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Gazebo Semar: An Android-based Farmer Education Platform for Agricultural Waste Management

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ABSTRACT

Agricultural waste and lack of knowledge about agricultural waste management is an environmental problem in Karanganyar Regency. Farmers in Karanganyar only handle agricultural waste, such as rice straws, husks, and corn stalks by burning them. Therefore, this study attempts to create innovation by educating farmers on properly treating agricultural waste. This study implemented mix method, namely application development and application evaluation by conducting survey. The Gazebo Semar application is built using a Kodular service begins with concept planning, interface design, features, and coding. Application evaluation were collected from a survey using a questionnaire of 120 farmers in Karanganyar Regency to evaluate the usability testing using USE (Usefulness, Satisfaction, and Ease to use) questionnaires and use the Likert scale for measurement. Gazebo Semar is a solution to provide information on agricultural waste types, waste management, and marketing of processed agricultural waste products. This application allows the users to easily access information about agricultural waste and Zero Waste without visiting multiple websites or blogs. The Gazebo Semar App has nine main features: Home Screen, Zero Waste, SDGs, Waste Source, Waste Classification, Waste Management, Gazebo Semar Store, Quiz, and About Us. Gazebo Semar provides a number of novelties in terms of substance and features, so that it is expected to have an impact on local farmers especially in the field of agricultural waste processing. The results show that the score of Usefulness, Satisfaction, and Ease of Use is above 71%, which means Gazebo Semar has provided the application that fits with the needs of farmers. The research contribution is to improve the mindset of farmers in processing agricultural waste into other forms that are more economically valuable. The significance of this study is to increase public knowledge about agricultural waste, zero waste, and waste management.

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1. INTRODUCTION

Agriculture is Indonesia's most important source of livelihood; agricultural land can be found in almost every area. Agricultural waste is a problem caused by a large amount of agricultural land. In 2025, researchers estimate that the global population will exceed 10 billion, further expanding the scale of the food supply, thus leading to a continuous increase in agricultural waste production [1]-[2]. Agricultural waste is a by-product of the agricultural production process that comes from plantations, cattle, fisheries, and other agricultural industries. Rice straw, horticultural crop straw, husks, rotten fruit and vegetables, and livestock dung are some of the agricultural waste. If processed properly and correctly, agricultural waste offers important benefits.

Farmers play an important role in waste management [3]. Farmers' knowledge, on the other hand, still needs to be improved in the waste of agricultural waste. Usually, farmers dispose of agricultural waste, especially straw and plastic packaging, by burning it, which creates new issues in the form of pollution, specifically air pollution [4].

The massive volume of agricultural waste and farmers' lack of understanding of how to transform the waste into valuable items lead to this burning of agricultural waste. Global agricultural waste production exceeds 220 billion tons annually [5]. According to Ministry of Agriculture data from 2015, the quantity of rice straw was 106,063,000 tons, corn straw was 35,899,000 tons, and cassava waste was 17,633,000 tons, demonstrating the vast amount of agricultural waste produced by food crop farming. Agricultural waste is available very much and has not been managed properly, so it is referred to as waste. According to research, 60% of farmers were unaware that burning rice straw meant releasing away organic fertilizer ingredients [6]. Indonesia ranks 5th as a country with CO_2 emissions from burning agricultural waste. Top ten CO_2 equivalent emitting countries by burning crops residues (agricultural waste) during 2010–2017 show in Fig. 1.

