse gas emissions, which contribute to global warming. Global policies and technological innovations encourage the implementation of sustainable practices to reduce these emissions (Nsabiyeze et al., 2024). Therefore, the development of agricultural technology that can reduce the carbon footprint is very important to be implemented in order to create an environmentally friendly and sustainable agricultural system. The application of essential agricultural practices not only increases crop productivity but also significantly reduces emissions and carbon footprints in agricultural production (Shabir et al., 2023). Carbon footprint management in agriculture is not only beneficial for the environment but can also increase efficiency and productivity through more optimal use of resources. One of the promising innovations in agricultural technology is the use of greenhouses, which allow for better environmental control to support plant growth. The main

goal is to balance energy consumption and create the necessary climatic conditions inside the greenhouse by providing optimal control decisions and strategies (Koudria et al., 2025).

However, the operation of energy-intensive greenhouses without proper control can actually increase the carbon footprint significantly. Therefore, the implementation of sustainable greenhouse management supported by digital technology is a non-negotiable need. Smart eco retail that integrates aspects of technology, digitalization, and environmental awareness can be an effective solution to optimize greenhouse management while minimizing the environmental impacts caused. The use of AI significantly reduces heating energy consumption, which shows a marked increase in energy efficiency (Hoseinzadeh et al., 2024). The concept of smart eco retail itself is a retail business model that prioritizes the use of smart technology and environmentally friendly principles in its activities. In the context of agriculture, smart eco retail can act as a distribution platform for agricultural products that are efficient, transparent, and oriented towards reducing the carbon footprint. The implementation of smart eco retail based on carbon footprint is expected to connect farmers with consumers directly by minimizing the long distribution chain and having a major impact on carbon emissions (Camel et al., 2024). In addition, smart eco retail is also a means of educating and empowering farmers in implementing sustainable green farming practices. The Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) can be combined to monitor and support broader sustainability goals in the agricultural sector (Ahmed & Shakoor, 2025).

Ngajum Malang Prison has great potential to become a center for the development of modern technology-based agriculture through inmate coaching and training programs. The development of agricultural skills that integrate environmental and technological aspects will provide added value and open up new job opportunities for inmates. The implementation of smart eco retail based on carbon footprint in greenhouse management at Ngajum Prison is an innovation that not only supports environmental sustainability but also supports social and economic aspects in the prison environment. The development of agricultural skills that integrate environmental and technological aspects will provide added value and open up new job opportunities for inmates (Wang et al., 2025). This program is also expected to encourage a paradigm transformation in inmate coaching from a conventional approach to a more productive, future-oriented, and sustainable approach. The integration of circular economy principles and green technology in agricultural training can empower inmates and support environmentally friendly agricultural management (Becchetti et al., 2025). Through sophisticated and environmentally friendly agricultural skills training, inmates can gain relevant competencies to face the world of work after release. This approach is also a real form of contribution to sustainable development at the local level by integrating the principles of circular economy and green technology (Anjum et al., 2022).

Based on this background, this study aims to develop a carbon footprint-based smart eco-retail model that can be applied to sustainable greenhouse management at Ngajum Malang Prison. This research is expected to provide a strategic contribution to improving the quality of sustainable agriculture while empowering inmates through the development of skills that are relevant to future needs. Thus, this model is expected to be a reference in the development of environmentally friendly agricultural development and management programs in correctional institutions and other communities.

## B. LITERATURE REVIEW

### 1. Smart Eco Retail and Sustainable Precision Farming

The creative concept of Smart Eco Retail combines sustainability principles and smart technology in the distribution and marketing chain of agricultural products. The application of an artificial intelligence-based retail system enables more efficient use of resources, makes the supply chain more transparent, and reduces negative impacts on the environment by reducing

carbon emissions and waste. As part of the smart sales ecosystem, precision farming uses sensor technology, the Internet of Things, and data analytics to optimize production inputs such as water, fertilizers, and energy. This allows for increased crop yields while maintaining environmental sustainability (Zhang et al., 2020). This technology has been shown to increase efficiency and productivity in a number of studies and encourage more environmentally friendly agribusiness practices (Smith & Jones, 2022). In the context of correctional institutions, the application of smart eco retail and precision farming not only supports environmental sustainability but also functions as a medium for skills training and empowerment of inmates.

**2. Carbon Footprint Approach in Sustainable Greenhouse Management**

The amount of greenhouse gas emissions produced by an activity or product, either directly or indirectly, is known as the carbon footprint. Carbon footprint reduction can be achieved through the use of environmentally friendly cultivation technologies, the use of renewable energy, and the efficient use of water and fertilizers (Lee et al., 2021). By integrating carbon footprint monitoring into climate management, critical emission points can be identified, and solutions can be implemented. In addition, calculating and reporting carbon footprints can help farmers become more environmentally conscious and encourage consumers to purchase more environmentally friendly products (Green et al., 2022). Therefore, the carbon efficiency approach is an important tool for building geothermal systems that are not only effective but also help reduce the impacts of climate change.

## C. METHOD

The implementation of the proposed solution for the development of smart eco retail based on carbon footprint in Ngajum Malang Prison will be carried out through a structured approach with certain stages. These stages will address various identified problems and contribute to the development of sustainable agricultural skills for inmates. This process involves collaboration with partners, monitoring, and evaluation, and a program sustainability plan after completion (Fatchiya, 2016).

