Smart Waste Planning As An Effort To Utilize Plastic Waste Through The Making Of Paving Blocks By The Community In Pisugi District

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Abstract

Plastic waste management remains a critical environmental challenge in Indonesia, particularly in remote areas like Pisugi District, Jayawijaya Regency, Mountains Papua. High plastic consumption combined with limited waste infrastructure leads to significant environmental and public health risks. This community service project applies the Smart Waste Planning concept to empower local residents by transforming plastic waste into paving blocks, a sustainable and economically valuable product. Conducted through a participatory and educational approach, the program involved field observation, socialization, hands-on technical training, mentoring, evaluation, and sustainability planning. The two-day training successfully enhanced public awareness, technical skills, and cooperation among 16 participants from district leadership and community representatives. Challenges such as limited equipment and material variation were addressed through collaborative problem-solving. The paving blocks produced demonstrate promising structural quality for light infrastructure use, opening new economic opportunities and reinforcing local environmental stewardship. Support and involvement from district government strengthened program legitimacy and sustainability prospects. This initiative integrates environmental preservation, social empowerment, and economic development, aligning with sustainable development and circular economy principles. The Smart Waste Planning model serves not only as a technical solution but as a comprehensive community empowerment strategy toward a stronger and self-reliant local society.

Keywords: *Smart Waste Planning; Plastic Waste Management; Paving Blocks; Community Empowerment and Sustainable Development.*

I. INTRODUCTION

Plastic waste has become one of the most pressing environmental problems in Indonesia. The high level of plastic consumption is not balanced by an adequate waste management system, resulting in a significant environmental burden. Based on data from the Ministry of Environment and Forestry (KLHK), Indonesia produces around 9.85 billion pieces of plastic bag waste each year. This figure shows the large volume of plastic waste that has the potential to pollute the environment if not managed properly. [7] Plastic is a synthetic material that has high resistance to natural degradation processes. It takes between 20 and 500 years for plastic to completely decompose in the environment. This resistance makes plastic waste a long-term threat to the ecosystem, especially if it is not recycled or reused creatively and productively. The accumulation of unmanaged plastic waste not only pollutes the soil, water, and air, but also reduces the aesthetic quality of the environment, disrupts the comfort of people's lives, and risks causing various diseases due to contamination with hazardous substances. [4]In addition to the ecological impact, the problem of plastic waste is also closely related to social and economic aspects. In many areas, including remote and rural areas, the lack of public awareness of the dangers of plastic waste and limited waste management facilities have caused the volume of waste to continue to increase.

The lack of education and sustainable waste management infrastructure has meant that people have not been able to process plastic waste into more useful products. Therefore, an innovative approach such as the smart waste planning concept is needed to overcome this problem, namely by utilizing plastic waste as an alternative raw material in the construction of light infrastructure, such as paving blocks, which are not only environmentally friendly, but also have economic value and can empower local communities. [1] [8] Pisugi District, located in Jayawijaya Regency, Papua Pegunungan Province, faces similar challenges in terms of waste management, especially plastic waste. Although administratively this area is the location of the

Jayawijaya Regency Final Disposal Site (TPA), in reality waste management at the district level is still not optimal. Remote geographical conditions, coupled with limited infrastructure and lack of public awareness in sorting and processing waste, have led to the accumulation of plastic waste that has not been handled properly.This accumulation has a negative impact on various aspects of life, especially environmental quality and public health. Plastic waste scattered in residential areas and public facilities not only pollutes the soil and waterways, but also reduces the comfort and aesthetics of the environment. In the long term, this condition has the potential to cause various environmental-based diseases and worsen the quality of life of the community. In fact, the presence of the TPA in Pisugi District should be a strategic opportunity to improve the waste management system in the area in a more structured and sustainable manner.

