


# Maximizing Economic Efficiency in Urban Mustard Farming through Pipe, Soil, and Bottle-Based Systems

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INFORMASI ARTIKEL	ABSTRAK
<b>Kata Kunci:</b> Pertanian perkotaan Pertanian berkelanjutan Efisiensi sumber daya Memaksimalkan keuntungan ekonomi Tanggung jawab lingkungan	Pengabdian masyarakat ini bertujuan untuk memaksimalkan efisiensi ekonomi dalam pertanian sawi perkotaan melalui penggunaan sistem berbasis pipa, tanah, dan botol. Metode yang digunakan adalah program pengabdian masyarakat yang melibatkan edukasi praktis bagi warga di Desa Peguyangan, Bali, tentang cara memanfaatkan limbah plastik sebagai media tanam. Melalui pelatihan langsung, peserta diajarkan untuk membangun dan memelihara sistem penanaman menggunakan pipa dan botol bekas. Hasil penelitian menunjukkan bahwa setelah pelatihan, partisipasi masyarakat dalam pertanian urban meningkat dari 30% menjadi 85%. Selain itu, penerapan sistem ini terbukti dapat meningkatkan daya tahan kelembaban tanah dan mengurangi kebutuhan air, sehingga menghasilkan panen sawi yang lebih baik. Simpulan dari studi ini mengindikasikan bahwa penggunaan bahan daur ulang tidak hanya berkontribusi terhadap keberlanjutan lingkungan, tetapi juga meningkatkan ketahanan pangan dan kemandirian ekonomi di daerah perkotaan.
<b>Keywords:</b> Urban farming Sustainable agriculture Resource efficiency Maximizing economic Environmental responsibility	<b>ABSTRACT</b> This study aims to maximize economic efficiency in urban mustard farming through the use of pipe, soil, and bottle-based systems. The method employed was a community service program that involved educating residents in Peguyangan Village, Bali, on how to utilize plastic waste as a planting medium. Through hands-on training, participants learned to construct and maintain planting systems using recycled pipes and bottles. The findings indicate that after the training, community participation in urban agriculture increased from 30% to 85%. Additionally, the implementation of this system proved to enhance soil moisture retention and reduce water consumption, resulting in improved mustard yields. The conclusion of this study highlights that the use of recycled materials not only contributes to environmental sustainability but also enhances food security and economic resilience in urban areas.
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## I. PENDAHULUAN

Urban agriculture has increasingly gained recognition as a viable approach to addressing the challenges posed by urbanization, food security, and sustainability. The title "Maximizing Economic Efficiency in Urban Mustard Farming through Pipe, Soil, and Bottle-Based Systems" encapsulates the potential of innovative agricultural practices designed to optimize resource use and enhance productivity in urban settings. This research is particularly essential as cities continue to expand and confront environmental and economic pressures, necessitating efficient agricultural solutions that align with sustainability goals.

The increasing global awareness and emphasis on sustainability underscore a pivotal shift towards developing environmentally-friendly products and initiatives aimed at promoting eco-consciousness and responsible consumption. Urban farming emerges as a significant trend in this movement, leveraging innovative methods to produce food sustainably while addressing pressing environmental concerns. The goal of urban farming is not only to enhance food security but also to create systems that are economically viable, socially inclusive, and environmentally sound (Whittinghill & Sarr, 2021; , Nowysz et al., 2022).

A variety of sustainability practices have been identified as fundamental to fostering the continuity of urban farming. Research indicates that incorporating external social practices—such as community engagement and education about environmental practices—can reinforce the link between urban agriculture and local communities, thereby enhancing support for these initiatives (Yoshida & Yagi, 2023). This community involvement is critical; when residents are aware of the sustainable methods employed by local farmers, they are more likely to support such endeavors, thus reinforcing a cycle of sustainability (Yoshida & Yagi, 2023; , Sanyé-Mengual et al., 2018). Furthermore, urban agriculture serves as a platform for educational opportunities, allowing consumers to appreciate the benefits of sustainability and actively participate in responsible consumption practices (Teoh et al., 2024).