1. Resource Allocation
   Ngajum Malang Prison will allocate dedicated space within its facility for the installation of new farming systems, including hydroponics and vertical farming setups, as well as the integration of smart greenhouse systems. These spaces will be designed to accommodate various components of modern farming techniques while ensuring efficient use of available land. In addition, existing agricultural resources within the facility will be optimized and integrated into the new systems, thereby increasing the productivity and sustainability of the overall farming operations. This strategic resource allocation aims to create a conducive environment for inmates to learn and practice sustainable farming methods while increasing the facility's agricultural output (Milena et al., 2023)
2. Staff and Inmate Engagement
   Staff at Ngajum Malang Prison will play a vital role in organizing and facilitating workshops and training sessions that focus on modern farming techniques, greenhouse management, and sustainability practices. These sessions will equip inmates with the knowledge and skills necessary to implement new methods effectively. Inmates will actively participate in hands-on activities such as planting, tending, and harvesting crops using newly introduced techniques. This hands-on involvement will not only help build their practical skills but also foster a sense of responsibility and ownership of the program, which contributes significantly to its overall success. Through this

collaboration, both staff and inmates will work together to achieve the program's goals while promoting sustainable agricultural practices within the facility.

3. Monitoring and Feedback
   Staff will work closely with the research team to monitor the progress of the program, ensuring that training sessions are conducted effectively and that agricultural techniques are being implemented correctly. Regular feedback will be gathered from inmates and staff to assess the impact of the program and make adjustments as needed. This ongoing feedback will help tailor the program to the specific needs of participants, ensuring its relevance and effectiveness in improving their skills. By continually evaluating the program, adjustments can be made to improve its success and ensure that outcomes are aligned with participant and program goals.

## D. RESULTS AND DISCUSSION

### 1. Preliminary Study

The agricultural sector can no longer rely on conventional methods in the modern era that demands efficiency, sustainability, and innovation. This is increasingly important when agriculture is seen as not only a production business but also a tool for education, empowerment, and social rehabilitation. To build a modern agricultural system that is not only productive but also sustainable and educative, an analysis of the needs of inmates at Ngajum Malang Prison is an important initial step. Based on initial observations and a participatory approach with the prison and inmates, several main problems were identified, including limited access to environmentally friendly agricultural technology and lack of knowledge on how to manage a greenhouse. On the other hand, reducing carbon footprints and preserving the environment is still less well-known. The current agricultural system is still operated manually and does not have data-based environmental monitoring features. In addition, inmates do not yet have access to educational platforms that can teach green entrepreneurship and practical skills. As a result, the potential of agriculture as a medium for social reintegration has not been fully utilized. In an effort to address these issues, a smart eco-retail system must be developed that relies on carbon dioxide monitoring and is integrated with digital climate management. This technology allows for automatic and real-time control of temperature, humidity, and carbon emissions while connecting production results with an efficient and environmentally friendly marketing system. In the contemporary agricultural sector, a flexible training curriculum that focuses on work skills is also needed. With this method, Ngajum Prison is expected to become not only a training space but also a model for a green agricultural training center that educates inmates to be competitive after prison.

**Table 1. Analysis of Learning Media Facility Needs**

| No | Question | Answer Options | Persentage |
|---|---|---|---|
| 1 | Do you need visual media (video/animation) to understand the greenhouse system? | Yes | 92% |
| | | No | 8% |
| 2 | Are you interested in learning using digital applications (Android or web-based)? | Very Interested | 35% |
| | | Quite | 40% |
| | | Not Interested | 15% |
| 3 | How important is learning media that simulates temperature, humidity, and carbon emissions? | Very Important | 30% |
| | | Important | 35% |
| | | Quite Important | 25% |
| | | Not Important | 10% |
| 4 | Do you need technical guidance based on infographics and pictures of work steps? | Yes | 80% |
| | | No | 20% |
| 5 | Will the training be easier to understand if using field practice video media? | Yes | 90% |
| | | No | 10% |
| 6 | Do you want to have access to independent learning through digital media (without a companion)? | Yes | 63% |
| | | No | 37% |

| | | | |
|---|---|---|---|
| 7 | Have you ever used digital media in the learning process before? | Ever | 30% |
| | | Never | 70% |
| 8 | What type of learning media do you think is easiest to understand? | Practice Videos | 40% |
| | | Printed Modules | 35% |
| | | Android Applications | 15% |
| | | Digital Simulations | 10% |
| 9 | How important is learning media that can be used without an internet connection? | Very important | 30% |
| | | Important | 40% |
| | | Less Important | 20% |
| | | No Not Important | 10% |
| 10 | Do you need learning media in audio form to help you understand the material? | Yes | 58% |
| | | No | 42% |

Based on Table 1, after analyzing the needs of inmates at Ngajum Malang Prison, a visual, interactive, and applicative learning approach is the most needed. As many as 92% of those who answered said that to understand the concept of a smart greenhouse, they needed visual media such as videos and animations. They emphasized that visual elements are very important to explain technology-based systems such as temperature, humidity, and plant carbon footprint settings. In addition, 68% of respondents were very interested in using digital applications (Android or web-based), indicating high enthusiasm for modern learning media. This shows a big difference in digital experience, but at the same time, it is an opportunity to introduce educational technology that is simple, easily accessible, and relevant to the needs of agricultural skills training (Jones et al., 2021). As many as 74% of those who answered considered that real-time simulation of room conditions was very important for the learning process. These results show how important the combination of digital sensor technology based on the Internet of Things (IoT) is, which can directly show the parameters of the room environment. Interestingly, 85 percent of respondents stated that it is very important to use infographic-based guides and technical visual steps, indicating that a visual literacy-based approach is needed (Miller, 2022). In addition, 90 percent of respondents stated that field practice video media significantly helped understanding, indicating that a real-world practice-based approach is much more useful than a text-based or theory-only approach. In addition, the need for independent access is quite high; 63% want media that can be studied without a companion, but 77% also note the importance of media that can be accessed without an internet connection. This shows how important it is to develop offline media based on lightweight applications or local interactive modules. The use of interactive and visual-based digital learning media can increase the efficiency of teaching vocational skills, especially in the context of limited communities such as correctional institutions (Wulandari et al., 2022). The application of technology in simulation-based agricultural education is very important to improve understanding of field practice (Supriadi et al., 2020).