[7] [8] [9] By utilizing the potential of existing landfills and encouraging innovation in plastic waste processing, such as utilizing used plastic as raw material for paving blocks, this problem can not only be solved, but can also create new economic opportunities for the local community. [16] This is in line with the principle of sustainable development which emphasizes the balance between environmental, social, and economic aspects. This innovation not only provides a solution to the waste problem, but also opens up opportunities for economic empowerment for the local community. The management of plastic waste into paving blocks has proven effective in reducing waste volume and providing additional economic value. [2] [3] [4] [5] For example, in Sukaraja Village, the activity of managing plastic waste into paving blocks has succeeded in increasing the income of underprivileged communities. The process of making paving blocks from plastic waste involves several stages, starting from collection, washing, melting, to molding. The resulting paving block products have good strength and can be used for local infrastructure development. [21] In addition, in Kota Agung Village, Pesawaran Regency, similar activities have also been carried out with positive results. The local community received training on the process of making paving blocks from plastic waste, which not only reduces the volume of waste but also creates new business opportunities. [1] [8] The concept of Smart Waste Planning or smart waste management planning is present as a holistic approach in dealing with waste problems based on local potential and needs.

By actively involving the community in the process of collecting, sorting, and producing paving blocks from plastic waste, this program is expected to increase environmental awareness, technical skills, and economic independence of Pisugi residents. [8] [17]Through this community service activity, it is hoped that Pisugi District can become an example of the application of the concept of effective, efficient, and inclusive waste management. This program not only aims to reduce the negative impact of plastic waste on the environment, but also to empower the community in creating useful products that can improve their welfare. [8] [17]This community service activity is based on a participatory approach and community empowerment, which emphasizes the importance of active community involvement in identifying problems, designing solutions, and carrying out activities collectively. Empowerment theory states that communities will be able to develop their capacity if given space to learn, participate, and manage local potential independently. In this context, the utilization of plastic waste through the production of paving blocks becomes a means of education as well as real action to increase community efficiency in managing waste and creating products of economic value. [8] [12]In addition, this activity also refers to the theory of sustainable development (sustainable development theory) which includes three main aspects: environmental, social, and economic

By converting plastic waste into alternative construction materials, this program contributes to environmental preservation (because it reduces waste accumulation), strengthens social aspects (through community cooperation and training), and improves economic aspects (because production results have sales value). This approach is in line with the concept of a circular economy that prioritizes the principle of reuse and waste reduction as an effort to maintain the sustainability of natural resources. [3] 17] [20] By combining the principles of empowerment theory and sustainable development, Smart Waste Planning is not only a technical solution to environmental problems, but also a social strategy to strengthen community participation in regional development based on local potential.

II. METHODS

The method used in this community service activity is a participatory and educational approach that actively involves the community in all stages of the activity. This method was chosen to encourage community empowerment and create sustainable long-term impacts. [17] [23] The implementation of the activity is carried out in several stages as follows:

1. Field Observation and Problem Identification. The initial stage began with a survey and direct observation to Pisugi District to identify the condition of plastic waste management, human resource potential, and local infrastructure readiness. The community service team also conducted informal interviews with community leaders and local residents to understand the needs and challenges that exist.
2. Socialization and Education. After the identification stage, socialization activities were carried out to the community regarding the dangers of plastic waste, the importance of sustainable waste management, and the potential for utilizing plastic waste into paving blocks. The material was delivered in the form of group discussions, interactive lectures, and simple simulations.
3. Paving Block Making Training. The community is directly involved in technical training on making paving blocks from plastic waste. The training includes the following stages:
   a) Collection and sorting of plastic waste
   b) Cleaning and shredding
   c) Melting plastic using simple tools
   d) Printing paving blocks using molds
   e) Cooling and testing the strength of the resulting product

   (The entire process is carried out practically and simply so that it can be easily replicated by the community independently). [8] [14]
4. Mentoring and Evaluation. After the training, the community service team provided assistance in the trial of paving block production by the community. This process was complemented by a participatory evaluation to determine the extent to which understanding and skills had been mastered. The evaluation also included identification of obstacles, tool needs, and local market opportunities for paving block products.
5. Monitoring and Sustainability Plan. This activity is closed with the preparation of a sustainability plan with the community and village government. This plan includes the formation of working groups, collective production management, and partnership opportunities with related agencies to support product marketing.