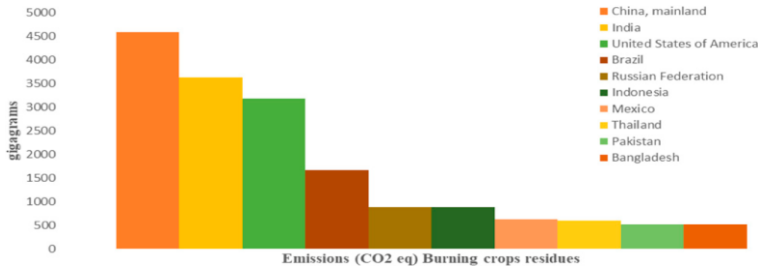


Fig. 1. Top ten CO_2 equivalent emitting countries by burning crops residues (agricultural waste) during 2010–2017 [7]

The challenge for agricultural waste management is the low quality of social knowledge due to the recycling process of agricultural waste [8]. People think agricultural waste management is less important than chemical and plastic waste management. Meanwhile, many agricultural activities have potential to produce waste such as crop residue, livestock waste, agro-industrial waste, and aquaculture waste [9]. Many people in the world still process agricultural waste by burning it (disposal), especially in several waste producing countries such as China [10], Taiwan [11], Bangladesh [12], and Indonesia [13]. Even though agricultural waste can have a negative externality impact if no preventive measures are taken for the community [14]. Public education is needed to increase awareness regarding agricultural waste [15], so that waste disposal can be suppressed and produce processed waste products that are environmentally friendly. For a long-term step, Indonesia requires recommendations on agricultural waste management and the adoption of healthy planetary diets to enable agriculture's smooth transition to a sustainable enterprise [16]. The waste hierarchy show in Fig. 2.

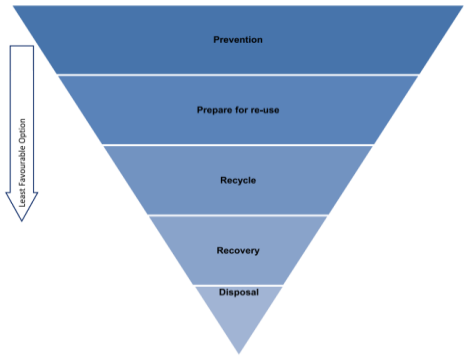


Fig. 2. The Waste Hierarchy [17]

This section presents previous work related to our manuscript. Many great platforms have been proposed in the field of waste management platform. In a later work [18] the author developed a waste management system using deep learning with IoT. In their work, they can only detect five categories of indigestible waste, so it cannot be implemented in agricultural waste processing. In a study paper [19] the author proposed a waste classification model to identify the types of waste using neural network models. The system can classify

organic and recyclable waste types. This research only classifies organic waste without providing educational material about the processing of organic waste. In another research [20], the solid waste application has a different system. In their program, to access the content, it is needed to create an account and log in to access the application. In previous research [21], the author used the programming language java SE to develop the software program by integrating the flowchart, mathematical model and user interface.

The research contribution is to improve the mindset of farmers in processing agricultural waste into other forms that are more economically valuable. This is the first study to develop a zero waste mindset for farmers and achieve a healthy and clean environment. Another contribution of this research is to support the implementation of the Sustainable Development Goals (SDGs). This study achieves sustainable development goals aim of (4) Quality Education, (7) Affordable and Clean Energy, (12) Responsible Consumption and Production, (13) Climate Action, and (15) Life on Land. SDGs will be implemented at the village level. Attaining sustainable development goals can improve the quality of the environment for the better over time [22]. The implication of this research can maintain the quality of the agricultural environment so that it can be used in the future.

The significance of this study is to increase public knowledge about agricultural waste, zero waste, and waste management. Raising public knowledge concerning waste can be done with educational interaction between educators (academics) and actors (farmers) [23]. Gazebo Semar application users can access all the features of the Semar Gazebo application to read all the articles described. Gazebo Semar users can also check their abilities by accessing the quiz feature. The Gazebo Semar application can increase knowledge about waste and the Zero Waste movement. With increasing public knowledge, it is hoped that it can be applied in the future.

