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OPTIMUM ROUTE PLAN FOR EFFECTIVE COLLECTION OF AN INDUSTRY LEVEL BY PRODUCT/WASTE

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ABSTRACT

Effective waste management is critical for sustainable development in manufacturing industries, especially in managing industrial waste. Industrial waste can be transformed into high-quality products through circular economic practices, promoting sustainable development. This research aims to develop a methodology to identify an optimal route plan for collecting and distributing industrial waste and products, promoting circular economy practices. To achieve this objective, waste generated by a selected industry needs to be investigated to determine its potential for reuse in other industries. Data on the quantity and variety of waste generated daily was collected, and industries that use waste as a resource to develop their products were identified. The linkage between industries that demand waste as a raw material and those that generate waste can be established using a Geographical Information System. The study focuses on concrete demolition waste and aims to link metal crushing, aggregate suppliers, and concrete block manufacturing industries. The optimized route plan would benefit third-party sub-distributors, reducing transportation costs and facilitating effective transportation. Additionally, it would enable new entrepreneurs to establish industries and maintain a good supply chain, creating jobs.

KEYWORDS: *Optimum Route Plan, Concrete Waste, Algorithm, Waste Collection*

1 INTRODUCTION

The fundamental reason behind this study is the requirement for an effective supply chain for the products and wastes produced by various industries. The main objective of this study is to create a general method to find an optimum route plan to effectively collect and distribute products/wastes throughout the relevant industries. The major outcome of this study would be an algorithm to be used for ICT tool, that could represent all the related industries and the least time-consuming routes to reach their destinations. The system would be able to provide numerous benefits for sustainable development worldwide. Koisicek and Tesar's (2012) paper provides an analysis of a module enterprise information system aimed at developing an optimum route plan to improve the transportation system, considering various constraints such as fuel, capacity, movement costs, pickup costs, number and type of mobiles, roadmap graph types, initial locations, initial fuel, and locations. In this study, a comprehensive system to improve the supply chain management will be developed.

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Mahavar V. et al. (V, 2019) have proposed an optimum route plan for a city using GIS technology to facilitate effective transportation and reduce traffic congestion. They used Q-GIS and ArcGIS network analyzing tools to analyze road network data. Their research helped to determine the service area coverage of facilities by finding the shortest routes and reducing travel time and distance. These findings were used to improve the supply chain management system of this study.

Finally, Kumarage S.P. (2018) research shows that crowdsourced travel time data and transport planning operations can be identified using data from the Google Distance Matrix API. They developed a method for estimating traffic flow based on machine learning for urban roads. Their research provided valuable insights into using journey time data, which was used to identify the optimal route and develop an effective transportation system for this study.

2 METHODOLOGY

This study aims to establish an effective waste management system that promotes a circular economy by identifying waste-demanding industries and waste-generating industries. The methodology involved identifying waste-demanding and waste-generating industries, developing a case study methodology, creating a database, and developing a general methodology. The following steps were taken to achieve the objectives of the study:

The first step involved identifying industries that could use waste materials as raw materials for their production. The study identified these industries based on their product demands and their willingness to use waste materials in their production process. Additionally, the study identified the locations of these industries and the waste materials required from other industries.

The second step involved identifying industries or ongoing projects that generate waste material that could be used as raw material by another industry. The study identified these industries based on their waste production rates, waste composition, and the potential demand for their waste materials.

The third step involved selecting a waste material as a case study and developing a methodology to establish an effective supply chain between the industries. The methodology was designed to ensure continuous supply and demand throughout the industries, and an effective transportation system was deemed essential. The case study methodology was developed based on the following steps:

- Analyzing the waste material properties and the requirements of the waste-demanding industry.
- Assessing the transportation requirements and costs.
- Establishing a communication platform between the waste-generating and waste-demanding industries.
- Developing a monitoring system to track the waste material flow and the production of the waste-demanding industry.

The fourth step involved creating a database that included all the details about the waste materials generated by the industries and the industries that used the waste materials in their production. The database was designed to collect data and information on the daily or weekly demand of the industries and their production capacities. Additionally, the database provided a platform to purchase and sell materials between industries.

