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Waste Processing and Recycling Product Marketplace Application Using Tensorflow and Midtrans API Technology

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***Abstract*— The increasing volume of waste that is not optimally managed is a serious challenge for sustainable development. Public education about waste processing and recycling is critical to increase their awareness and involvement. The recycling process can not only help reduce the amount of waste but also produce new products with economic value. In order to support this effort, information and communication technology, especially Android-based applications, can be an effective solution. This application can provide education, recommendations, and a marketplace platform for recycled products, hoping to allow the public to access information and market their products more efficiently. This study shows that Android-based waste processing and recycled product marketplace applications have great potential in helping to overcome waste problems. The test results of the application features show that all functions work well, which is my expectation. In addition, the user acceptance test shows that the majority of respondents agree that this application is effective in reducing waste accumulation (88%), facilitating the recycling process (93.36%), and providing economic value for recycled products (89.6%). This research provides innovative technology-based solutions to support the Sustainable Development Goals (SDGs) related to effective waste management and utilization.**

***Index Terms*— Waste; Recycled; SDGs; Application; Tensorflow**

I. INTRODUCTION

The use of information technology in the form of One of the complex problems faced by countries, both developing and developed throughout the world, is waste [1]. This problem is global and occurs in various countries. *Waste* is defined in the Great Dictionary of the Indonesian Language as a collection of goods or objects that are no longer used or have no use value. (http://kbbi.web.id/sampah). Based on the National Waste Management Information System (SIPSN) of Kementerian Lingkungan Hidul dan Kehutanan (KLHK) in 2022, the amount of waste stored nationally was recorded at 21.1 million tons based on input from 202 districts/cities throughout Indonesia has been achieved. Of the total state waste production, 65.71% (13.9 million tons) can be managed, while the remaining 34.29% (7.2 million tons) is not managed correctly.

Given that there is still unprocessed waste, the government is looking for solutions to overcome it by involving local communities in waste management. In addition to increasing public awareness of waste management, this initiative also aims to reduce the government's costs to overcome waste problems [2]. Low levels of education lead to a lack of knowledge about waste management. Therefore, socialization plays a vital role in disseminating knowledge about waste management to the community. The opposite can happen if the lack of community socialization and education about waste management results in less than optimal waste management [3].

Therefore, public education about waste processing must be improved, especially regarding waste recycling. This is because the waste can be converted into commercial waste or waste that can be sold and processed into other products, thus generating profits from further processing [4]. Inorganic waste can be sold and processed into household decoration materials, equipment, and art objects. Knowledge about sorting, selecting and placing storage locations, finding places to buy and recycle collected waste, and how to analyze sales results [5]. Recycling means changing the shape and reusing it [6]. This process creates new products that can be reused. After carrying out this process and already having a recycled product, a platform such as a Marketplace or E-Commerce for recycled products is needed to make it easier to market recycled products widely [7][8].

The problem related to the waste problem is based on the results of an interview conducted on December 23, 2023, with Fajar Ramadhan, a resident who lives in an area near the Bantar Gebang TPA. He said that the amount of waste in the TPA has exceeded capacity and is already mountainous. Because the people there are close to the TPA, they immediately throw their waste into the TPA, but there are also quite a few who still litter, which makes it scattered on the roads and rivers. According to him, the awareness of the people there

about waste management is still very lacking, and what is even more concerning is that they see firsthand the phenomenon of waste that has become very mountainous. However, their awareness is still significantly lacking in reducing this.

To overcome these problems, information and communication technology are needed to provide education about waste processing and recycling. Many human activities have now utilized technology to access information easily anywhere and anytime. One of them is the Smartphone, which utilizes the Smartphone and its features such as cameras, etc. It is expected to be able to create an application that can overcome this waste problem, mainly by providing education to the community. With proper education, the community is expected to be able to change its consumption patterns and behaviour in managing waste [9]. This will have an impact on reducing waste generation, increasing the amount of waste that can be processed, and increasing the economic value of waste.

Several studies have been conducted to support this research. Based on previous research an Android-based mobile device application needs to be developed to help the community uses sensors from smartphone [10]. It was found that this technology can provide education and recommendations to users regarding waste processing and recycling. The Android platform was chosen because it is an open-source licensed operating system, so developers can quickly develop it to support their daily activities and tasks [11].