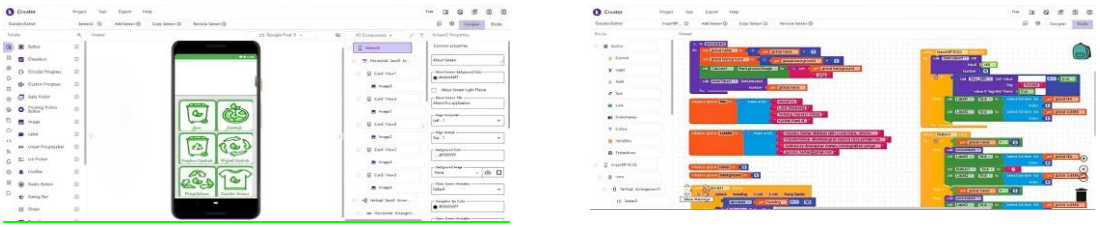
Gazebo Semar is a solution to provide information on agricultural waste types, waste management, and marketing of processed agricultural waste products. The Gazebo Semar application includes several features of various types of agricultural waste, waste sorting, and the Zero Waste movement all in one application. This application allows the general public, especially farmers, to easily access information about agricultural waste and Zero Waste without having to visit multiple websites or blogs. It is hoped that this application will increase public awareness and have an impact on daily life. Public awareness regarding the importance of waste treatment can be increased through public recycling knowledge [24].

2. METHODS

This study implemented mix method, first, we develop the application of the Gazebo Semar. Second, we applied quantitative approach by conducting the survey to evaluate the application. The Gazebo Semar application was developed using the Kodular framework. Then the application was tested on respondents using a questionnaire. We interviewed 120 farmers in Karanganyar Regency randomly to evaluate the usability testing using USE (Usefulness, Satisfaction, and Ease to use) questionnaires and use the Likert scale for measurement.

2.1. Application Development

The Gazebo Semar application is built using a Kodular service that can be accessed using an internet network. Kodular is used to design mock-ups and place materials according to the initial sketch. Coding uses block material with internet sources. Each layer is saved as a ".ais" file, and each project is saved as a ".aia" format. The programmed software comprised seven programming nodes for the main screen, model selection, add new, compute, save, import data, and return to the main screen or home, which are configured in 14 codes. Application development using show in Fig. 3.



(a) (b)

Fig. 3. Application Development Using Kodular (a) User Interface Kodular, (b) Block Material Kodular

2.2. Application Evaluation

Application evaluation was conducted by survey using a questionnaire to evaluate the usability testing using USE (Usefulness, Satisfaction, and Ease to use) questionnaires [25]. The USE Questionnaire is a standard scale created by Arnold Lund in 2001 [26] that includes three major points of measurement: usefulness, satisfaction, and ease of use. The Usefulness, Satisfaction, and Ease of Use (USE) questionnaire, a validated and reliable tool, is used to evaluate user satisfaction with the technology-supported exercise program and the home-based exercise program [27]. Following the use of the Gazebo Semar App, participants were asked to complete an online survey with 19 questions.

In this research, the questionnaire will be divided into two parts. In the first part, respondents will be asked about their knowledge of agricultural waste. The second part will ask respondents for their opinion about the Gazebo Semar application. The second part of the questionnaire will use the Likert scale. The Likert scale is a psychometric scale that gives respondents a choice regarding opinions or feelings about an issue. The Likert scale that will be used is a Likert scale with a range of 1 (strongly disagree) to 7 (strongly agree). The Likert scale is more appropriate as the evaluators preferred it because of its simplicity [28]. The following feasibility category reference is used to determine the feasibility of an application based on three USE aspects [29]. Application feasibility category show in Table 1.