The final step involved developing a general methodology that incorporated the case study methodology and the database. The general methodology provided an effective supply chain throughout all the relevant industries and ensured continuous supply and demand. The general methodology was based on the following steps:

- Analyzing the waste material properties and the requirements of the waste-demanding industries.
- Assessing the transportation requirements and costs.
- Establishing a communication platform between the waste-generating and waste-demanding industries.
- Developing a monitoring system to track the waste material flow and the production of the waste-demanding industries.
- Utilizing the database to collect data and information about industries and their demands.
- Providing a platform to purchase and sell materials between industries.

There are various materials like demolished concrete, porcelain waste, timber dust, polystyrene waste, and chemical wastes, etc. generated by industries that can be used as raw materials for other industries. As mentioned earlier concrete waste has been chosen as the focus of the case study.

In this case, demolished concrete debris has been chosen as the raw material for the block-making industry, as it is generated by ongoing building and road construction projects. Therefore, the system being introduced must be capable of effectively collecting and distributing the material to various industries. Additionally, the block-making industry requires crushed concrete, which must also be taken into account when developing the optimal route plan.

Furthermore, there is an intermediary requirement for these materials, which is an important factor to consider when selecting the case study material.

2.1 Data collection for the case study

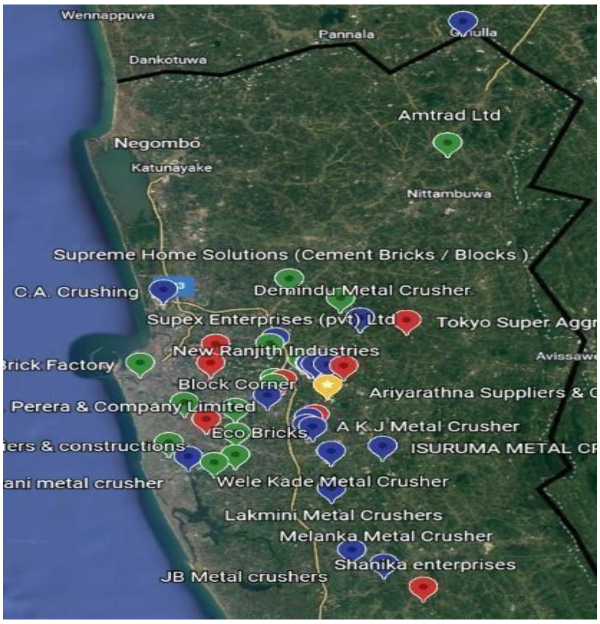

Figure 1: Locations of the case study

Destinations	Representative color
Metal crushers	Blue
Aggregate suppliers	Red
Brick Manufacturing industry	Green

Figure 2: Color notations

Data collection of buyers

Table 1: Data collected from the block manufactures

Company name	**Location**	**Output capacity (Pcs) /per day**	**Have you ever tried crushed concrete as a Material ?**	**If it is effective and meeting the same strength requirements are you willing to ?**
Supreme home solution	No,31/2, Kandy Rd, Kadawatha	1500	No	Yes
Supex Enterprises (pvt) Ltd	No 99/C, Mabima Heiyanthuduwa, 11618	4000	No	Yes
My cement block industries	267/2, High level Rd, Maharagama, 10280	1500	No	Yes
Dahara International cement block	Millewa road, Millewa	4000	No	Yes

Data collection of Intermediaries (Metal crushers)

Table 2:Data collected from the metal crushers

Company Name	**Location**	**Crushing variants (up to now)**	**Max. Output Per day (Lorry cub)**	**Stocking capacity (lorry cub)**
Isuruma Metal crusher	Tummodera - Puwakpitiya Rd	6’x4’	12	-

Datyarathne metal crusher	Gemunu Mawatha, Homagama North	6’x4’, demolished concrete	20	50
Jayakmala metal crusher	2471/A, vaikkiya Wasththa Rd, Kaduwela 10640	6’x4’	90	20
Isuru metal crushers	No 382, Yakala Rd, Kaduwela 10640	6’x4’, 6’x9’	135	-

2.2 Developing a methodology to have an effective transportation.

The theoretical methodology that exists to execute the optimum route plan is the “Transportation Problem’’ **-** “A specific kind of linear programming issue called the transportation problem seeks to reduce the price of conveying a good from M suppliers to N destinations.’’ – Google