This method is expected to not only solve technical problems of waste management, but also increase community capacity, form collective awareness, and strengthen local economic resilience based on the environment. [18]

III. RESULTS AND DISCUSSION

Community service activities that carry the Smart Waste Planning concept in Pisugi District have shown encouraging results in efforts to manage plastic waste productively and sustainably. The implementation of the activity for two days on April 14-15, 2025 successfully involved 16 participants, consisting of district heads and community representatives. The participants showed enthusiasm and active participation during the series of activities, starting from the socialization session to direct practice of making paving blocks from plastic waste.

1. Increasing Public Awareness and Knowledge

Through intensive socialization and education activities, participants gain a more comprehensive and in-depth understanding of the various negative impacts of plastic waste, not only from an environmental perspective but also from a public health perspective. The material presented systematically explains how the accumulation of plastic waste can pollute soil, water, and air, and contribute to various diseases due to exposure to hazardous chemicals contained in plastic. This understanding is an important starting point in building public awareness of the urgency of better and more structured waste management.The interactive discussion session

provides an open space for participants to share experiences, ask questions, and express opinions regarding the condition of waste management in their area.

This approach not only creates an inclusive and participatory learning atmosphere, but also encourages the formation of collective awareness that waste management is not solely the responsibility of the government, but requires the active involvement of all elements of society.The presentation of materials that have been adapted to the local context of Pisugi District, both in terms of language, culture, as well as the geographical and socio-economic conditions of the community, has proven effective in bridging the information gap that has been an obstacle to environmental education. The delivery of information with relevant real examples makes it easier for the community to understand and accept the message being conveyed. As a result, there has been an increase in concern for environmental issues, as indicated by the emergence of a commitment from several participants to start sorting waste in their respective households, as well as an interest in developing independent recycling efforts. [22]

Fig 1. Socialization of Material

Thus, this socialization and education activity not only succeeded in transferring knowledge, but also became a trigger for changes in community attitudes and behavior towards the environment. This initial step is very important in building a foundation towards independent, sustainable waste management, and based on active community participation. [19]

2. Strengthening Technical Capacity through Training

Technical training in making paving blocks from plastic waste is one of the core activities that provides direct and meaningful experience for the community. Through a direct practice approach (learning by doing), this training aims to equip participants with applicable technical skills in processing plastic waste into products that have utility and sales value. The training process is structured in stages and systematically so that it is easy to understand, even for participants who do not have a technical background or previous experience in the field of waste processing.All participants showed high enthusiasm and involvement throughout the training process.

They actively participated in each stage, starting from collecting and sorting plastic waste according to type and color, washing to remove dirt and hazardous substances, shredding into small pieces, melting plastic using simple heat-based equipment, to printing paving blocks using manual molds prepared by the service team. In addition, participants were also introduced to product cooling and drying techniques, as well as simple methods for testing the basic strength of the mold results.The results of the practice showed that the majority of participants were able to understand and apply the basic techniques taught quite well. In fact, several participants succeeded in producing paving blocks that not only had precise shapes, but also showed sufficient strength and compactness of the material for light use such as paths or yards. This proves that with the right training and an approach that is appropriate to the local context, communities are able to process waste independently and productively.

Fig 2. Training Activities

Furthermore, this training activity also serves as a vehicle to build a spirit of cooperation among participants, encouraging them to help each other and share roles in every stage of the production process. Training is not only a place for technical learning, but also a medium to foster a sense of responsibility, independence, and concern for the environment. This capacity building is an important provision for the community in developing small businesses based on waste management, while strengthening the resilience of the local economy with an environmental perspective. [10] [23]

3. Challenges and Learning in the Production Process

During the technical training process for making paving blocks from plastic waste, a number of technical and operational obstacles emerged as part of the natural field dynamics in practice-based activities. One of the main challenges faced was the limited plastic melting tools. The available tools were still simple and had limited capacity, thus slowing down the production process and reducing training efficiency. [12] In addition, variations in the quality of plastic waste collected from the surrounding environment were also an obstacle. Different types of plastic waste such as HDPE, LDPE, and PP have different melting points and physical characteristics, thus requiring special adjustments in the melting process. [1] [6] Another problem arose in terms of consistent melting temperature control. [11] Several participants had difficulty maintaining the ideal temperature, especially since the heater used was not equipped with an automatic temperature regulator. This caused some paving block molds to initially have deformed shapes or not reach the optimal density level. [13] However, these obstacles were actually an important part of the learning process, where participants were invited to understand firsthand the technical challenges that they would likely face if they applied this technology independently in the future.Interestingly, all the obstacles encountered during the training were successfully overcome through a collaborative and participatory approach between the facilitator and participants.

