Enhancing Waste Bank Efficiency Through a Web-Based Information System with Haversine Method Route Optimization

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ABSTRACT

The Government of Mojokerto City is an enclave area within Mojokerto Regency, East Java Province, which has faced challenges in waste management. One effective solution is by utilizing a waste bank system. As a recent innovation, researchers have introduced Waste Bank, a concept of collection boxes for donating clothes and fabric scraps, in collaboration with the Department of Environment of Mojokerto City to manage textile waste. The process involves managing the outputs with Sewing house. The development of the Waste Bank management information system utilizes the Waterfall Method, with the Leaflet JavaScript Library for Open Street Maps visualization and the haversine method for finding nearby routes. Haversine is an effective algorithm for calculating distances between two points based on geographic coordinates on Earth's surface, used to determine the distance between two points on the globe from longitude and latitude coordinates. The result of this research is the waste bank website application, which assists Mojokerto City residents in finding the nearest waste bank locations, monitoring the distribution of waste bank, and real-time navigation using Google Maps.

INTRODUCTION

Information technology has become very common and has become a habit among people today. The existence of fast and easy information technology is expected to produce the information needed. Currently, information technology has presented a new innovation, namely the combination of information systems and geographic science, namely geographic information systems (GIS) which currently continues to develop along with advances in information technology. Geographic information systems can be used as information that refers to location specifications in a place, space, population and geographical elements contained on the earth's surface and displayed on a map in order to provide a more precise and accurate description of an object. Geographic information systems are widely used to make various decisions, design and analysis.

Data contained in the National Waste Management Information System shows that in 2023 there will be more than 17 million tons of waste generation throughout Indonesia. However, no more than 67% of this waste can be managed. The Department of Environment is located at Raden Wijaya Street Number.19, Prajurit Kulon Sub-district, Mojokerto City, East Java. Textile waste in Mojokerto city has not received more attention and has not been managed optimally by the local government community. Most of the textile waste was dumped in the randegan landfill in Mojokerto City.

Wiragatra comes as an innovation that helps the Environmental Service in managing textile waste. Wiragatra is a Management Information System Website for the waste bank and Geographic Information System for the nearest route search feature which aims to develop information for textile waste management and help reduce landfill waste in

Randegan Landfill, Mojokerto City. The purpose of the waste bank is to minimize the amount of waste that pollutes the environment and generate added value through textile waste recycling (upcycling). Donors will get points that can be exchanged for works in the Wiragatra shop. The development of the Wiragatra Waste Bank Management Information System is implemented with the Leaflet JavaScript Library to visualize maps sourced from Open Street Maps, the search for the closest route between the user's location and the waste bank location in this web GIS is applied the haversine method.

The Haversine Formula is used to calculate the great circle distance between two points on a sphere such as the Earth. This formula can be used to determine the distance traveled between two points on the surface of the Earth, for example to determine the distance between two cities or GPS positions. Meanwhile, Dijkstra's Algorithm is used to find the shortest path between two points in a graph. Dijkstra's algorithm is very commonly used in navigation and route optimization applications, such as finding the shortest path in a road map or transportation map. Based on the description above, researchers try to plan and design a Website Management Information System that can be a source of information on the distribution of waste banks in Mojokerto City. The results of the Wiragatra Website are expected to be useful for donors to care about the environment and manage textile waste properly.

WIRAGATRA WASTE BANK

Wiragatra is taken from 2 Indonesian words, Wira and Gatra, which means environmental warrior. Waste bank is a textile waste management system that involves the community to collect, donate, and manage waste generated in their neighborhood. The waste bank concept aims to reduce the amount of textile waste that goes to landfills. Solutions to the textile waste problem include upcycling or adding value to existing products. The meaning of upcycling itself is to utilize or reprocess unused goods by modifying and then adding value to the goods so that they have a selling value.

Figure 1. Wiragatra Waste Bank

TEXTILE WASTE

The textile waste managed is solid textile waste which is the remnants of the clothing and fabric production process. Solid textile waste is a serious environmental problem because it is difficult to decompose and often ends up in landfills or in the environment, causing pollution. The textile waste to be managed by Wiragatra includes Clothing and Perca Fabric. Handling solid textile waste is becoming increasingly important in an effort to reduce its negative impact on the environment. Initiatives such as recycling, upcycling, and public awareness education can help reduce the amount of textile waste that ends up in landfills.