Table 1. Application Feasibility Category

No.	Category	Interval Class
1.	Very feasible	81 – 100 %
2.	Feasible	61 – 80 %
3.	Neutral	41 – 60 %
4.	Less feasible	21 – 40 %
5.	Not feasible	0 – 20 %

3. RESULTS AND DISCUSSION

3.1. Application Development

Application development begins with concept planning, interface design, features, and coding. The main concept of developing this application is to educate farmers about agricultural waste. The information offered includes the definition of agricultural waste, sources of agricultural waste, forms of agricultural waste, methods of processing agricultural waste, and an online store prototype called "Gazebo Semar Store". The information was obtained from the Indonesian Ministry of Agriculture's Research and Development Center (Balitbangtan Kementan). The application has a concept containing various information, so the interface is decorated with bright colors and professional transitions. The interface must be friendly to make it easier to understand the content inside the application [30]. Several icons with high color contrast are also used in the application, giving it a fresh look. The framework of Gazebo Semar App show in Fig. 4.

Waste production in Indonesia is increasing every year. Data from the Central Bureau of Statistics show that in 2019, waste production in Jakarta reached up to 39,65 tons daily. This became a new problem because the waste management process needs to be performed successfully. Report on the Implementation of Achievements of the 2019 Sustainable Development Goals (TPB/SDGs) shows that the amount of landfill waste that is recycled does not reach the specified target, it does not even reach the baseline. The target set was 61.5 million tons with a baseline of 13.5 million tons, while the results achieved by Indonesia were only 8.02 million tons. The agricultural waste is also produced each year. The agricultural residue is mostly used for cooking fuel, animal feed, and organic things used for farming [31]. High usage of chemical fertilizer and packaging also becomes a waste source, resulting in environmental damage [32].

Waste is one of the difficult problems to solve. Waste contamination is a serious problem because it threatens the environment's balance. The increase in population, urbanization, and improvement in the economy affect the quantity of waste. The quantity of waste increased due to food production, which means agricultural waste [33]. This phenomenon must be addressed immediately with various efforts to raise waste awareness, one of which is this application. The Gazebo Semar application was developed in response to public concern about waste management and zero waste. This application includes several features that can provide information about waste and how to deal with it. There are also features such as hunger problems, quizzes, and an online store. This application is expected to instill a love of the environment in the community. This application intends to inspire a love of the environment in the community. If people are already aware and understand the waste problem, their habits to reduce waste production will develop. Research from similar fields by Bogevska [34] stated that people would be more aware of producing waste if they had more

information about the negative impact of waste production. Because it is a profitable business opportunity, the community will also begin managing waste. As a result, the environment will be healthier and cleaner.

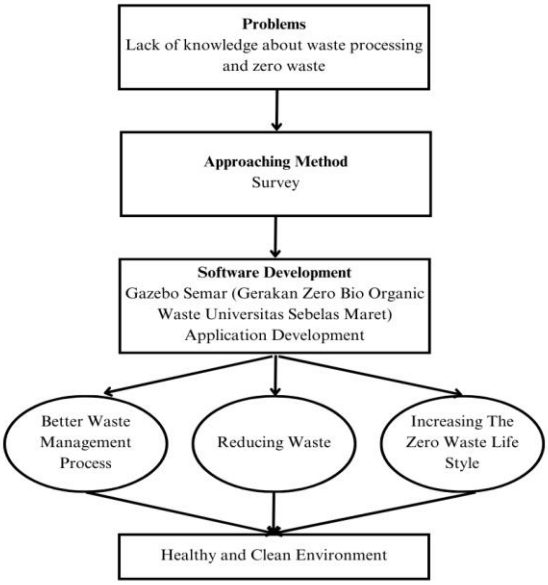


Fig. 4. The Framework of Gazebo Semar App

The Gazebo Semar App has nine main features: Home Screen, Zero Waste, SDGs, Waste Source, Waste Classification, Waste Management, Gazebo Semar Store, Quiz, and About Us. Following is an explanation of the main features (Fig. 5).

The Gazebo Semar application is designed to provide farmers with information and knowledge about agricultural waste and how to handle it. As a result, the Gazebo Semar application must be designed to make it as simple as feasible for users to access the features. The Gazebo Semar application uses icons to show each of its features and so that users can easily understand their functions. The Gazebo Semar also uses green and white as its main color which means that this application has a purpose for the environment (Fig. 6).