This approach allows for a two-way learning process, where participants are not only recipients of the material, but also play an active role in formulating solutions to the problems faced. For example, when the melting tool could not function optimally, participants took the initiative to try to make simple modifications based on their local experiences and ideas. Meanwhile, the facilitator provided technical direction and recommendations that allowed the tool to continue to function according to training needs. [15]

The post-training evaluative discussion was a very useful forum for identifying root causes and formulating future improvement steps. Several important points that were agreed upon included the need to provide more efficient and durable plastic melting equipment, as well as the importance of ongoing education regarding the household waste sorting process. [5] With a sorting system in place from the start, the quality of raw materials can be more assured and the paving block production process can run more smoothly and consistently. This discussion also resulted in an agreement to form a community working group responsible for the periodic collection and management of plastic waste. [17]Thus, although the training faced various challenges, this

process actually strengthened the adaptive capacity and spirit of mutual cooperation of the community in dealing with environmental problems. This is a very important social capital for the sustainability of the Smart Waste Planning program in Pisugi District.

4. Economic Potential and Program Sustainability

Paving block products produced from plastic waste show promising potential to be developed as an alternative lightweight construction material in the surrounding environment. In field trials, paving blocks produced by the community have proven to have a structure that is strong and stable enough to be applied to areas with light to medium loads, such as footpaths in residential areas, yards, community parks, and other public areas. The use of this material not only contributes to reducing the volume of plastic waste, but also provides an innovative solution to the need for affordable and environmentally friendly local infrastructure.
In addition to the technical and environmental benefits, the success of paving block production opens up new economic opportunities for the community. With relatively low production costs and abundant raw material availability—because it comes from plastic waste that has not been utilized so far—the paving block processing business becomes a sustainable, environmentally based economic activity. The community not only gains new skills, but also has the opportunity to create local jobs, increase household income, and strengthen economic independence based on regional potential.

[17] As a follow-up to the training and participatory discussions conducted during the activity, all participants together with representatives of the district government agreed to form a community working group. This group will act as the main manager in the paving block production process, starting from the collection of raw materials, technical processing, to product marketing strategies. The formation of this group is based on the spirit of collaboration and commitment to maintaining the continuity of the program, as well as an effort to strengthen community institutions in circular economy-based waste management. [18]The plan to form this working group is also accompanied by an agreement on a collective work system, task division mechanism, and utilization of production results. In addition, identification of supporting needs such as advanced training, provision of more efficient production tools, and development of partnership networks with government and private institutions that are concerned with environmental issues and community empowerment is also carried out. With this approach, it is hoped that the Smart Waste Planning program will not only be a momentary activity, but will be able to grow into an independent local movement that has a broad impact on environmental sustainability and community welfare in the Pisugi District.

5. Collaboration between Government and Community as a Key Factor

The presence of the district head in all of these activities is an important symbol of real synergy between the government and the community in an effort to overcome environmental problems collaboratively. The direct involvement of the district government not only strengthens the legitimacy of the program, but also shows the existence of local political commitment to encourage innovative and sustainable community-based initiatives. [7] In various discussion sessions, the district head also provided direction, listened to the aspirations of the participants, and expressed support for the plan to form a community working group as a follow-up to the training that had been carried out.Support from the district government is expected not to stop at the symbolic aspect alone, but also to continue in the form of concrete facilitation. This includes the provision of more adequate and efficient production tools, the implementation of regular advanced training to improve the technical skills of the community, and the opening of local and regional market access for plastic waste-based paving block products. With ongoing support from the government, the production capacity of community working groups can be increased gradually, while expanding the impact of the program to surrounding areas.Moreover, the presence and support of the district government are key elements in creating inclusive and participatory waste management governance.