The COVID-19 pandemic has exacerbated existing vulnerabilities in food systems, highlighting the need for resilience-oriented food policies. This crisis has prompted a reevaluation of food security frameworks, demonstrating how urban farming can contribute to sustainable food systems (Nemes et al., 2021). Initiatives that integrate urban farming within local governance and community planning can promote adaptive strategies that not only enhance food production but also address social inequities (Haryanti et al., 2023). The importance of fostering community-centric farming models is further emphasized by studies demonstrating that urban farming can lead to improved health outcomes and enhanced local economies through job creation (Nowysz et al., 2022; , Othman et al., 2018).

Challenges such as limited space and resource competition in urban areas require innovative solutions such as vertical farming and smart gardens, which can maximize yield while minimizing resource use (Panotra et al., 2024). These technological advancements reflect a broader shift within the agricultural sector towards integrated systems that emphasize sustainability and efficiency. The development of such systems is crucial as traditional farming practices increasingly struggle to meet the demands posed by urbanization and climate change (Panotra et al., 2024).

Thus, the diverse approaches to sustainability in urban farming—ranging from community engagement to technological innovations—highlight the critical role that urban agriculture can play in fostering sustainable consumption patterns. The intersection of agriculture, ecology, and social responsibility presents a unique opportunity to redefine urban food systems, paving the way for healthier, environmentally-conscious, and economically viable communities (Whittinghill & Sarr, 2021; , Nemes et al., 2021; , Nowysz et al., 2022).

The potential of urban agriculture to enhance food provisioning and contribute to sustainability is underscored by recent studies indicating that commercial urban agriculture can generate tangible impacts and benefits in urban settings (Milestad et al., 2024). Moreover, the diversification of the urban environment through practices such as community gardens has been shown to improve ecosystem services, thereby enhancing urban resilience (Dobele et al., 2022). With urban areas increasingly bearing the brunt of climate change, the exploration of smart agriculture strategies becomes paramount. These strategies can lead to enhanced compliance and economic growth in urban regions, which are typically characterized by unpredictable weather patterns and limited agricultural space (Čerņiševs et al., 2024).

Innovation in agricultural practices, such as the incorporation of sustainability practices, plays a critical role in ensuring the longevity and success of urban farming ventures, particularly within the context of mustard cultivation. External social sustainability initiatives have been tied to increased community support for urban agriculture, which signals the necessity of integrating community-driven practices into urban farming strategies (Yoshida & Yagi, 2023). As urban populations continue to rise, foundational strategies to navigate these challenges include implementing targeted policies that promote urban agriculture, such as wastewater reuse and educational campaigns focused on community engagement (Alam & Naem, 2024).

The implementation of vertical farming, hydroponics, and other advanced systems shows promise in overcoming space limitations inherent in urban environments. These concepts not only promote enhanced food security but also reduce the carbon footprint associated with food miles through localized production (Al-Kodmany, 2018). Furthermore, urban agriculture offers multifunctional benefits beyond food provisioning, including economic empowerment and social cohesion within communities, as indicated by studies illustrating successful slum-based urban farming initiatives (Surya et al., 2020).

In the context of Peguyangan Village, Uma Palak Lestari as one of the urban farming communities has made various innovations in utilizing narrow land for plant cultivation. Various programs have been implemented to educate the public about the importance of sustainable agriculture and how to process waste

into productive planting media. However, until now, there are still challenges in optimizing cultivation methods so that the results obtained are more optimal, especially in the use of a combination of pipes, soil, and used drinking bottles for vegetable plants such as mustard greens.

The current community service focuses on urban mustard farming in Peguyangan Village, utilizing innovative pipe, soil, and bottle-based systems to address the challenges of limited space and plastic waste management. While previous community service initiatives have explored sustainable agriculture practices, they often relied on conventional cultivation methods without effectively leveraging available urban waste materials.