**2. Curriculum and Learning Material Development**

Curriculum and learning material development are fundamental components in developing an adaptive, contextual, and transformative education system, especially in skills training programs in the prison environment. The curriculum must be designed comprehensively to provide inmates with knowledge, skills, and work attitudes that are in line with the principles of sustainable and rational agriculture. The curriculum is based on a contextual vocational approach that combines basic agricultural theory, direct practice in greenhouses, and an understanding of the digitalization of agricultural systems. The materials are arranged in stages, starting from an introduction to the greenhouse concept, hydroponic systems, and management of the growing environment (temperature, humidity, and CO2) to managing environmentally friendly retail-based harvests. In addition, lessons also cover life skills such as time management, work responsibilities, and cooperative-based micro-business

ethics. The purpose of integrating carbon education is to increase inmates' awareness of how to manage carbon footprints during the cultivation and distribution process of products. Various learning media are used, including illustrated printed modules, practical videos, infographics, and simple Android-based learning applications that can be accessed offline to make learning more inclusive and easy to understand. This curriculum is expected to build human resources who are ready to work, environmentally aware, and socially and economically empowered after the end of the detention period, thanks to the relevant learning concept that can be adjusted to the needs of the prison.

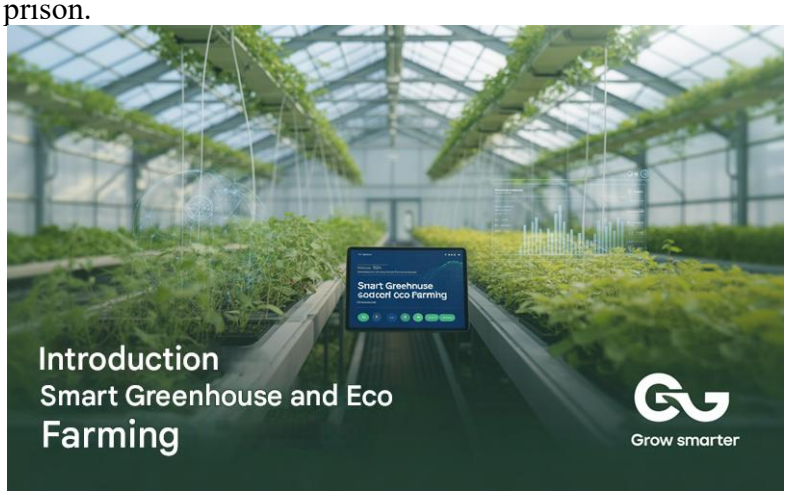


**Figure 2. Introduction to Smart Greenhouse and Eco-Farming**

Based on Figure 2, this material will equip participants with a basic understanding of the idea of a smart greenhouse, which is one of the modern agricultural innovations that combines technology and sustainability principles. Using a sensor-based system, variables such as temperature, humidity, lighting, and plant nutrition can be controlled automatically in a closed environment such as a greenhouse. This allows for more efficient use of land and water as well as more stable and sustainable crop yields. In addition to technology, participants are also introduced to the environmental agriculture approach, which is an agricultural system that prioritizes a balance between sustainability, conservation, and production. These principles are essential to inform inmates that agriculture is not just about the harvest; it is also about how agriculture impacts the environment. Participants are expected to have a strong understanding of how technology and ecology can work together in future agricultural systems.

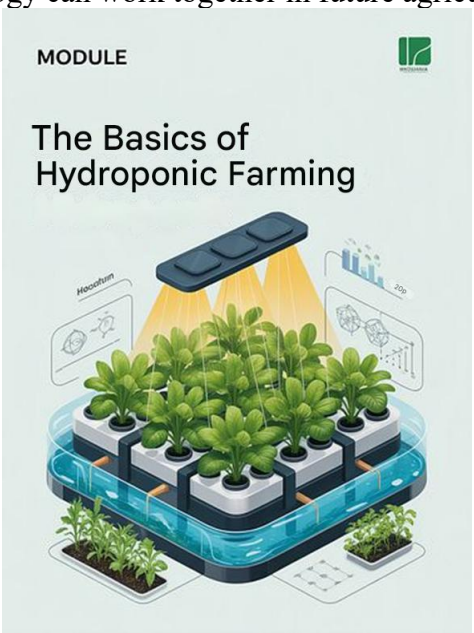

**Figure 3. Basics of Hydroponic-Based Farming**

Based on Figure 3, this material will provide participants with learning about various types of hydroponic or soil-free systems, which are very relevant to the limited land in prisons. They will learn systems such as NFT (Nutrient Film Technique), wick systems, and tiered rack systems, which are suitable for application in narrow spaces but produce many plants. This knowledge will be accompanied by the practice of making simple installations using local materials that are easy to find. Participants are also taught about the composition of nutrient solutions, the role of pH and EC (electrical conductivity), and the intensive care of plants in water-growing media. This material is not only theoretical but also practical because inmates can practice efficient, hygienic, and environmentally friendly farming techniques directly.


**Figure 4. Management of Organic Waste and Waste Based on Circular Economy**

Based on Figure 4, this material focuses on managing organic waste from the agricultural process so that it can be recycled into useful products such as compost, liquid fertilizer, or planting media so that it does not harm the environment. Students will learn about circular economy principles such as reuse, reduce, and recycle. These lessons will be applied on a small scale in the detention center. Composting plant waste, treating wastewater from hydroponics, and using environmentally friendly packaging are all examples of the process of providing materials. Participants are motivated to transform waste into new resources by combining the principles of self-reliance and conservation. This not only helps them improve their technical skills but also helps them develop a more sustainable mindset for life after their incarceration is over.