Research conducted by Samer regarding the creation of the smartphone application "Biogass Calculator" to calculate agricultural waste into biogas. The research uses application development and data acquisition methods, the same as the method in this paper. As the result, the application is able to process agricultural waste into biogas with computer analytical methods. However, the application weakness is it can only be used on agricultural waste from livestock manure. In contrast to the Semar Gazebo application which can be used on various types of agricultural waste. Another research was conducted by [35] regarding Data-driven Applications using the Stochastic Program and Wasserstein DRO methods. This application runs to calculate the estimated amount of energy that can be produced by processing agricultural waste. However, this application is web-based. This data-driven application does not include a tutorial on processing agricultural waste into an energy source. In contrast to the Gazebo Semar application which provides a guide for readers to be able to process agricultural waste into energy.

Gazebo Semar is an innovation in processing agricultural waste. This application provides updated information from the Ministry of Agriculture Republic of Indonesia. The Gazebo Semar application is the first application with 7 agricultural waste processing features. The Gazebo Semar application has the benefits of providing various agricultural waste processing features, having a fresh user interface, a simple UI design, and the application size is only 17 Mb, making it light enough to run on a smartphone. Gazebo Semar provides a number of novelties in terms of substance and features, so that it is expected to have an impact on local farmers especially in the field of agricultural waste processing. With this impact, farmers are expected to have a lifestyle in managing agricultural waste so that they can improve environmental quality in the future. However, Semar Gazebo requires innovative improvement, namely the addition of features that can connect farmers with stakeholders on a peer-to-peer program. This program aims to achieve application novelty and ensure that the Gazebo Semar application can be used in future.

Home Screen 	The home screen page is the start page that displays the features of an application. At the top of the home screen displays news and articles about zero waste. The home screen also displays buttons to go to other features.
Zero Waste 	The Zero Waste feature provides information about the zero waste movement. This feature explains the 5R (Refuse, Reduce, Reuse, Recycle, and Rot) for processing waste. The function of this feature is as a movement to support the zero waste movement.
SDGs 	The SDGs feature explains the first point of the SDGs: a world free from hunger. This feature contains guidance on the eight steps to alleviating hunger according to the Food and Agriculture Organization (FAO). The eight steps include the Zero Hunger target, saving mothers and babies, ending malnutrition, investing, providing proper nutrition, treating iron deficiency, reducing infant mortality, and social welfare.
Waste Source 	The waste source feature explains the sources of waste and waste producers. The eight main sources of waste are residential, commercial areas, institutions, construction and demolition of buildings, public facilities, industry, incinerators, and agriculture. Waste producers include natural waste, human waste, consumption waste, and radioactive waste.
Waste Classification 	The waste classification feature is divided into three parts: waste based on the processing method, waste based on characteristics, and waste based on decomposition. Waste based on the processing method is easy to decompose components, large volume components, small volume components, flammable components, powder or ash, and sludge. The classification of waste based on its nature is organic waste, inorganic waste, and toxic and hazardous waste. Waste based on its decomposition is divided into biodegradable waste and non-biodegradable waste.
Waste Management 	The waste management feature contains ways to process household waste that is usually done. This feature includes how to make compost from organic waste, make crafts from inorganic waste, make fuel from animal waste, and recycle plastic waste.
Gazebo Semar Store 	Gazebo Semar Store is an online store that sells various processed waste products. This feature is one of the implementations of the development of domestic waste management. Gazebo Semar Store will later work with local MSMEs to supply processed waste products that will be sold to consumers. This feature will be one of the nation's innovations that will encourage the creation of new jobs, empower local MSMEs, and improve the country's economy.
Quiz 	The quiz feature in the Gazebo Semar application provides various questions related to waste management and zero waste. Users can answer the questions and see the score results after collecting them. Users can take this quiz many times to improve their understanding of waste management and zero waste.
About Us 	About Us, the feature will contain general information about the Gazebo Semar Apps mobile application.