The gap identified in previous programs is twofold: first, they failed to integrate the use of recycled plastic products as a practical solution for enhancing agricultural efficiency in densely populated areas. Second, these initiatives did not prioritize hands-on training tailored to the specific conditions and resource constraints of urban settings, which is critical for maximizing community involvement and ensuring the sustainability of agricultural practices.

This study contributes new insights by implementing a comprehensive educational approach that empowers residents to utilize local plastic waste effectively, transforming it into productive planting media. By demonstrating a significant increase in community participation—from 30% to 85%—and improved agricultural yields through innovative techniques, this research not only fills a crucial gap in urban farming practices but also sets a benchmark for future programs aimed at achieving environmental sustainability and food security in urban environments.

While previous community service initiatives have laid the groundwork for sustainable agriculture education, the current research distinguishes itself by combining the principles of urban farming with innovative recycling practices, thus offering a fresh framework that other urban communities can replicate.

Overall, maximizing economic efficiency in urban mustard farming requires a comprehensive understanding of the interplay between innovative agricultural technologies and socio-economic frameworks that promote sustainability and resilience within urban settings.

## II. PROBLEM

The primary problem of urban farming in Peguyangan, Bali, stems from the limited space available for agricultural activities due to rapid urbanization. With residential areas expanding, the land for traditional farming is scarce, making it challenging to grow crops like mustard greens effectively. Additionally, the improper disposal of plastic waste contributes to environmental pollution, exacerbating the problem. As urban farming practices in Peguyangan predominantly relied on conventional methods, these were insufficient to meet the growing demand for sustainable food production. Many residents had little awareness of how to optimize available space for agriculture, leading to underutilized land and low crop yields. Furthermore, there was a lack of innovative techniques for utilizing urban waste materials, particularly plastic, which is abundant in the area. Given these challenges, Universitas Pendidikan Nasional (Undiknas) decided to engage in a community service program focused on utilizing recycled materials like plastic bottles and pipes for farming. This initiative aims to address the issues of limited space and environmental pollution while educating the community about sustainable farming practices. By introducing innovative, space-efficient farming methods, the program encourages residents to adopt environmentally friendly and resource-efficient techniques, ultimately contributing to both food security and environmental sustainability in Peguyangan.



Figure 1. Location "Uma Palak Sari"

### III. METHODS

The training process is designed to provide participants with practical, hands-on experience in creating and using a sustainable planting system. By focusing on the use of recycled materials, specifically pipes and plastic bottles, the training encourages participants to adopt environmentally friendly methods for urban gardening. Through direct demonstrations, participants gain insight into how to set up and maintain a planting system that promotes the growth of mustard greens. The sessions are structured to ensure participants understand every step of the process, from the initial setup to the ongoing care and management of the plants.

One of the key aspects of the training involves showing participants how to create the planting medium using materials that are often discarded. By utilizing pipes and bottles, the training introduces a cost-effective and eco-friendly approach to urban farming, which can be particularly beneficial for individuals who may have limited space or resources. The use of these recycled materials not only reduces waste but also provides a way for participants to create functional gardening systems at a fraction of the cost of traditional methods.

The first step in the training is dedicated to demonstrating how to create the planting medium from used pipes and plastic bottles. Participants are taught how to prepare these materials to ensure they are suitable for planting. This step is critical because the planting medium needs to provide adequate support for plant roots, allow for proper drainage, and retain enough moisture for healthy plant growth. The use of pipes and bottles in this context serves as an innovative way to utilize materials that are commonly discarded, offering both environmental and economic benefits.

Once the planting medium is prepared, the next focus is on the actual planting process. Participants are shown how to plant mustard greens, a suitable crop for this kind of system. Mustard greens are an ideal choice because they are hardy, grow relatively quickly, and can thrive in small spaces. The training emphasizes the importance of proper planting techniques to ensure that the mustard greens have the best chance of success. These techniques include spacing the plants correctly, ensuring the roots have adequate space to grow, and providing the right amount of soil to support the plants' needs.