Notations for the locations

C–Optimum route (less traffic and shortest distance)
O–Construction sites (concrete debris sellers)
D–Buyers (Block makers), Intermediaries (Metal crushers)

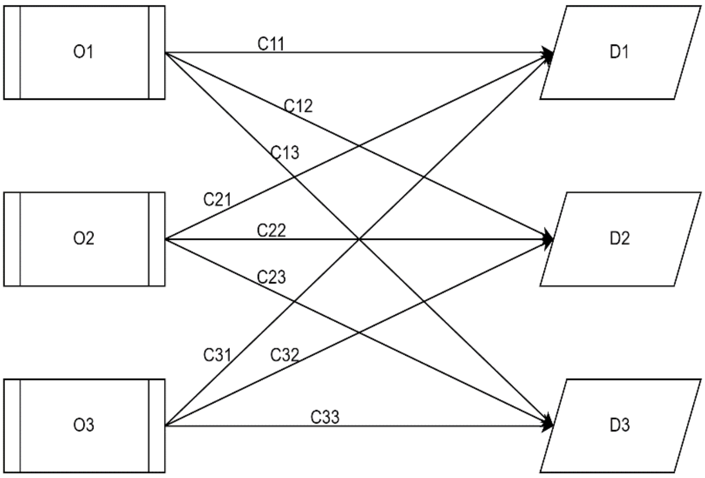

Figure 4: Representation of the theory of Transportation problem

(1)	D1	D2	D3
O1	C11	C12	C13
O2	C21	C22	C23
O3	C31	C32	C33

D – Intermediary (Metal crusher)
O – Concrete debris seller
C – Optimum route

(2)	D1	D2	D3
O1	C11	C12	C13
O2	C21	C22	C23
O3	C31	C32	C33

D– Buyer (Cement block maker)
O – Intermediary (Metal crusher)
C – Optimum route

Figure 5 : Processors of the theory of transportation

This is a representation of a methodology to execute an optimum route plan and probably it would work for a few chosen industries but not for all. So that is where it requires a proper methodology to execute an optimum route plan.

3 RESULTS

Given the technological advancements of today's world, it is advantageous to create a general methodology for finding the optimal route using web-based applications. Google Maps' GIS and Google API are two identified methods for determining the shortest and least congested route, as well as the nearest company to the transporter.

Both of these systems require a specific format for executing the optimal route, which can be achieved through a web-based mobile application carried on the transporter's device. To this end, an algorithm has been developed based on a specific case study.