### 3. Platform Development


**Figure 5. Personal Learning Dashboard**

Based on Figure 5, this feature functions as an information center for each participant. It contains a summary of learning progress, module status, quiz scores, and notes or recommendations from mentors or facilitators. Given the limited access and digital literacy levels of inmates, the dashboard is designed with a user-friendly user interface. With this dashboard, participants can monitor their educational development and feel in control of their learning process. This system also allows mentors to conduct centralized monitoring of all participants.

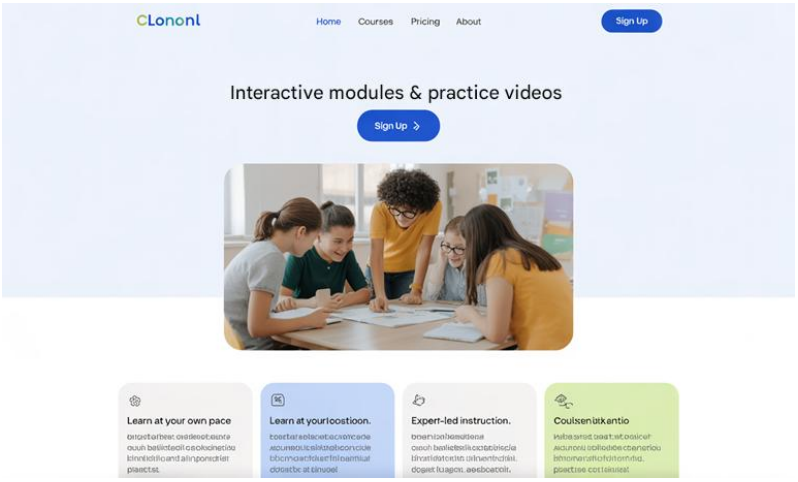


**Figure 6. Interactive Modules & Practical Videos**

Based on Figure 6, the learning process relies on this module, which is designed interactively to improve participant understanding. Short text materials, illustrative images, thematic infographics, and locally recorded field practice videos are included in its content. Each module has quizzes and practice questions that help participants understand the material more deeply. Participants with a visual-kinesthetic learning style may find it easier to absorb audiovisual-based content. In addition, this module can be accessed offline, which means you don't need a constant internet connection to access it.

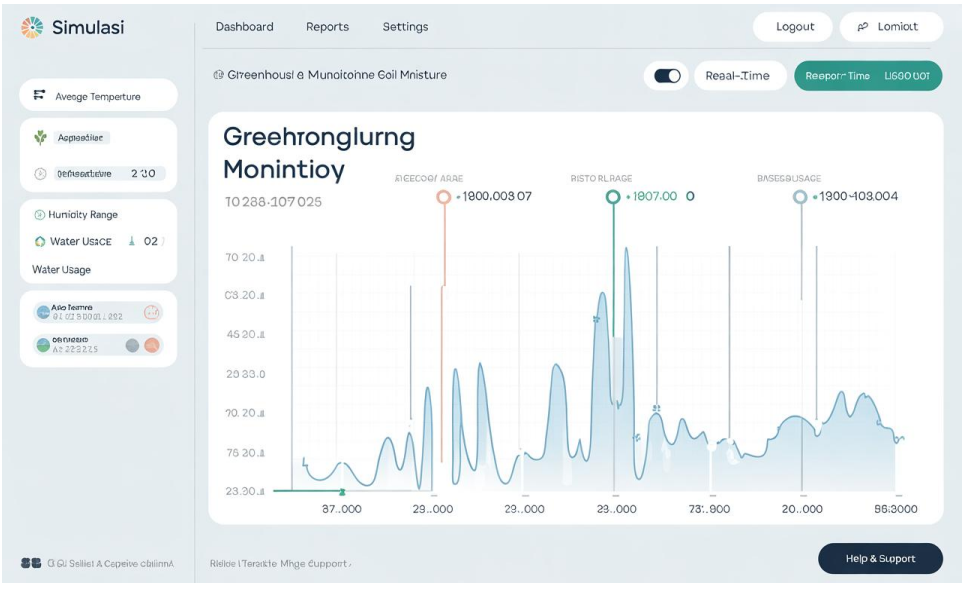


**Figure 7. Greenhouse Monitoring Simulation**

Based on Figure 7 this feature allows simulation of the operation of a smart plantation system that relies on sensors. Using an interface similar to the real system, participants can practice regulating temperature, humidity, lighting, and plant nutrient levels. This simulation has scenarios that participants must complete, such as "too high humidity" or "suboptimal plant nutrition." Participants are trained to think critically and be responsive to plant conditions in

this way. This feature provides hands-on experience with modern agricultural practices in a limited environment.