In addition to the planting process, the training also covers the essential maintenance techniques that participants will need to follow to ensure their crops grow healthily. Maintenance includes regular watering, monitoring plant health, and providing nutrients. Since the system relies on limited resources such as the water stored in the pipes and the nutrients from the soil in the bottles, participants are taught how to carefully manage these resources. The goal is to minimize waste and make the system as efficient as possible. This aspect of the training is especially important in urban environments, where water and space are often limited, and it teaches participants how to be resourceful in their gardening practices.

As part of the training, participants are also taught how to evaluate the growth of the mustard greens. Regular evaluation allows individuals to track the plants' progress and determine if any adjustments need to be made in terms of watering, nutrient levels, or general care. Monitoring the plants helps ensure that they are growing at an optimal rate and receiving the proper care throughout their development. This evaluation process also teaches participants to observe plant health closely and respond to any issues, such as disease or pest infestations, before they become serious problems.

The final aspect of the training focuses on monitoring the use of water and nutrients within the planting system. Since the system relies on a closed-loop design, where water and nutrients are recycled, it's important to ensure that these resources are used efficiently. Participants are taught how to track water usage, monitor nutrient levels, and make necessary adjustments. This aspect of the training helps participants understand the principles of sustainable gardening, where the goal is to create systems that minimize environmental impact while maximizing the use of available resources.

To reinforce learning, the training is conducted in a group setting, allowing participants to work together and practice the techniques they are being taught. Group activities foster collaboration, enabling participants to share ideas, ask questions, and learn from each other's experiences. Working in groups also allows participants to see the practical application of the techniques in different contexts and with varying materials. This collaborative environment ensures that everyone is engaged and has the opportunity to practice the skills being taught, leading to a deeper understanding of the process.

Furthermore, the group-based approach allows participants to receive feedback from both the instructor and their peers. This feedback is valuable because it provides different perspectives on how the techniques can be improved or adapted to suit individual needs. By practicing the techniques in real-time, participants can refine their skills, troubleshoot any challenges they may face, and become more confident in their ability to apply the knowledge gained.

This hands-on approach is essential for building the participants' confidence and competence in using the planting system. It helps ensure that they are not only aware of the theory behind urban gardening with recycled materials but also capable of implementing it in their own environments. The training empowers participants to take control of their food production, even in limited spaces, and provides them with the knowledge to make the most of their available resources.

In addition to the technical skills gained, the training also promotes a sense of community among participants. Working together on a shared goal fosters a sense of collaboration and connection, and the shared experience of learning and practicing new techniques creates a strong support network. This sense of community can be a powerful motivator, as participants can continue to learn from each other and share their progress even after the training is over.

By the end of the training, participants are expected to have a comprehensive understanding of how to create and maintain a sustainable planting system using recycled pipes and bottles. They will have learned how to prepare the planting medium, plant and care for mustard greens, evaluate plant growth, and monitor water and nutrient usage. Most importantly, they will have had the opportunity to directly apply the techniques in a supportive group setting, allowing them to build confidence and gain hands-on experience.

The training offers more than just technical knowledge, it also provides participants with the skills and confidence to become more self-sufficient in urban gardening. By focusing on sustainable practices and the use of recycled materials, the training also contributes to a greater awareness of environmental issues and encourages participants to adopt more sustainable lifestyles. This combination of practical skills, environmental awareness, and community-building makes the training a valuable experience for anyone interested in urban farming and sustainable food production.

#### 1. **Preparation Stage:**

- a. **Observation and Needs Assessment:** The community service team conducted an initial survey to assess local conditions and understand the specific needs of the residents regarding urban agriculture. This involved discussions with community members and stakeholders to identify challenges related to space constraints and plastic waste management.
- b. **Material Selection:** The team determined the materials necessary for the project, which included recycled plastic bottles, pipes, soil, and fertilizers. These materials were selected based on their availability locally and their suitability for creating effective planting systems.
- c. **Concept Development:** A detailed plan was developed outlining methods to optimize planting media using pipes, soil, and used plastic bottles, ensuring that the approach was tailored to the community's needs.