Considering the problems mentioned above, it can be concluded that it is necessary to build an Android-based Waste Processing and Recycled Product Marketplace Application [12][13]. By building this application, it is expected to provide education to the public about waste processing and make it easier for the public to recycle and produce recycled products that have economic value where this application provides a marketplace feature to sell the results of recycled products that have been made by the public [14].

With this application, it is hoped that the public can better understand the importance of waste management and recycling, and can utilize waste into useful products. The results of this research can provide innovative technology-based solutions to support the Sustainable Development Goals (SDGs) in terms of Sustainable Consumption and Production related to effective waste management and utilization.

II. RESEARCH METHODS

This research consists of several critical stages. First, Problem Identification is carried out to understand the problem thoroughly. Next, Data Collection is carried out to obtain relevant information. After that, enter the System Analysis and Design stage to compile the right solution based on the data that has been collected. After the design, the implementation stage is carried out to apply the designed solution. Finally, Testing is carried out to ensure the system runs as expected and corrects errors. This stage flow ensures that the research results run systematically and effectively. Research flow and stages show in Fig1.

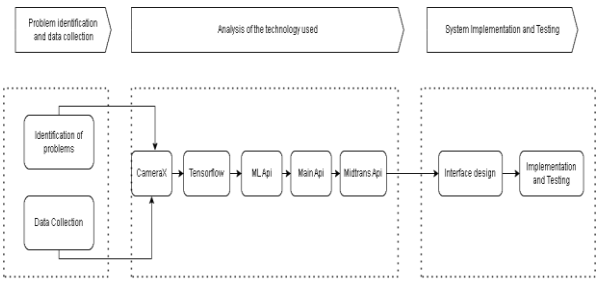


Fig. 1. Stage of research

2.1 Identification of problems

At this stage, researchers identify and understand various problems faced by the community related to waste management and recycling. Some problems found include low levels of public awareness and knowledge regarding the importance of proper waste management and difficulties in implementing the concept of recycling due to a lack of understanding. In addition, the community also faces obstacles in marketing recycled products because no particular platform can support the optimal marketing of these products. Identifying these problems is the basis for determining the focus and direction of research to find the right solution.

2.2 Data Collection

Once the problem has been identified in detail, the next stage is to collect the data needed to support the development of the solution. Data collection is carried out in various ways, such as literature review, direct observation, and interviews with residents around the Bantargebang TPA. The literature review includes the integration of payment gateway services and the development and use of APIs. Meanwhile, observations and interviews are conducted to gain a deeper understanding of user needs and expectations, including their preferences for the features presented in the developed application.

2.3 Analysis And Planning

In this analysis and design stage, an in-depth analysis of the data that has been obtained is carried out in order to develop a targeted solution. This process covers various aspects, from the study of the planned system, designing the optimal architectural structure, and selecting the technology to be used, such as CameraX, TensorFlow, Restful API, and Midtrans API. In addition, this analysis also considers non-technical needs such as hardware and software needed to support system performance. Not only that, this stage also includes the development of use cases and

interface design to ensure that the system is easy to operate and meets user expectations.

2.4 Implementation and Testing

The implementation process involves developing an application according to the designed design. The first step is to build a Restful API to support the exchange of data needed in the application. Next, integration is carried out with the Midtrans API as a payment gateway to handle payment transactions. In addition, the mobile application will also call all the APIs needed to ensure that all features function in an integrated manner. After the application is developed, the next stage is to conduct testing to assess performance, functionality, and user experience. This testing process ensures that all features function according to the specifications and meet user needs. In addition, testing also aims to identify and fix bugs or problems that may arise to ensure that the application can run smoothly and effectively.

III. Results And Discussion

The system built must meet the needs and provide solutions to existing problems; from the main problem, the picture of the system to be built has features to provide education about waste processing, provide recommendations for recycled products and procedures or stages in recycling waste based on waste that has been detected by the application, and provide a marketplace feature to market recycled products that users have made.

3.1 System Architecture

The image in Fig. 2 describes the system architecture in the Android-based waste processing and recycling marketplace application.