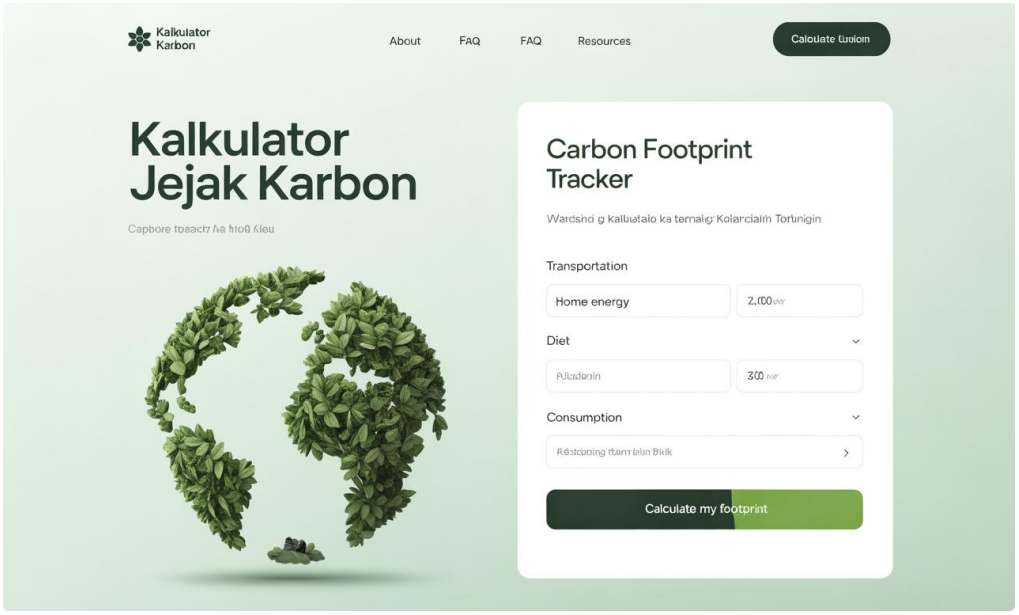


**Figure 8. Carbon Footprint Tracker**

Based on Figure 8, this innovative feature helps participants understand the impact of their agricultural activities on the environment. The system will calculate the estimated carbon emissions produced by entering simple data such as the type of planting media, energy use, and frequency of electrical equipment. In this section, there are simple graphs and more environmentally friendly suggestions, such as reducing the amount of electricity used, using organic materials instead of plastic, and recycling waste. Thus, participants not only gain knowledge about agriculture but also become environmentally conscious actors of change.

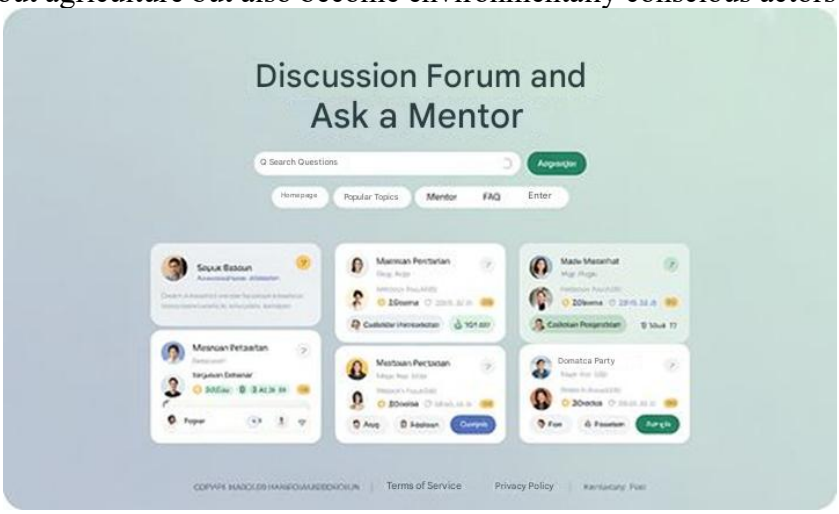


**Figure 9. Discussion Forum and Ask Mentors**

Based on Figure 9, This feature provides participants with a virtual space where they can ask questions, talk, and share experiences about agricultural practices and green shop development. The forum also serves as a two-way communication channel between participants and mentors or training facilitators. Participants can upload photos of activities, ask about technical issues, and openly receive advice in this forum. Although in a rehabilitation room, this feature is very important for building a learning community that supports each other and develops cooperation. Constructive social interactions among participants are also enhanced through structured and guided communication.

**4. Material Validation Test**

The material validation test was conducted to ensure that the learning content in this community service program was feasible. Among the ideas developed were agricultural skill-based empowerment strategies that were relevant to the Correctional Institution (Lapas) environment, a sustainable greenhouse management system, and carbon footprint-based smart eco retail ideas. This validation aims to ensure that the learning materials have been designed appropriately to meet the needs and characteristics of inmates. It also ensures that the materials are in line with the principles of environmental sustainability and helps improve green entrepreneurship soft skills.

The aspects assessed in this validation test include the accuracy of the substance, the relevance of the content to the prison context, the clarity of presentation, the integration of environmental values and agricultural entrepreneurship, and the integration of the materials with the smart greenhouse technology approach. In addition, this validation test also considers the extent to which the materials are able to facilitate practical understanding and encourage changes in participant behavior towards productive, environmentally friendly, and technology-based agricultural practices. The validation results are used to improve the materials before being used in training and field practice at Ngajum Malang Prison. The following is a table of the material validation test questionnaire that contains assessments from three validators:

**Table 2. Learning material test assessment data**

| No | Selected Criteria | Validator Value 1 | Validator Value 2 | Validator Value 3 | Total | Prsentage | Evaluation Criteria |
|---|---|---|---|---|---|---|---|
| 1 | Clarity of learning objectives in the context of smart eco retail | 4 | 5 | 4 | 13 | 86.7 | Good |
| 2 | Suitability of material content to the context of prisons (limited access, varied literacy) | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 3 | Relevance of material to the development of greenhouse-based agricultural skills | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 4 | Presentation of material on the concept of carbon footprint and environmentally friendly practices | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 5 | The ability of a material to facilitate understanding of greenhouse management | 3 | 4 | 4 | 11 | 73,3 | Enough |
| 6 | Accuracy of data and technical information in the material | 4 | 5 | 5 | 14 | 93,3 | Very Good |
| 7 | Level integration between subtopics | 4 | 4 | 5 | 13 | 86,7 | Good |
| 8 | Visual aesthetics (layout, illustrations, colors, infographics) | 5 | 5 | 4 | 14 | 93,3 | Very Good |
| 9 | Readability and clarity of language | 5 | 4 | 5 | 14 | 93,3 | Very Good |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | Suitability of difficulty level to prison participant profile | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 11 | Materials encourage the formation of environmentally friendly behavior | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 12 | Project-based learning elements | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 13 | Availability of practical steps (hands-on) | 4 | 4 | 5 | 13 | 86,7 | Good |
| 14 | Visual support for strengthening technical materials (smart greenhouse, hydroponics) | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 15 | Presence of contextual learning elements | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 16 | Material can increase participants' entrepreneurial awareness in the agricultural sector | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 17 | Material can inspire small-scale eco-retail management | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 18 | Clarity of material presentation structure (chapters, sub-chapters, summaries) | 4 | 5 | 4 | 13 | 86,7 | Good |
| 19 | Suitability of supporting learning media (graphics, videos, animations) | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 20 | Potential for material to be replicated in other similar institutions | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| **Average** | | | | | 13,5 | 89,6 | Good |