Figure 2. Handicraft Exchange Shop

Wiragatra website mechanism starts with the donor bringing the clothes or rags to be donated to the waste bank then the donor accesses the website to find out the location of the waste bank using the nearest route search feature in the vicinity. After the donor arrives at the location of the waste bank, data collection will be carried out by the environmental service officer who is guarding it and weighing and inputting the weight of the donation to the points. Points collected by donors can be redeemed according to the nominal exchange there are placemats 200pts, Scrap Fabric Mats 400pts, Patterned Doormats 600pts and Used Fabric Bags 800pts.

RESEARCH METHOD

A method is an organized way used to achieve a certain goal or result. A method is the same as an effective way or step to solve a problem. Solving a problem with a method, one can reduce the waste of time, energy, and resources in the process of achieving a goal.

PROBLEM IDENTIFICATION

In this research, the process of problem identification through a survey of the case study location at the Mojokerto City Environmental Service. After conducting observations, interviews and data collection, researchers were given direction regarding the adjustment of Problem Identification with the innovation raised. That the Mojokerto City Environmental Service has promoted a waste reduction campaign by sorting organic and inorganic waste. Given, the growing waste production has resulted in waste piling up at Randegan landfill. Especially those from household waste. The Regional Head of Mojokerto City revealed that his party continues to strive to change the waste management system so that it does not only end up in the landfill. Because it tends to

pollute the environment. According to him, reducing waste production can be started by sorting. Namely by categorizing waste according to the type, amount and nature of the waste. If managed better, Household waste can still be used by sewing house.

Figure 3. Mojokerto City Environment Office

From various categories of waste, it was found that the waste problem that the researchers thought was relevant to the proposed innovation and the management output could be realized by working with sewing house was textile waste left over from clothes or rags. Researchers came up with the innovation of procuring a waste bank which aims to be a special distribution box for textile waste to be recycled. Efforts to help the Environmental Service and minimize the than optimal management of randegan landfill and also Reduce Reuse Recycle Waste Management in Mojokerto City.

OBSERVATION

Observation or direct observation in this study is to observe the Environmental Service Raden Wijaya Street No.19, Prajurit Kulon Sub-district, Mojokerto City, East Java. Which aims to obtain the information needed and find out the flow or process related to textile waste donation that runs.

INTERVIEW

Researchers conducted interviews and asked questions directly related to the research topic to the Environmental Service. In this case the researcher conducted an interview with Mr. Daryono who holds the position of staff environmental department. With interviews conducted, researchers can find out information and can formulate the need to build a waste bank management information system and search for the closest route in Mojokerto City. It is intended that the website-based management information system developed later is truly appropriate.

LITERATURE STUDY

Literature study is useful as a theoretical study for research that is being carried out by researchers because it is to underlie the testing and development that will be carried out. Researchers take from journals, books and articles related to geographic information systems that use the Leaflet JavaScript Library for Open Street Maps visuals and the haversine method for the closest route. So it is hoped that later it can help researchers about development and testing in carrying out research.

SYSTEM DESIGN

The development of the Wiragatra Waste Bank Management Information System followed the Waterfall methodology, ensuring a structured and sequential approach. The key stages included:

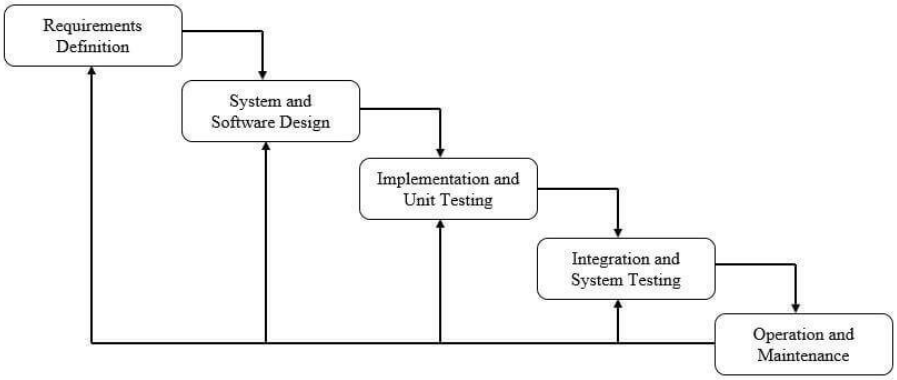


Figure 4. Metode Waterfall

Source: https://ranahresearch.com/metode-waterfall/

1. **Requirement Definition:** Collecting needs from the case study of the Mojokerto City Environmental Service through observation and interviews to find out what needs are needed in building the Wiragatra system.
2. **System Design:** Using the Leaflet JavaScript Library for map visualization and implementing the Haversine method to calculate the shortest routes to nearby waste banks.
3. **Implementation:** Developing the system using the Laravel framework for back-end processes and integrating GPS for real-time location tracking and user authentication.
4. **Testing:** Conducting extensive testing, including black-box testing to evaluate system functionalities and User Acceptance Testing (UAT) to ensure the system meets user expectations.
5. **Operation & Maintenance:** This stage also be interpreted as a form of responsibility to ensure that the system can run smoothly and also to improve system capabilities.

RESULTS AND DISCUSSION

The results section simply and objectively reports what the researcher found, without speculating on why the researcher found these results. The discussion interprets the meaning of the results, puts them in context, and explains why they are important.

SYSTEM IMPLEMENTATION

In implementing the system, researchers designed and developed a website-based waste bank management information system application in Mojokerto City with a waterfall system development or approach and for the closest route search using the haversine formula method. 3 actors involved in this system include admin, officers and donors who have their own access and views. In the implementation stage, map visualization uses Leaflet JavaScript Library, digital maps sourced from Open Street Maps and website support using the Laravel framework. Realtime navigation output is directed to Google Maps.

HAVERSINE FORMULA CALCULATION

To calculate the distance between two points on the Earth's surface given their geographical coordinates (latitude and longitude), we can use the Haversine formula. This formula accounts for the spherical shape of the Earth and provides accurate results for long distances on the Earth's surface. Here are the steps and explanations of this calculation:

First, we need to calculate the change in latitude (Δlat) and the change in longitude ($\Delta long$). Δlat is the difference between the latitude of the second point ($lat2$) and the latitude of the first point ($lat1$), while $\Delta long$ is the difference between the longitude of the second point ($long2$) and the longitude of the first point ($long1$).

Second, we use the Haversine formula:

$$a = sin^2\left(\frac{\Delta lat}{2}\right) + cos(lat1) \cdot cos(lat2) \cdot sin^2\left(\frac{\Delta long}{2}\right) \text{ (1)}$$

Where a is a value between 0 and 1 calculated based on the changes in latitude and longitude as well as the cosine of the latitudes of both points. Next, we calculate the value of c using the inverse tangent function with two parameters, which helps in computing the angle from the value of a:

$$c = 2 \cdot atan2\left(\sqrt{a}, \sqrt{1-a}\right) \text{ (2)}$$

Finally, to get the distance (d) between the two points, we multiply the value of c by the radius of the Earth (R), which is approximately 6371 km:

$d = R \cdot c$

Where:

- R is the radius of the Earth, which is 6371 km.
- Δlat is the amount of change in latitude.
- $\Delta long$ is the magnitude of change in longitude.
- c is the axis intersection calculation.
- d is the distance in kilometers

It is important to note that for calculations using the Haversine formula, one degree must be converted to radians, which is equivalent to 0.0174532925 radians per degree.

BLACK BOX TESTING

Black box testing is a software testing method that focuses on the functionality side, especially on the input and output of the application (whether it is as expected or not). This testing stage is one of the stages that must exist in a software development cycle. With this black box testing, it is hoped that if there are errors or deficiencies in the application, researchers can find out as early as possible.

USER ACCEPTANCE TESTING (UAT)

UAT testing is a testing process by users which is intended to produce documents that are used as evidence that the system developed is acceptable or not by the user, if the test results can be considered to meet the needs of the user then the application can be implemented. Testing with UAT is done by asking several questions to agency employees who act as users, this test involves 10 staff environmental department (Daryono, Ika Seftiarini, Lilis Sugiyarni, Agus Zainal, Sulistyo Wahyudi, Anjiatno, Marjuki, Robit Fuadzi, Nonik, Syahrul Badri).