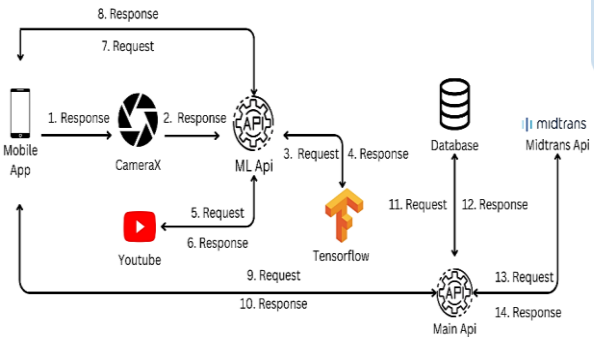


Fig. 2. Architecture of the system

Midtrans API is registered and holds a license from Bank Indonesia and the Payment Card Industry Data Security Standard, using the AES-256 electronic encryption standard so that from a security perspective it can ensure that sensitive data can be protected.

TensorFlow merupakan framework machine learning dan deep learning terpopuler yang dikembangkan oleh Google. Keunggulan utama TensorFlow terletak pada fleksibilitas, skalabilitas, dan performa yang baik.

3.2 CameraX Analysis

CameraX is a library designed to ease the use of cameras on Android devices, especially in dynamic applications involving cameras [15]. CameraX supports devices with Android 5.0 (API Level 21) and above and extends the capabilities of the Camera API, replacing the deprecated native Camera API [16]. With CameraX, various camera functions can be easily implemented in just a few lines of code, and compatibility issues with older devices have been resolved. In the applications built, CameraX takes pictures of objects or trash, which are then processed to find out how to manage and recycle them into products of saleable value. Fig. 3 show about CameraX analysis.

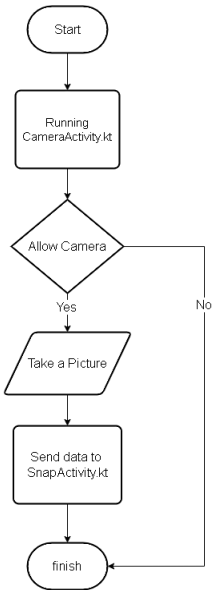


Fig. 3. CameraX Analysis On System

The process flow of using CameraX on the application to be developed:

1. The system runs CameraActiviy.kt to activate the camera.
2. The system asks for permission from the user to activate the camera connected to the device being used.
3. After getting permission, the system starts activating the camera to capture images of objects to be detected.
4. After getting an image of the detected object, the data is sent to SnapActivity for processing.

3.3 TensorFlow Analysis

TensorFlow is an open-source framework from Google for machine learning and deep learning. It provides tools for building and training AI models and supports multiple platforms and programming languages [17]. The analysis of TensorFlow usage in

this application focuses on how it detects objects in the form of garbage that appear in the application. The following is the process of object detection in the ML model.

Fig. 4 show how Tensorflow are use in this application.

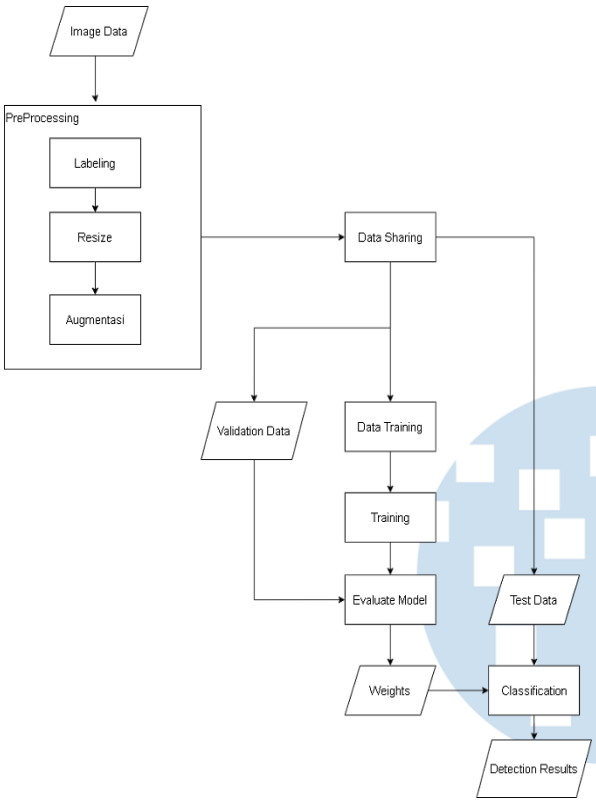


Fig. 4. Detection Object using Tensorflow

The following is an explanation of Fig.4 Object Detection Process using Tensorflow:

1. Image data is data used for preprocessing.
2. After collecting the image data, it enters the preprocessing section, which consists of three processes, including the following:
   a. image labelling to label the image data.
   b. resize, which is to adjust the image size to make it easier to process.
   c. Augmentation is a technique for increasing the diversity of your training set by applying random (but realistic) transformations, such as image rotation.
3. After preprocessing, the next step is data division. In this data division process, the data will be divided into three processes, namely:
   a. Validation Data is the process of validating data from preprocessing, which is then continued in the model evaluation stage.
   b. Training Data is the process of training data here using the CNN Method. After training, it is continued to model evaluation, and finally, the weights from the training results are obtained, which are continued for classification using the CNN method.
   c. Test data is data that will be used for the classification stage using the CNN method until finally, the object detection results are obtained

3.4 ML Api Analysis

ML API is an API where the trained TensorFlow model is converted into a flask app, which is then deployed to the cloud run to be accessed by the mobile app to be built [18][19]. The analysis of the use of ML API focuses on object detection in the application to be built. The following is the process of obtaining data from ML API.

1. Get a response containing the detected object in JSON format as shown in Fig.5.


```
{
    "answer": "Plastic Packaging.",
    "description": "Plastic packaging waste
refers to the type of waste resulting from the
use of various kinds of plastic packaging in
daily life.\n\tPlastic packaging is commonly used
to package food, beverages, household goods,
beauty products, and various other
items.\n\tPlastic packaging waste can have a
negative impact on the environment and
ecosystems. If not managed properly, plastic
packaging can pollute oceans, rivers, and
land.\n\tDiscarded plastic can damage natural
habitats and harm marine life that ingest it or
become entangled in it.\n\tCollective efforts
from individuals, governments, and industries to
reduce single-use plastic packaging, increase
recycling, \n\tand foster innovation in eco-
friendly packaging can help mitigate the plastic
packaging waste problem and preserve our
environmental sustainability.\n",
"file_urls": [
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Plastic%20Flowe
r.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Keychain.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Wall%20Decorati
on.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Bag%20%281%29.j
pg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Tissue%20Holder
.jpg",
"https://storage.googleapis.com/bucket-bayu-
3/Recomendation/Plastic/Packaging/Mat.jpg"
    ]
}
```


Fig. 5. ML Api Response

2. Convert objects to JSON representation. This is used to connect between JSON and Kotlin objects in the class as shown in Fig. 6.

```
data class TrashResponse(
   @field:SerializedName("answer")
   val answer: String? = null,
   @field:SerializedName("description")
   val description: String? = null,
   @field:SerializedName("file_urls")
   val fileUrls: List<String?>? = null
)
```

Fig. 6. JSON ML Api Representation

3. Displays object data that has been detected in the application. The data displayed is in the form of detailed information from the waste and recommendations for recycled products that can be made on. This process show in Fig. 7.

```
fun postSnapPlastic(file: File):
LiveData<Result<TrashResponse>> = liveData {
    emit(Result.Loading)
    val imageMediaType =
"image".toMediaTypeOrNull()
    val imageMultiPart: MultipartBody.Part =
MultipartBody.Part.createFormData(
        "file",
        file.name,
        file.asRequestBody(imageMediaType)
    )
    try {
        val response =
apiServiceML.uploadPlastic(imageMultiPart)
        emit(Result.Success(response))
    } catch (e: Exception) {
        e.printStackTrace()
emit(Result.Error(e.message.toString()))
    }
}
```

Fig. 7. Displays the detected garbage data.

3.5 Fire Play Analysis

The main API is a Restful API built using Express.js, a Node.js framework that makes it easy to create web applications and APIs [20]. And MySQL, a popular relational database management system [21]. This API serves as a connector for data exchange within the application being developed, facilitating communication between various system components and ensuring effective data integration [22]. The analysis of the use of Main Api focuses on the exchange of user and marketplace data within the application to be built. The following is the process of getting data from Main Api.