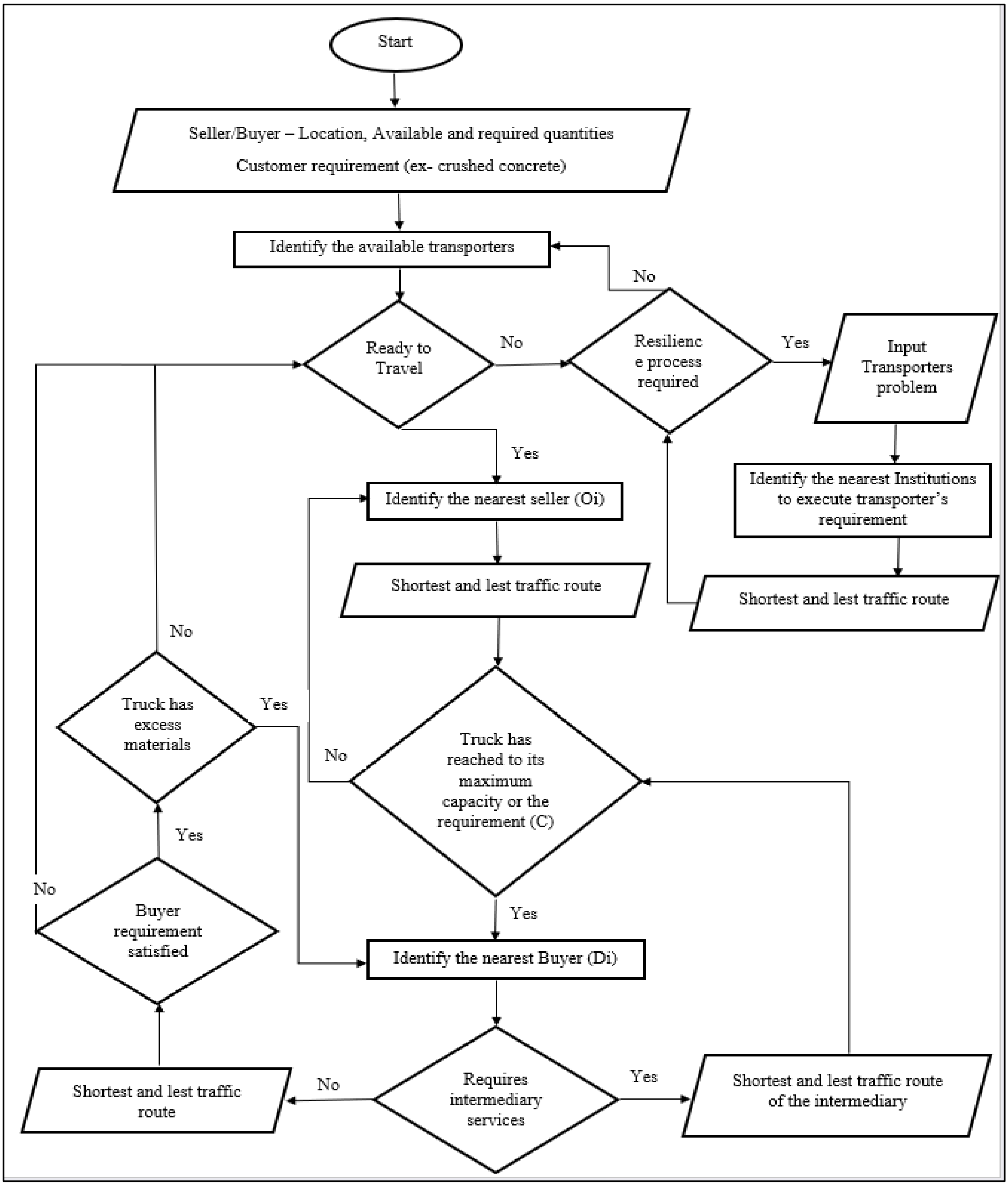

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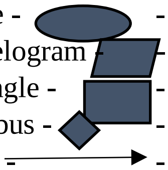
Figure 6 : Algorithm for the case study

3.1 Algorithm

The assumption that have been considered when creating the algorithm – There is a continuous demand and supply for the material.

Notation of Algorithm



Ellipse - - Starting node
Parallelogram - - Inputs/Outputs
Rectangle - - Processing (Active state)
Rhombus - - Decision node
Arrow - - Control Flow

3.2 Data

1) Available vehicles (Trucks) – Truck Capacity (C)
2) Origin Locations (Oi)
3) Destination Locations (Di)
4) Available Routes – The roads which has no restrictions for heavy vehicles, shortest and less traffic route.
5) Supply quantities from each origins (Xi) – X1, X2, X3…Xn
6) Distributive quantities for each destinations (Yi) – Y1,Y2,Y3…Yn

3.3 Truck capacity equations

X1+X2+X3+…+Xn =< C
Y1+ Y2+Y3+…+Yn =< C

3.4 Example based on hypothetical data to demonstrate the mobile application of the algorithm

Inputs -
Seller – Project/ Building Construction by seller 1
Location - 278 Union Pl, Colombo 00200
Available Material – Concrete test cubes
Available quantity – 3 Lorry cubes

Buyer – Project / Buyer 1
Location - 56/1 Pagoda Rd, Nugegoda 11222
Required material – Crushed concrete
Required quantity – 4 lorry cubes

- There is a requirement of intermediary

Intermediate party – intermediate party 1
Location – 436/3, Hokandara 10012

Process – Identify the available transporters by there feedbacks and send details about the route and work which has to be done.
If "transporter is available to travel'' – Give an **output** - the seller's details (ex:-Location - Samson Metal Crushers & Company, 436/3, Hokandara 10012, Graphical representation of the Route)
Or else – "Procced to the resilience requirement''

- After the truck is been loaded by sellers available quantity

If "The driver confirms that the truck has reached it's maximum capacity (C)" **Process** - Check for the intermediary requirements
Output – The intermediary details (The optimum route, location, contact details)

After the concrete has been crushed and loaded as per the requirement of the buyer,

If "The truck has reached its maximum capacity and it has no requirement of intermediary services"

Output – The buyer details – (Graphical representation of the Route, Location - 56/1 Pagoda Rd, Nugegoda 11222

If "The buyer requirement is satisfied" - the driver could end the work
Or else "The driver is being asked to travel again''

This is the algorithm that has been created to demonstrate the procedure of the of the web based mobile application. In order to have a continuous procedure requires a data-base which collect and stores all the data and information.