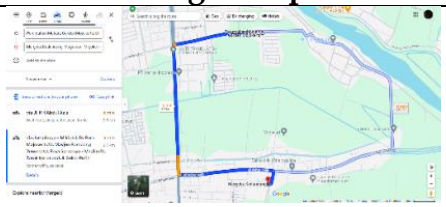
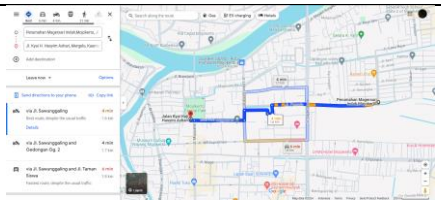
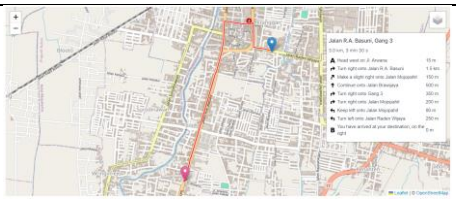
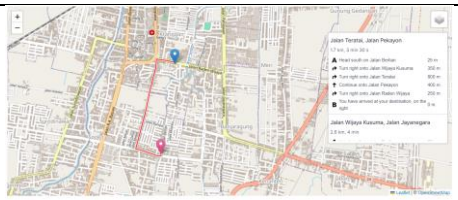
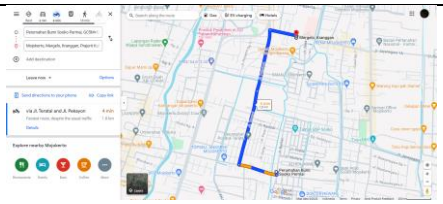
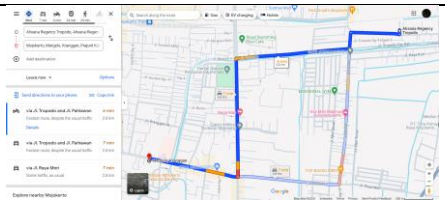
TESTING SAMPLE

Wiragatra Website Customization Sample regarding the closest route search between Open Street Maps and Google Maps.

Table 3.1. Housing Sample in Mojokerto

No	Address	Latitude	Longitude
1	**Mutiara Garden Housing** Banjar Mlati, Lengkong, Mojoanyar, Mojokerto Regency, East Java 61364	-7.450266665407423	112.46748412003461
2	**Magersari Indah Housing** Pisang Street No.63-81, Mergelo, Wates, Magersari, Mojokerto City, East Java 61317	-7.462750250816446	112.44432551678537
3	**Wisma Sooko Indah Housing** R.A Basuni Street No.83, Sooko, Mojokerto District, East Java 61361	-7.495836378249211	112.42425193085323
4	**Bumi Sooko Housing** Berlian Street, Mergelo, Sooko, Mojokerto District, East Java 61361	-7.491410485246065	112.43261012693156
5	**Ahsana Regency Tropodo** Tropodo Street, Mergelo, Magersari, Mojokerto City, East Java 61315	-7.472857635888468	112.4502510636483

Table 3.2. Wiragatra Nearby Box Testing Sample with Google Maps

No	Nearby Box Wiragatra	Google Maps	Description
1			Suitable
2			System Finds the Nearest Route
3			Google Maps Finds the Nearest Route
4			Suitable
5			Suitable

MAINTENANCE

The last stage in the waterfall method is the operation and maintenance of the system. System maintenance is carried out in stages on a system that has been finished and used by users. Developers can make improvements to system errors that were not detected in the previous stages. System maintenance includes error correction, system upgrades and system adjustments to the needs and perhaps there are additional suggestions from the Mojokerto City regarding the development of this Wiragatra system.