#### 2. **Implementation Stage:**

- a. **Training Workshops:** Hands-on training sessions were organized where participants learned how to construct and maintain the planting systems using the selected recycled materials. These

- workshops emphasized practical skills, such as preparing the planting medium, planting mustard greens, and caring for the plants.
- b. **Community Involvement:** Local residents were actively involved throughout the process, fostering a sense of ownership and collaboration. Participants included not only community members but also local officials, which added credibility to the initiative.
  - c. **Real-Time Feedback and Adaptation:** During the training, participants received immediate feedback from instructors and peers, allowing them to refine their techniques and adapt the methods to suit their particular circumstances.
3. **Data Collection and Monitoring:**
- a. **Pre- and Post-Program Surveys:** Surveys were conducted before and after the training to assess the level of community interest in urban farming practices and to measure changes in participation rates and agricultural output.
  - b. **Yield Measurements:** Throughout the cultivation period, data on mustard greens yield was collected to evaluate the effectiveness of the implemented planting systems.
  - c. **Reporting and Evaluation:**
  - d. **Documentation:** The entire process, including participant engagement, training outcomes, and agricultural results, was documented to provide a comprehensive account of the program's impact.
  - e. **Community Feedback:** Follow-up discussions with participants helped gather insights on their experiences and suggestions for future improvements.

#### IV. RESULT AND DISCUSSION

The results of mustard greens cultivation activities using the pipe, soil, and used bottle integration method carried out on February 11, 2025 by community service participants in Peguyangan Village. This activity aims to increase public awareness of the importance of utilizing plastic waste as a planting medium, while introducing more environmentally friendly urban farming methods. In this activity, community service participants together with the community and the Village Head, Head of the Environment conducted training and direct practice in creating a simple planting system using used plastic bottles and pipes as a mustard greens planting medium. This method aims to optimize narrow land in urban areas and reduce the negative impact of plastic waste on the environment. With this program, it is hoped that the community will be more aware of the importance of innovation in urban agriculture and the benefits of reusing plastic waste. In addition, this method also has the potential to increase crop yields more efficiently, considering that the planting medium used can maintain soil moisture better and reduce water needs (Rahmawati et al., 2020). The sustainability of urban agriculture does not only depend on technology, but also on public awareness in implementing a more environmentally friendly lifestyle.



Figure 2. Planting Plants with Urban Farming Method

This joint planting activity took place with enthusiasm at Uma Palak Lestari, Peguyangan Village, attended by the Village Head, Babinsa, Head of the Environment, local residents, and Community Service participants. The event began with a brief briefing on the importance of urban farming based on plastic waste as an innovative solution in utilizing limited land. After that, the participants together with the residents began planting mustard greens using used pipes as horizontal planting media and used plastic bottles as planting containers, which had been prepared beforehand. The Village Head and Babinsa participated in the planting process, motivating residents to apply this method independently. During the activity, Community Service participants also explained plant care techniques, including watering patterns and proper nutrition.

The active participation of all elements of society in this activity reflects great support for the development of sustainable agriculture and the reduction of plastic waste in urban environments.



Figure 3. Brief briefing on the importance of urban farming based on plastic waste as an innovative solution in utilizing limited land by Ms. Putu Putri Prawitasari from Universitas Pendidikan Nasional



Figure 3. Activity Participants

Once all activities were completed, a group photo session was organized to document and commemorate the success of the program. The photo included the Village Head, Babinsa, Head of the Environment, local residents, and community service participants who had been involved in the event. This moment symbolized the collaboration between students and the community in advancing urban agriculture through the use of plastic waste. The residents appeared enthusiastic and proud of their achievements, while the community service participants were pleased to have shared their knowledge and experiences. The group photo also serves as a source of inspiration, encouraging the community to continue adopting and expanding sustainable farming practices in urban settings.

Before the community service program, the involvement of residents in the plastic waste-based agricultural initiative in Peguyangan Village was minimal, with only about 30% of residents showing interest in this concept. However, after the program's training and hands-on practice, participation surged to 85%, showcasing the success of the educational efforts and the effective implementation of new farming methods. Previously, plastic waste in the village was typically discarded or poorly managed, contributing to growing environmental problems. Since the program, the community has embraced the use of recycled plastic bottles and pipes as planting media, significantly reducing waste and mitigating its environmental impact.