Fig. 5. Gazebo Semar App Feature

Fig. 6. Gazebo Semar Application Display

There are limitations to the Gazebo Semar application to farmers regarding the limited resources. Penetration of innovation to farmers requires a continuous extension approach. The characteristic of farmers who are skeptical about adopting agricultural innovations [36] has hampered the implementation of the Gazebo Semar application. This limitation causes the evaluation to not reach the potential impact stage on the environment. It would be useful to discuss the potential impact of the application on the environment and the local economy, as well as any potential barriers to adoption by farmers. For further research, researchers are advised to conduct data acquisition with more empirical evidence. With empirical evidence, Gazebo Semar application developers can measure the potential impact on the environment and the local economy.

3.2. Application Evaluation

Application requirements highlight the need for information, which is obtained through surveys. The application must be evaluated to improve the quality of the application [37]. The survey was conducted with farmer respondents in Karanganyar related to agricultural waste. This survey aims to determine the level of interest among farmers in applications that provide information on agricultural waste. Respondent frequency distribution show in Table 2.

Table 2. Respondent Frequency Distribution

Characteristic	Frequency	Percentage (%)
Sex		
Man	78	65
Woman	42	35
Age		
0-18 years	9	7.5
18-65 years	84	70
>65 years	27	22.5
Educational Level		
Elementary School (SD)	63	52.5
Junior High School (SMP)	37	30.8
Senior High School (SMA)	18	15
Bachelor's Degree (S1)	2	1.7

The characteristics of respondents show that the most respondents are men between the ages 18-65 years old. Respondent's educational level shows that most education levels are elementary school, and the least education level is a bachelor's degree. No farmer has an educational background as an associate degree, master's degree, and doctoral degree. Farmers' education level increases the ability to obtain, process and use information relevant to new profitable technology [38]-[39]. Questionnaire score of application request show in Table 3.

Table 3. Questionnaire Score of Application Request

Indicator	Score (%)
I know the meaning of agricultural waste	44.2
I know the types and source of agriculture waste	41.7
I know how to process agricultural waste	30
I took the initiative to process agricultural waste into usable good	23.3

Farmers in Karanganyar have little knowledge of agricultural waste. Agricultural waste is abundant and there is a potential if people can manage it to provide its benefits, especially the farmers [40]. Farmers only

have 44.2% of the information about agricultural waste. Low knowledge also leads to a low rate of agricultural waste treatment initiation, which is only 23.3%. Table 4 shows the respondents' survey regarding the usefulness of the Gazebo Semar Application.

Table 4. Questionnaire Score of Usefulness

Usefulness	Score (%)
The Gazebo Semar application provides information about agricultural waste	83.2
The Gazebo Semar application provides information about agricultural waste process	83.8
The Gazebo Semar application is practical and easy to understand	75.7
The Gazebo Semar application is useful for farmers	80.8

The average score obtained is greater than 71%, which means that the application is very useful for subjects. The question aspect of "The Gazebo Semar application provides information about agricultural waste process" has the highest result with a score of 83.8%. While the lowest score question aspect is "The Gazebo Semar application is practical and easy to understand" with a score of 75.7%. Perceived usefulness enhances the expected benefits of platform use, and thus it is associated with satisfaction [41].

Table 5 shows the results of respondents on the satisfaction aspect of the Gazebo Semar application. It can be seen that all aspects have a score of more than 71%, meaning the application provides many satisfactory information for respondents [42]. Aspects of the question "The information in the Gazebo Semar application makes me satisfied" have the highest score of 89.8%. While the question aspect of "The Gazebo Semar application can be a farmer's need in obtaining information" has the lowest score with a value of 81%. The usefulness and usability were the most important factors for people to use the application as it can provide exactly what people need [43].