CONCLUSION

The designed management information system can assist the Mojokerto City Environment Office in managing textile waste, user data, and monitoring the distribution of Wiragatra waste bank locations. In addition, the developed Wiragatra website aims to

help donors find the distribution of Wiragatra waste banks by calculating the distance between two points using coordinates based on the length of a straight line on longitude and latitude, which implements the nearest route search from the Haversine method. Real-time navigation results are directed to Google Maps.

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REFERENCES

Arfiani, I., Prasetyo, P., & Suratin, M. D. (2022). Penerapan Haversine Formula dalam Pencarian Lokasi Bank Sampah di Kabupaten Bantul. *Sainteks*, *19*(2), 129. https://doi.org/10.30595/sainteks.v19i2.13470

Change, W. 4. (2020). Kekno Klambimu: Sumbangkan Baju Tidak layak pakai untuk Dikreasikan Menjadi Barang Baru - Artikel Dan Berita Pengelolaan sampah Dari Waste4Change.https://waste4change.com/blog/kekno-klambimu-sampah-tekstil/

Chiang, T. W., Yang, C. Y., Chiou, G. J., Lin, F. Y. S., Lin, Y. N., Shen, V. R. L., Juang, T. T. Y., & Lin, C. Y. (2022). Development and Evaluation of an Attendance Tracking System Using Smartphones with GPS and NFC. *Applied Artificial Intelligence*, *36*(1).

Elgamar. (2020). *Buku Ajar Konsep Dasar Pemrograman Website dengan PHP*. Ahlimedia Book.

Hermansyah, F. (2022). *DLH Kota Mojokerto Galakkan Pemilahan Sampah*. Jawa Pos Radar Mojokerto. https://radarmojokerto.jawapos.com/mojokerto/821010252/dlh-kota-mojokerto-galakkan-pemilahan-sampah

Holdi, A., Irwansyah, M. A., & Novriando, H. (2021). Aplikasi WebGis Fasilitas Umum Menggunakan Library Leaflet dan OpenStreetMap. *Jurnal Sistem Dan Teknologi Informasi (Justin)*, *9*(3), 334. https://doi.org/10.26418/justin.v9i3.44442

Lamanauskas, V. (2019). 3rd international Baltic symposium on science and technology education "Science and technology education: Current challenges and possible solutions (BalticSTE2019)": Symposium review. *Švietimas: politika, vadyba, kokybė / Education Policy, Management and Quality*, *11*(1), 42-48. http://oaji.net/articles/2019/513-1567660630.pdf

Juliandy, C., Andy, A., & Siahaan, A. (2021). Penerapan Sistem Informasi Geografis Pelaporan Kecelakaan Lalu Lintas di Kota Medan Berbasis Web Menggunakan Metode Haversine Formula. *Jurnal Ilmiah SMART*, *5*(1), 251–257.

Nurtaqiya, I., Gusti, I., Putra, L., & Prismana, E. (2023). Sistem Informasi Geografis Berbasis Web untuk Pemetaan Pondok Pesantren di Kabupaten Tuban Menggunakan Library Leaflet Js. *Journal of Informatics and Computer Science*, *05*, 28–36.

Pamungkas, C. A. (2019). Longitude Dengan Metode Euclidean Distance. 5.

Renaldi, R., & Anggoro, D. A. (2020). Sistem informasi geografis pemetaan sekolah menengah atas/sederajat di Kota Surakarta menggunakan leaflet javascript library berbasis website. *Emitor: jurnal teknik elektro*, *20*(2), 109-116.

Ridha, A. (2023). *Penentuan rute terdekat penjemputan sampah menggunakan metode Haversine pada aplikasi refresh app* (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).

Setiawan, M. H. F. (2020). *Sistem Pencarian Wisata Bima Berbasis Android Menggunakan Metode Haversine Formula* [STMIK AKAKOM Yogyakarta]. https://eprints.utdi.ac.id/8886/

SIPSN. (2023). *Capaian Kinerja Pengelolaan Sampah*. https://sipsn.menlhk.go.id/sipsn/

Tamara, P. (2022). *Sistem Informasi Geografis Pemetaan Reklame di Kota Medan Berbasis Web*. Universitas Negeri Sumatera Utara Medan.

Yudhanto, Y., & Prasetyo, H. A. (2019). *Mudah Menguasai Framework Laravel*. Elex Media Komputindo.