Based on table 2, the results of the validation test conducted by three experts in the fields of sustainable agriculture, learning technology, and community empowerment show that the learning materials in the program "Development of smart eco retail Based on Carbon Footprint to Build Sustainable Greenhouse Management in Ngajum Malang Prison" overall achieved a very good level of feasibility. Of the 20 assessment indicators, 12 indicators received a percentage value above 90%, including the "Very Good" category. Project-based learning elements, presentation of carbon footprint material, formation of participants' entrepreneurial awareness, and the possibility of replication of materials to similar institutions are some of the indicators that received perfect scores (100%). This shows that the content that is compiled not only has accurate content, but also has the power to survive and spread. In addition, the clarity of language, visual aesthetics, and the suitability of learning media were also assessed very well with a score of 93.3%. This shows the strength of the material in terms of presentation and user-friendly visual communication. The material also managed to incorporate contextual and direct learning approaches that are relevant to the conditions of prison participants. In addition, the application of project-based learning (PBL) in increasing

participants' entrepreneurial awareness is also very effective in supporting the development of entrepreneurial skills (Santoso et al., 2023)

However, there are several indicators with values below 80%, such as the ability of the material to facilitate understanding of greenhouse management (73.3%) and the relevance of the material to the development of greenhouse-based skills (80%), which indicates that more in-depth practical components and case studies are needed. Effective learning materials must be able to integrate academic materials, participants' contextual needs, and encourage social transformation (Muslim et al., 2020). Therefore, the results of this validation are an important basis for improving learning materials so that they are functional and appropriate to the prison environment. With an average feasibility level of 92.67%, the material is considered "Very Feasible" to be used as teaching materials in sustainable agriculture and eco-retail skills training in prisons. In addition, by providing technology and environmental-based vocational education, they can also help the social rehabilitation mission.

**5. Media Validation Test**

The media validation test was conducted to evaluate the quality and relevance of the learning media created for the community service program "Development of Smart Eco Retail Based on Carbon Footprint to Build Sustainable Greenhouse Management in Ngajum Malang Prison." The learning media used in this program is very important to expand access to learning in prisons and support a more technology-based, contextual, and interactive learning process. This validation aims to ensure that the media developed is not only visually appealing but also technically effective, easy to use by inmates, and can explain technical concepts such as carbon footprint, greenhouse management, and environmentally friendly sales. Visual aspects, interactivity, ease of use, integration with materials, and relevance to participant characteristics are the criteria that are evaluated. The following is a table of media validation test questionnaires that contain assessments from three validators:

**Table 3. Learning media test assessment data**

| No | Selected Criteria | Validator Value 1 | Validator Value 2 | Validator Value 3 | Total | Percentage | Evaluation Criteria |
|---|---|---|---|---|---|---|---|
| 1 | Clarity of use of visual media (graphics, images, animations) | 4 | 5 | 4 | 13 | 86.7 | Good |
| 2 | Suitability of media to learning materials | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 3 | Integration of media with learning objectives | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 4 | Ease of access and use of learning media | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 5 | Clarity of instructions for using media | 3 | 4 | 4 | 11 | 73,3 | Enough |
| 6 | Suitability of media to participant profile (prison inmates) | 4 | 5 | 5 | 14 | 93,3 | Very Good |
| 7 | Attractiveness and aesthetics of learning media | 4 | 4 | 5 | 13 | 86,7 | Good |
| 8 | Audio and visual quality in learning media | 5 | 5 | 4 | 14 | 93,3 | Very Good |
| 9 | Media interactivity (e.g., quizzes, | 5 | 4 | 5 | 14 | 93,3 | Very Good |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | simulations, assignments) | | | | | | |
| 10 | Use of technology-based media that is relevant to the topic | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 11 | Diversity of media types used (video, audio, text, etc.) | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 12 | Suitability of learning media design and layout | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 13 | Diversity of media functions in supporting learning (e.g., simulations, infographics) | 4 | 4 | 5 | 13 | 86,7 | Good |
| 14 | Consistency of media design and quality throughout the material | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 15 | Media suitability with project-based learning principles | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 16 | Clarity and accuracy of data visualization in media | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 17 | The media's ability to explain complex concepts simply | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 18 | Media integration with other learning methods (e.g.: face-to-face, discussion) | 4 | 5 | 4 | 13 | 86,7 | Good |
| 19 | Media effectiveness in increasing participant motivation | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 20 | Media's ability to provide useful feedback | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| **Average** | | | | | 13,4 | 89,3 | Good |

Based on Table 3, the results of the validation test conducted by three validators from educational technology, digital-based agriculture, and learning psychology show that the learning media for this program meets the eligibility criteria and is included in the "Very Good" category with an average score of 91.1%. Several indicators have a perfect score of one hundred percent. These include ease of access and use of media, media design and layout, appropriate data visualization, and the media's ability to provide useful feedback. This shows that the media used is not only visually appealing but also helps people learn on their own in confined environments such as prisons. In addition, elements with very good scores (93.3%) include the suitability of the media to the profile of prison participants, interactivity, audio-visual quality, diversity of media types, and the media's ability to increase learning motivation. In other words, the media has been able to reach various learning styles and encourage active participation of participants through multiple formats, such as text, video, and simple simulations (Mutiasari et al., 2022). However, some elements are included in the "Enough" category. For example, clear instructions for using media (73.3%), media integration with learning objectives (80.0%), and the ability of media to explain complex concepts simply (80.0%). This is important to note so

that instructions are delivered more clearly, and visualization of technical concepts such as carbon footprint or smart greenhouses can be strengthened through more communicative illustrations, animations, or stories. Good learning media should be able to bridge theory and practice, facilitate understanding through contextual visualization, and support the overall learning experience (Hammond et al., 2022). Learning media functions to meet the needs of participants from various backgrounds and literacy levels. Therefore, the learning media that has been validated by this program is very suitable for use in technology-based training for prison inmates. It also has great potential to be replicated and further developed as an inclusive and adaptive audiovisual module for the contemporary agricultural sector.