1. Get a response in the form of user data logged into the application in JSON format. This process show in Fig. 8.

```
{
    "payload": {
        "token":
"eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJpZF9wZW1
iZWxpIjozNCwaWF0IjoxNzI2A"
    },
    "status_code": 200,
    "message": "Login successful",
}
```

Fig.8. Displaying Login Response

2. Convert the object to JSON representation. This is used to connect between JSON and Kotlin objects in the LoginResponse class. This process show in Fig.9.

```
data class LoginResponse(
   @field:SerializedName("status_code")
   @field:SerializedName("pagination")
   @field:SerializedName("payload")
   @field:SerializedName("message")
)
data class Payload(
   @field:SerializedName("token")
)
```

Fig.9. JSON Representation of Main API Login

3. Method for sending a request to log in to the application. This process show in Fig.10.

```
suspend fun login(
    email: String,
    password: String
): LiveData<Result<LoginResponse>> = liveData {
    try {
        Log.d("UserRepository", "Attempting login
with email: $email")
val loginRequest = LoginRequest(email, password)
val response = apiService.login(loginRequest)
        Log.d("userRepository", "Login response:
$response")
        }
    } catch (e: Exception) {
        Log.e("UserRepository", "Login failed:
${e.message}")
        e.printStackTrace()
        val errorMessage = when (e) {
            is HttpException -> {
                when (e.code()) {
                 401 -> "Invalid email or
password"         404 -> "User not found"
else -> "Login failed, please try again later."
}
            }
```

Fig. 10. Method Login

3.6 Midtrans Api Usage Analysis

Midtrans API is a payment gateway service that enables the integration of payment systems into applications or websites [23]. Midtrans provides various payment methods, such as credit cards, bank transfers, and e-wallets, as well as features for managing transactions and payment verification. This API makes it easy for developers to implement secure and efficient payment solutions in their applications [24]. The Midtrans API payment gateway service is used in this study because it provides various payment methods for transactions within the application. API integration with Midtrans involves creating an invoice that allows users to choose the appropriate payment method. Fig.11 shows the response obtained from creating an invoice using the Midtrans API.

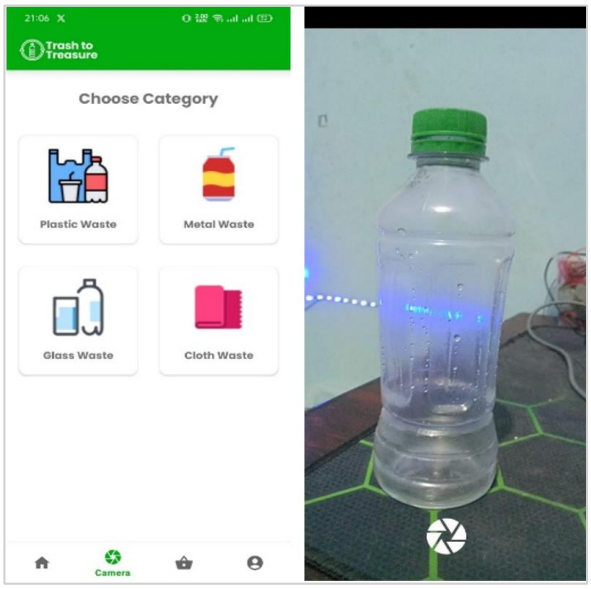
```
{
    "success": true,
    "message": "Successfully created invoice",
    "data": {
    "order_id": "b9e79430-92c-4112-8cd2",
    "invoice_number": "INV-172620065341",
    "published_date": "2024-09-13 11:17:48,
        "due_date": "2024-09-14 11:17:45,
        "invoice_date": "2024-09-13 11:17:45",
            "customer_details": {
            "id": null,
            "name": "Eko",
            "email": "eko@example.com",
            "phone": "62812345689"
        },
        "item_details": [
            {
                "item_id": null,
                "description": "midtrans pillow",
                "quantity": 1,
                "price": 50000
            }
        ],
        "id": "66e3bcecad0dd74431",
        "status": "pending",
        "gross_amount": 50000,
        "pdf_url":
"https://assets.midtrans.com/invoices/A3EvrJB",
        "payment_type": "payment_link",
        "virtual_accounts": [],
        "payment_link_url":
"https://app.midtrans.com/payment-links/14490b03"
    }
}
```


Fig.11. Response Midtrans Api

IV. Results And Discussion

The implementation of the interface is the result of the implementation stages of the research that have been designed previously according to user needs. So, in this case, the researcher intends to provide an overview of the implementation results that have been made for the waste processing application and recycling marketplace. The implementation of the application interface in Fig. 12 shows the process of selecting the category of waste type and the process of taking pictures of object.