The research by Koisicek and Tesar's (2012) shows that the Route Planning Module (RPM) is a subsystem of ERP (Enterprise Relation Management), CRM (Customer Relation Management), or Supply Chain Management (SCM). Transportation for supply and distribution needs to be well-planned to achieve sustainability goals. Mainly, the system requires a database that includes information about customers, employees, goods, locations, etc. and a way to collect all that information. For the process of transportation planning, a list of merchandise, a list of initial locations, a list of available vehicles, etc., must be maintained. All the lists are composed of detailed information such as the dimensions of the cargo space, the maximum weight of cargo, the places of loading, the quantities, etc. The system that is going to be executed must be able to provide the desired output information, such as a list of generated routes with their descriptions, an assigned vehicle and driver, and a list of merchandise. The result should be dynamic in the sense that the data can be modified during the journey (e.g., the state of being transported, shipped, or waiting for transport) according to current conditions, and the information should be able to be shared with the relative parties (sellers, buyers, and transporters)

3.5 Data Base

The most convenient option for a database is to create a website to share and web database to store all the required data and information in according to have a successful and continuous procedure for the system.

3.6 Optimal route

The transporter has to drive to several locations so, when choosing the location, it should be the nearest located company which require services and the route that is been chosen to drive must be shortest one and the least congested one. We can easily obtain those facilities from the Google Maps and API system provided by the Google.

3.7 Finalized system

As mentioned earlier, executing the whole procedure, requires a database that includes all the details and data that must be used as inputs/outputs for the algorithm. The main inputs for the mobile application would be data from the Web database (supplier or buyer -- location, quantities, etc.). The main process through this mobile app would be to identify the locations of transporters, suppliers, and buyers as per the information given by the website and provide graphical information of the route that has to be taken by the driver. The information about the optimal route can be taken by the Google API system from the identified routes, and the mobile app could directly merge with the Google Map facilities. When using Google Maps facilities, the important part is to restrict the routes where it does not allow heavy vehicles and the routes where it has less width to drive heavy vehicles.

Also, keeping an active procedure it requires a resilience procedure to overcome the problems that occur during transportation. The mobile app would be able to identify the driver's problem through their feedbacks and to develop the connection with the nearest institutions like garages, service centres, hardware, etc. The system would have the same operating stage after the resilience procedure for the vehicle.

4 DISCUSSION AND CONCLUSION

This research project aims to address the need for an efficient supply chain for both products and waste generated by various industries. The primary objective is to develop a general methodology that ensures effective collection and distribution of materials throughout the relevant industries.

The initial phase of the project revealed that there are numerous materials that generate waste, as well as materials that can be repurposed as raw materials in different industries. Hence, it is crucial to have an efficient collection and distribution system for these identified materials. To develop a general methodology, a preliminary method based on one material is required. Demolished concrete debris has been chosen as the case study for this project, among various other materials like porcelain waste, timber waste, and chemical waste. Concrete debris generated from construction sites can be used as raw materials for the concrete block making industry.

The system that will be developed must meet several outcomes, including efficient transportation, continuous operation, value addition for materials, and cost estimation for delivered products. An IT-based solution has been chosen, given the prevalence of technology worldwide. Developing a mobile application will provide drivers with graphical information about their routes, making transportation more efficient. This can be done using API and GSI maps provided by Google services. The data required for the mobile application, such as location and available routes, will be collected and stored. Additionally, the system will require a web database for administration and efficient and continuous procedure. The database will collect information about customers, employees, goods, locations, etc. Furthermore, the website will provide more in-depth details on the uses of the materials, how they may be utilized as alternatives to manufacture other products, and how the world benefits from their contribution.

If the system is properly implemented, several benefits will be achieved, including reduced fuel consumption, reduced industrial waste, added value to waste materials, and the creation of new jobs for drivers and entrepreneurs.

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