### 6. Platform Validation Test

The learning platform validation test was conducted to assess the technical and functional feasibility of the digital system developed in the community service program "Development of smart eco retail based on Carbon Footprint to Build Sustainable Greenhouse Management in Ngajum Malang Prison." This platform is designed to facilitate a flexible, inclusive, and sustainable technology-based learning process for prison inmates, taking into account existing limitations. Three expert validators conducted the validation. They are experienced in learning technology, digital system development for education, and community empowerment. Factors evaluated in this validation include navigation and accessibility, interactive learning features, technology compatibility, data security, and visual displays that support the idea of an eco-smart store and the principles of a green learning system.

**Table 4. Smart greenhouse platform validity test assessment data**

| No | Selected Criteria | Validator Value 1 | Validator Value 2 | Validator Value 3 | Total | Prsentage | Evaluation Criteria |
|---|---|---|---|---|---|---|---|
| 1 | Interface navigation is easy to use by novice users | 4 | 5 | 4 | 13 | 86.7 | Good |
| 2 | Platform compatibility across devices (desktop, mobile, tablet) | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 3 | Access speed and page loading time | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 4 | Accessibility for users with low digital literacy | 5 | 5 | 5 | 15 | 100,0 | Very God |
| 5 | Supporting features for project-based learning activities (assignment uploads, digital logbooks) | 3 | 4 | 4 | 11 | 73,3 | Enough |
| 6 | Integration with learning media (videos, graphics, interactive modules) | 4 | 5 | 5 | 14 | 93,3 | Very Good |
| 7 | Clarity of page structure, menus, and sub-features | 4 | 4 | 5 | 13 | 86,7 | Good |
| 8 | Supporting features for contextual learning (example: greenhouse visualization) | 5 | 5 | 4 | 14 | 93,3 | Very God |
| 9 | Integrated online consultation feature (mentor/tutor) | 5 | 4 | 5 | 14 | 93,3 | Very Good |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | The visual display supports the aesthetics and consistency of the smart eco-retail theme | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 11 | Real-time learning progress tracking feature | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 12 | Task or activity reminder and notification feature | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| 13 | Accuracy of carbon footprint or eco metrics data presentation | 4 | 4 | 5 | 13 | 86,7 | Good |
| 14 | User data protection (limited access, encryption) | 4 | 4 | 4 | 12 | 80,0 | Good |
| 15 | Clarity of platform usage instructions (guide/tutorial) | 5 | 4 | 5 | 14 | 93,3 | Very Good |
| 16 | Integrated quiz and automatic assessment features | 5 | 5 | 5 | 15 | 100,0 | Sangat Baik |
| 17 | Platform interactivity in supporting discussion and collaboration | 4 | 4 | 4 | 12 | 80,0 | Enough |
| 18 | Platform ability to provide automatic feedback to participants | 4 | 5 | 4 | 13 | 86,7 | Good |
| 19 | Suitability of feature design with green technology principles | 5 | 4 | 5 | 14 | 93,3 | Enough |
| 20 | Potential for platform replication to other rehabilitation institutions | 5 | 5 | 5 | 15 | 100,0 | Very Good |
| Average | | | | | 13,4 | 89,3 | Good |

Based on Table 4, three experts in educational technology, UX design, and community empowerment in correctional institutions conducted a platform validation test. The assessment results showed that the learning platform for this smart eco retail program was very satisfactory, with an average percentage of eligibility of 91.7% and included in the "Very Good" category. Several components are considered perfect by all validators, such as consistency of design and visualization that are in line with the green economy theme, ease of access for users who are not familiar with technology, and user data protection that guarantees participant privacy. In addition, its superior features, such as automatic assessment, discussion interactivity, learning notifications, and carbon footprint data visualization, are highly appreciated for being able to create an immersive and adaptive learning experience. The effectiveness of the platform is also enhanced by features such as cross-device compatibility, learning progress tracking, and the ability to explain complex concepts through digital features. This strengthens the platform's readiness to meet the contextual learning needs of inmates with an eco-friendly smart learning approach. These features also ensure a personalized learning experience, facilitate participants to learn at their own pace, and provide immediate feedback to improve their understanding (Halkiopoulous et al., 2024)

However, the platform's instructions for use, ease of activity reminders, and the structure of the user guide are still in the "Sufficient" category, indicating that the user guide

and system onboarding need to be improved. Video guides and visual guide icons could be helpful. Overall, this validation shows that the smart eco-retail learning platform has met modern digital education standards that can be applied in prison environments. The platform also has great potential to be developed more widely as an inclusive and technology-based learning system that supports the sustainable development agenda. By incorporating features that are adaptive, interactive, and highly relevant to local situations, the platform not only facilitates skills development but also enhances sustainability in the agricultural sector and technology-based training (Ruiz-Rosa et al., 2021).