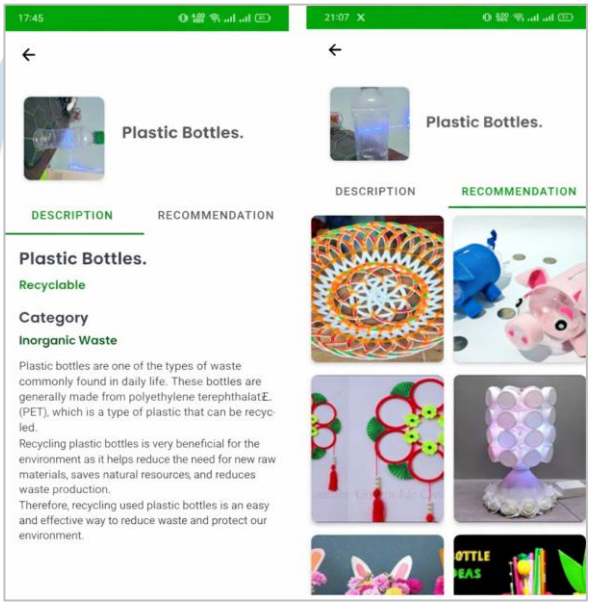
Figure 12 (a) shows the waste category selection page, where users can select the type of waste to be detected by the system. On this page, there are four categories of waste that can be identified through the TensorFlow model that has been deployed and converted into an API. The API is then integrated into the application to process and detect the type of waste selected by the user. This process allows the application to provide accurate detection results according to the selected waste category.



(a) (b)

Fig. 12. Select category (a) and Detect waste (b)

Figure 12 (b) shows the image capture process page using CameraX technology. On this page, users can take pictures of the waste objects they want to detect. After the image is taken, the image file is sent to the machine learning API (ML API) that has been prepared to detect and classify waste based on the TensorFlow model used. CameraX technology makes it easy for users to easily take pictures and send them to the API for further processing so that the entire process runs efficiently.



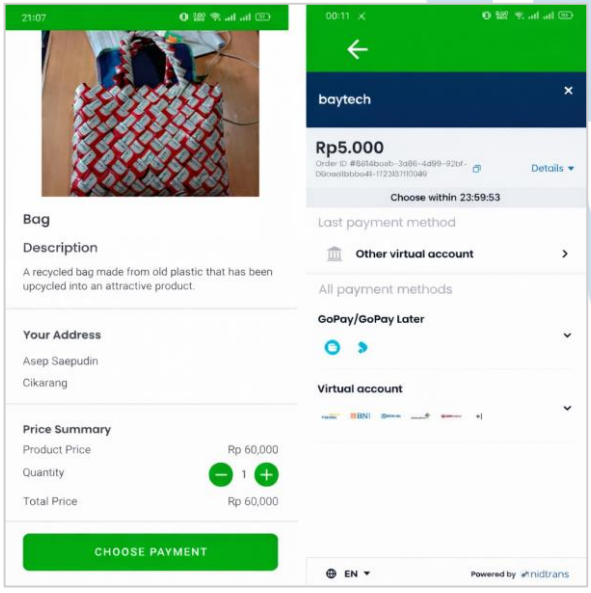
(a) (b)

Fig. 13. Waste Detection Results (a) and Product Recommendations (b)

Figure 13 (a) displays a page containing a complete description of the waste detection results, where users can see information about the type of waste detected,

the category of the waste, and a detailed explanation of the characteristics of the waste. These detection results are obtained from processing carried out by the TensorFlow model that has been deployed and converted into a Machine Learning API (ML API). After the waste image is uploaded and processed by the API, the system displays detailed and accurate results regarding the waste that has been analyzed. Users can understand more about the type of waste through the description provided, including what category the waste falls into and what its general characteristics are.

Figure 13 (b) shows a list of recommendations for recycled products that can be made from the detected waste. Based on the detection results from TensorFlow, the system provides various creative ideas on how the identified waste can be reprocessed into recycled products that have economic value. This list is compiled by considering the nature and category of waste, as well as its potential use in the recycling process. This not only helps users understand the type of waste produced but also provides practical guidance for utilizing the waste in an effort to protect the environment and produce useful products. This integration of waste detection with recycling recommendations provides added value for users, as it not only identifies environmental problems but also offers creative and sustainable solutions.