Table 1. Table summarizes the comparisons between the current study and previous community initiatives regarding urban agriculture practices.

Aspect	This Study	Previous Initiatives
<b>Participation Level</b>	Increased from 30% to 85% after training and hands-on practice.	Participation rates averaged 20% to 50% without sufficient training strategies.
<b>Awareness of Plastic Waste</b>	Successfully raised community awareness about plastic waste management.	Focused more on theoretical knowledge, leading to a lack of practical application understanding.
<b>Agricultural Outcomes</b>	Significant increase in mustard greens yield with improved water efficiency.	Relied on traditional methods, resulting in stagnated yields and production challenges.
<b>Practical Skills</b>	Participants trained to build and maintain	Practical skills taught were general and less

Aspect	This Study	Previous Initiatives
	systems using plastic waste.	relevant to urban farming challenges.
<b>Community Support</b>	Active collaboration among students, residents, and officials to ensure sustainability.	Limited involvement of local officials, reducing program effectiveness and ongoing support.

Prior to the program, the area's agricultural practices were based on traditional methods, which were hindered by limited space and a lack of innovation. However, after implementing the plastic waste-based planting system, the community has experienced improved mustard greens harvests, with the new planting medium demonstrating greater efficiency in retaining soil moisture and reducing water usage. This shift not only enhanced crop yields but also promoted a more sustainable farming approach, representing a significant positive change in both the village's agricultural practices and environmental awareness.

This activity was held in Peguyangan Village, Denpasar City, Bali, specifically at Uma Palak Lestari, an urban farming community focused on cultivating plants in small spaces. Peguyangan is a rapidly developing area with predominantly residential zones, making limited land a significant challenge for agriculture. Uma Palak Lestari was selected as the activity's location due to the community's efforts to implement sustainable farming practices by utilizing small plots of land and plastic waste as planting media. The activity also involved local government officials, including the Village Head, Head of the Environment, and community members, to ensure the program's long-term viability and to raise awareness about environmentally sustainable farming practices.

## V. CONCLUSION

The conclusion of the community service program focused on urban agriculture using pipe, soil, and recycled bottle-based systems indicates that this initiative successfully improved economic efficiency and sustainability of agricultural practices in urban environments. The data and analyses obtained during the activities support the following claims:

1. **Enhanced Knowledge and Skills:** Through hands-on training, participants gained a better understanding of how to build and maintain agricultural systems utilizing recycled materials such as plastic bottles and pipes. Evaluation results showed a significant increase in participants' confidence in managing urban farming.
2. **Increased Community Participation:** The active involvement of residents from Peguyangan Village in Bali, along with students and local officials, demonstrated effective collaboration in this program. With higher participation levels, there was an increase in awareness about the importance of sustainable agriculture and the reduction of plastic waste in their environment.
3. **Adoption of Sustainable Farming Practices:** Results from the activities indicated that the local community has embraced more environmentally friendly farming methods, which not only reduced the negative impact of plastic waste but also improved vegetable yields, particularly mustard greens.
4. **Model for Efficient Urban Agriculture:** This initiative not only provided practical skills to participants but also created a learning model that can be applied in other urban areas facing similar challenges. The use of recycled materials in agriculture proved effective in maximizing space and resources while reducing water consumption.

Looking ahead, expanding the variety of crops grown using these systems would offer more learning opportunities for participants and optimize small urban spaces even further. Incorporating advanced water management systems, such as drip irrigation or self-watering setups, could enhance water efficiency. Workshops on composting and sustainable fertilizers would also help participants improve soil health and reduce waste. Additionally, involving local schools, establishing seed exchanges, and hosting a harvest day could strengthen community engagement and create economic opportunities. Furthermore, establishing partnerships for food waste collection and implementing a monitoring system would support continuous improvement, while introducing recognition programs would further motivate individuals to engage in and grow urban farming initiatives.

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