Table 5. Questionnaire Score of Satisfactions

Satisfaction	Score (%)
The information in the Gazebo Semar application makes me satisfied	89.8
I will recommend the Gazebo Semar application to others	85.1
The Gazebo Semar application is interesting to use	84.7
The Gazebo Semar application is an application that has utilized technology in agriculture	88.1
The Gazebo Semar application can be a farmer’s need in obtaining information	81

Table 6 shows the results of respondents on the eases of use aspect of the Gazebo Semar application. All aspects have a score of more than 71%, which means the application is very easy to use for respondents. The data showing the respondent satisfaction from the questionnaire can be useful information to develop the application better [44]. "The question aspect of The Gazebo Semar application does not require large space storage" has the highest score of 86%. While the "easy to remember" aspect has the lowest score of 78.7%. Ease of use and perceived usefulness positively influence users' satisfaction [45].

Table 6. Questionnaire Score of Ease of Use

Ease of Use	Score (%)
The Gazebo Semar application has an attractive appearance	83.7
The Gazebo Semar application can be run without looking at the instruction	83.7
The Gazebo Semar application consistently provides agricultural information	80
The Gazebo Semar application can be used any time	82.2
The Gazebo Semar application does not require large space storage	86
The information in the Gazebo Semar application is easy to remember	78.7

Gazebo Semar is an application that provides information about agricultural waste. This application is built within Kodular platform with the development stage covering design, coding, and testing. The testing phase is carried out on targeted users, the farmers who live in Karanganyar Regency. The application trial uses the USE method which has aspects including usefulness, satisfaction, and ease of use and learning. This method is designed to measure the usability dimensions that are important to users. A questionnaire about the evaluation of the Gazebo Semar application was given to 120 respondents. The average score of the result is above 80%, which means the Gazebo Semar application has a very high USE value. Regarding usability, the statement "The Gazebo Semar application provides information about the agricultural waste process" has the highest score. The Gazebo Semar is a system that provides information in a user-friendly application with a

user-friendly layout and design. Information can be defined as data that is processed to be more useful and meaningful for the recipient. The process of delivering information begins by storing raw data in the database. This database will be processed as input and produced output in the form of information. This information will influence user decisions. The increase in knowledge or information can influence people's behavior in managing waste [46].

In terms of satisfaction, the statement "The information in the Gazebo Semar application makes me satisfied" has the highest score. This means The Gazebo Semar application provides sufficient and useful information to respondents. The quality of information is measured from several aspects. The aspects can be in the form of accuracy, relevance, and completeness of information. The Gazebo Semar application provides information about processing agricultural waste. This information is extracted from various sources.

In terms of ease of use, the statement "The Gazebo Semar application does not require large space storage" has the highest score. Smartphone memories store various data about activities carried out by the smartphone itself. A full memory will slow down the work of the smartphone. A full memory can also cause a smartphone not to be able to execute commands from the user. The Gazebo Semar application is an application that has a small size, about 18 MB. This application only takes up a little memory on a smartphone so it can be installed easily.

4. CONCLUSION

This android application "Gazebo Semar" offers solutions and information for people, specifically farmers, to manage their agricultural waste. The Gazebo Semar is a smartphone-based application built using a Kodular. A survey of 120 farmers in Karanganyar Regency was used to determine this application's evaluation. USE method is used to analyze the survey results. The results show that the score of Usefulness, Satisfaction, and Ease of Use is above 71%, which means Gazebo Semar has provided the application that fits with the needs of farmers. By using this innovation, farmers can process agricultural waste into organic fertilizer that is economically profitable.

For further research, researchers are advised to conduct data acquisition with more empirical evidence. Further research must guarantee that each respondent has used the Gazebo Semar application at a certain time. Further research requires additional resources to deepen the substance of the application and make the application more practical for everyone to run. Our paper provides direction for further research to be able to add technology to this application, for example adding Artificial Intelligence (AI), connecting with the Internet of Thing (IoT), and adding other sensors.

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