(a) (b)

Fig.14. Product Purchase Process (a) and Payment Process (b)

Figure 14 (a) displays a dedicated page for purchasing recycled products, where users can view a variety of important information related to the products they wish to purchase. The information displayed includes the product name, a brief description of the product, the buyer's shipping address, the product price, the purchase amount, and a button to proceed to the payment process. The product description provides a clear picture of the recycled materials used, the manufacturing process, and the environmental benefits generated. Users can also adjust the purchase amount as needed before proceeding to the payment stage. This page not only functions as a place for transactions but also as an educational tool for users about the benefits of recycled products, both from an economic and environmental perspective.

Figure 14 (b) displays the payment invoice page that appears after the user chooses to continue the transaction. On this page, users are presented with various payment methods available to complete the transaction. Integration with Midtrans allows users to choose the payment method that best suits their preferences, be it via bank transfer, e-wallet, or other payment methods. This simplifies the payment process while providing users with the flexibility to make transactions conveniently. This payment system also ensures security and speed in processing payments so that users can immediately complete their purchases of recycled products smoothly. Functional testing result show in Table 1.

TABLE I. FUNCTIONAL TESTING

Functional Tested	Test details	Testing Result
Register As Seller	Users fill out a form containing the bank name and account number.	Successfully seller registration process
Edit Seller Data	The user changes the data form containing the bank name and account number.	Successfully edited seller data
Order Information Incoming	The user presses the incoming order menu, then the system displays a list of incoming orders.	Successfully order menu
Displaying Marketplace Data	The user presses the marketplace navigation, after which the system will display the marketplace data.	Successfully display merketplace data
Performing Waste Detection	The user takes a picture of the trash and then the system detects the trash.	Succesfully take picture and detected the trash
Selling Products	The user presses the sell product button, then the system displays the product sales form.	Succesfully selling product
Showing my Products	The user presses the my product button, then the system displays a list of my products.	Successfully showing list product
Change my Product	The user clicks on one of the products displayed in the list, then the system displays a form to change the product.	Successfully change product data

Based on the testing that has been carried out using the black box method, the implementation of the various features that have been designed in this study was declared successful. It functioned according to

expectations [25]. Each feature was thoroughly tested to ensure that its functionality runs well without any significant errors or bugs [26]. This testing involves simulating the use of the application from the end user's perspective, where the system is tested in terms of input and output to ensure that all features, such as garbage detection, image capture, data processing, and payment processes, can run smoothly [27].

The test results show that the designed features have been implemented well, in accordance with the objectives of the study. This application was also tested directly by users through an User Acceptance Testing. for ensuring a system meets the real-world needs of its users [28]. Some questions related to the problems being solved are reducing waste accumulation, making it easier to recycle waste, making it easier to market recycled products, making waste have economic value, providing education about waste recycling.

Testing was carried out by distributing questionnaires to 25 respondents. User responses will be analyzed using a Likert scale to measure their perceptions of the performance and usability of the application [29]. The results of this analysis are expected to provide further insight into how well the application meets user needs and whether there are areas that need to be improved [30]. Table 2 show user testing result using a likert scale.

TABLE II. USER ACCEPTANCE TESTING RESULT

Questions	Result
Can the existence of waste processing applications and recycled product marketplaces help reduce the problem of waste accumulation?	88%
Can the existence of waste processing applications and recycled product marketplaces make it easier for people to recycle?	93,36%
Can the marketplace feature help people market their recycled products?	88,8%
Can the marketplace feature help turn waste that has no economic value into one that has economic value?	89,6%
Can the existence of waste processing applications and recycling marketplaces provide education about recycling to the public?	91,2%

IV. CONCLUSION

Based on the results of implementation, discussion, and testing, it can concluded that the Waste Processing Application and Recycled Product Marketplace have successfully provides innovative technology-based solutions to support the Sustainable Development Goals (SDGs) related to effective waste management and utilization. This application has succeeded in providing more knowledge to the public about waste management, which can help reduce waste problems. In addition, this application makes it easier for the public to recycle by providing appropriate recommendations based on the type of waste and also helps the public in marketing recycled products through the marketplace feature, so that these products can be promoted and sold more widely. Further research focus to develop a more comprehensive shipping and tracking delivery feature to improve the quality of service and customer satisfaction.

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