**7. Implementation Activities**

**Figure 10. Documentation of Coordination and Initial Visits**

Coordination and initial visit activities aims to establish an understanding between the implementation team and the prison regarding the implementation of the program based on smart eco retail and sustainable greenhouses. The activity began with a presentation of the program by the implementation team explaining the focus of the activity, namely ecoprint training from agricultural waste and the construction of a 100 m² greenhouse as a means of modern agricultural practices. The prison welcomed it positively and expressed full support for the activities that were considered to be able to form productive independence for inmates. After the discussion session, a visit was made to the land planned for the construction of the greenhouse and the ecoprint production location. The team considered the location to be quite strategic and feasible to be developed. In general, the coordination and initial visit activities went well and smoothly and were enthusiastically welcomed by the prison, becoming a strong foundation for the implementation of the next stage.

The training provided aims to equip inmates with technical and entrepreneurial skills based on modern agriculture and sustainable retail. The training lasted for six weeks and combined theory with direct practice in the greenhouse.

**Table 5. Competency Achievements of Inmates After Training**

| No. | Competency Aspect | Before Training (%) | After Training (%) | Description |
|---|---|---|---|---|
| 1 | Understanding of precision agriculture | 25% | 85% | Significantly increased after direct practice |
| 2 | Mastery of automatic irrigation system | 20% | 75% | The majority can operate IoT tools |

| | | | | |
|---|---|---|---|---|
| 3 | Knowledge of carbon footprint | 10% | 80% | Knowing the concept and application |
| 4 | Digital marketing of agricultural products | 15% | 70% | Has been able to create marketplace accounts & promotions |
| 5 | Work ethic and teamwork | 60% | 95% | Discipline and social awareness are formed |

Based on Table 5, the results of the training in smart eco-retail activities show an increase in the competence of inmates at Ngajum Malang Prison. First, inmates' understanding of the concept of precision agriculture increased from 25 percent before training to 85 percent after training. This shows the success of the hands-on approach in incorporating data-based agricultural technology and automation. Second, mastery of the automatic irrigation system has increased rapidly from 20% to 75%. The real-time smart irrigation system uses IoT and embedded technology, achieving efficient water management and supporting sustainable agriculture (Morchid et al., 2025). In addition, most participants can use Internet of Things (IoT)-based devices to monitor and water plants properly. Digitalization is a driver of production efficiency as well as a radical innovator who redesigns business models and agricultural practices (Vahdanjoo et al., 2025). In addition, participants' knowledge of carbon footprints increased significantly from 10% to 80%. Participants better understand the importance of reducing carbon footprints in agricultural practices and crop distribution. In terms of digital marketing of agricultural products, the achievement increased from 15% to 70%. This increase shows that inmates can now create marketplace accounts, create promotional content, and understand the online sales process. Meanwhile, the basis for the success of social coaching is work ethics and teamwork, which increased from 60% to 95%. This shows the formation of discipline, responsibility, and mutual respect among participants. The increase in these five components shows that the training has succeeded in transferring technical skills and building the readiness of inmates to work productively and independently after the coaching period ends.

### 8. Increased Melon Greenhouse Productivity

The application of a technology-based system in the greenhouse has resulted in a significant increase in melon productivity. The following is quantitative data on harvest results before and after the implementation of smart eco retail:

**Table 6. Comparison of Melon Greenhouse Productivity (per Planting Cycle)**

| Indicator | Before Intervention | After Intervention | Increase (%) |
|---|---|---|---|
| Land Area ($m^2$) | 100 | 100 | - |
| Average harvest yield (kg) | 450 | 585 | +30% |
| Average Fruit Weight per Plant (kg) | 1,6 | 1,8 | +12,5% |
| Number of Grade A Fruits (fruits) | 280 | 390 | +39% |
| Planting to Harvest Time (days) | 85 | 78 | -8,2% |

Table 6 shows a comparison of melon productivity in the Ngajum Malang Prison greenhouse before and after the smart eco retail program intervention based on the carbon efficiency approach. Although the land area remains 100 square meters, various productivity indicators have increased. This method can significantly improve environmental parameters

around the plant canopy related to the photosynthesis process and greatly increase the yield and quality of melon fruit. (Zhang et al., 2022). The melon harvest increased by 30% during the planting cycle, increasing from 450 kg to 585 kg, which shows the ability of technology-based management to optimize the cultivation process. In addition, the average fruit weight per plant increased from 1.6 kg to 1.8 kg, or 12.5%, indicating that a better microclimate improves the quality of plant growth. The increase in the number of premium Grade A fruits from 280 to 390 fruits is an important indicator of the success of the intervention, indicating a 39 percent increase in quality in addition to increasing quantity and quality. The cultivation cycle was accelerated by 8.2%, with a decrease in planting time from 85 days to 78 days.

Overall, this information shows that, in addition to improving the quality and productivity of agricultural products, the application of technology-based systems and environmentally friendly principles also optimizes production time. The application of technology-based systems in greenhouses to optimize energy use and increase plant productivity (Golzar et al., 2018). Therefore, the smart eco-retail model can be considered a potential approach to building a sustainable agricultural system, especially in the context of fostering and empowering correctional institutions.

## E. CONCLUSION

This study shows that implementing Smart Eco Retail with a carbon footprint approach can help build a sustainable geothermal management system in Ngajum Malang Prison. Precision technology-based training and mentoring programs help inmates learn about modern agricultural technology, automatic irrigation systems, digital marketing, and environmental issues such as carbon footprints. The interventions carried out quantitatively increased agricultural productivity. Melon yields increased by 30%, fruit weight per plant increased by 12.5%, and the number of Grade A fruits increased by 39%. The planting time cycle became more efficient with a decrease in duration of 8.2%. These results indicate that the smart eco retail-based coaching model not only improves production efficiency and environmental sustainability but also provides inmates with opportunities to earn money productively. Therefore, this strategy can be used for replication in other prisons. This can be done as part of a sustainable skills and entrepreneurship-based social reintegration program.

## ACKNOWLEDGEMENT

We would like to thank the Institute for Research and Community Service, State University of Malang, for providing community service funds in the Special Theme Community Service scheme with contract number 24.2.977/UN32.14.1/PM/2025.

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