Cross-sector collaboration between communities, government, academics, and other stakeholders will strengthen the framework that allows programs such as Smart Waste Planning to develop systematically and in the long term. This synergy also allows for the integration of environmental policies at the local level with community empowerment practices, thus creating solutions that are not only technically effective, but also socially just and contextual according to local needs.Thus, the involvement of district heads and other government institutions is expected to be a driving force that encourages the growth of similar initiatives in

other regions, as well as being an example in realizing development that is based on collaboration and oriented towards sustainability.Overall, this activity proves that the Smart Waste Planning approach is a strategy that is not only effective in solving technical problems of waste management, but also very relevant as a comprehensive community empowerment medium. This program shows that environmental problems, especially plastic waste, can be handled holistically by involving existing local elements in terms of human resources, institutions, and available socio-economic potential. The participatory approach applied in each stage of the activity has succeeded in encouraging active community involvement and creating a sense of ownership of the resulting solutions.

Through a series of activities including socialization, education, technical training, to evaluation and sustainability planning, the Pisugi District community is now not only more aware of the importance of waste management, but also has the knowledge and practical skills to process plastic waste into useful products. The results of the training show that with the right method and delivery that is in accordance with the local context, the community is able to absorb information and apply it directly in everyday life. The collective spirit that grows from this activity also becomes important social capital to maintain the continuity of the program in the future.Moreover, this initiative has succeeded in sparking a new spirit in the local community to see waste no longer as an environmental burden, but as a resource that can be utilized productively and economically. With the plan to form a working group and the commitment of the district government, an initial foundation has been created for the formation of a sustainable and community-based waste management system. [18] This effort also strengthens the social structure of the community through cooperation, mutual assistance, and sharing of knowledge.This program clearly reflects the principles of sustainable development, because it is able to integrate environmental aspects (through reducing plastic waste), social aspects (through empowerment and increasing community awareness), and economic aspects (through the creation of products with sales value and new business opportunities).

[17] In addition, the approach applied is also in line with the concept of a circular economy that emphasizes the importance of reusing resources, material efficiency, and creating a production system with minimal waste. [3] [20] In other words, Smart Waste Planning has succeeded in becoming a model for a local empowerment strategy that not only solves technical problems, but also builds a stronger and more independent social and economic foundation for the community.

IV. CONCLUSION

In conclusion, the Smart Waste Planning activity in Pisugi District has successfully proven the effectiveness of a participatory approach in managing plastic waste through the production of paving blocks. This program not only solves technical problems of waste processing, but also empowers the community by increasing their knowledge, skills, and environmental awareness. Synergistic support between the community and the district government is a key factor in ensuring the sustainability and development of this environmental-based business. By integrating environmental, social, and economic aspects, this initiative is in line with the principles of sustainable development and circular economy, thus opening up opportunities for improving community welfare while maintaining environmental sustainability in the area.

V. RECOMMENDATIONS

To support the sustainability of the Smart Waste Planning program in Pisugi District, it is recommended that the district government and related parties provide more adequate and efficient production facilities and equipment, especially plastic melting tools, so that the paving block manufacturing process can run more optimally. Regular follow-up training also needs to be carried out to improve the technical skills of the community while expanding their understanding of waste management and environmentally friendly product innovation. In addition, the development of a waste sorting system from the household level must continue to be encouraged through education and socialization so that the quality of raw materials can be maintained properly. Strengthening and mentoring community working groups that manage production collectively is important so that they are able to carry out these activities independently and sustainably, including in managing aspects of product marketing. To expand the reach of the business, efforts need to be

made to open access to local and regional markets and establish partnerships with various parties, both from the government and the private sector. Routine monitoring and evaluation are also highly recommended to ensure that the program remains effective and relevant to the needs of the community. Finally, the success of this program should be used as a model that can be replicated in other areas with adjustments to the local context, so that the positive impact of community-based waste management can expand significantly.

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