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Management of Food Waste by Using GIS Environment: A Review

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***Abstract*—** A problem of food waste becomes a critical issue and achieving won't be easy because of growing population and increasing urbanization. It affects the social and environmental problem. Every time food is wasted the other sources like water, energy, time, manpower, land, fertilizer, packaging and mainly money is also wasted. Waste has to paid twice once in the form of packaging and again for disposal. In food waste management collection of waste food from bins plays a crucial role and how it is reduce, reuse and recycling. This paper proposes a discussion about role of geographic information system in management of food waste and its use in collection of waste food for reuse, recycling and reduction in waste and optimization of waste food collection and transport.

***Keywords*—** Remote Sensing(RS), Geographic Information System(GIS), Food Waste, Food Waste Management(FWM). Network Analysis(NA).

I. INTRODUCTION

Today the world's largest problem is of solid waste management and food waste plays an important role. Waste management is the process of collection, sorting, optimization, recycling, reuse, transport and disposal of waste. There are number of social and environmental issue contends with the waste created by daily operation. Wasteful food-consumption is also leading to unsustainable demand for natural resources [1]. When huge quantities of food goes wasted instead of feeding hungry mouths, it ends up in a landfill means ultimately contributing to global warming by releasing methane gas and which has 21 times the global warming potential of carbon dioxide.

Food waste is defined to include refuse disposal from hotels and restaurant, wedding halls and grand parties. The quantity of food cooked is over rated on many other occasions and ultimately the surplus food goes to the waste bins. Wasteful food-consumption is also leading to unsustainable demand. Municipal solid waste management play important role to care of human health and environmental quality. GIS technology has not been conveniently used in Indian cities. There were no studies aimed at integrating these technologies into a planning process to improve the efficiency of municipal solid waste management [2].

To provide a set of Geographic Information System (GIS) tools that will allow the state to use GIS technology to map food waste location by waste types, waste quantities, and other variables, in order to facilitate improvement of composting or organics diversion infrastructure on a ward basis. Using GIS system, location can be digitizing on base maps that contain features such as streets and road, major traffic arteries, and ward boundaries. Users of the database or GIS system can view waste locations at scales ranging from generalized city maps to large scale maps that pinpoint food waste locations on individual streets [3].

A huge amount of food waste usually takes place at Weddings, Religious feasts, Parsadi, Paus Bara, and various social collections. At Bangalore, annually 943 tons of food wasted during weddings is enough to serve 2.6 core people a normal meal and at an average cost of 40/ - per meal the food worth Rs 339 crore is wasted. Wastage is more with buffet (22%) than served meals (20%). In Bhubaneswar food waste contributes to 26.63% of the city waste which is directly thrown into the bins. In Jaipur 835 tons of food is wasted every day out of the approximately 7500 tones food purchased every day [4]. However, there is no comparable investment in reducing food waste. We need to address our global resource challenges from a balanced perspective that includes bolstering efforts to improve the supply of resources, but it require better management of our resource demands, especially in improving efficiency and reducing waste.

Location modeling in GIS environment is a convenient way to improve services and efficiency in municipal solid waste management. To determine the location of a food waste bins from respective hotels and wedding halls. Differentiate the waste food by category and transport to recycling or optimization to hunger people and animal feed. In this study, they have included these factors and applied software that fully integrates GIS with location- modeling, for spatial location of food waste bins [5].

II. WASTE FOOD GENERATION

Waste generated from hotels according to their opinions very little food as the plates generally come back clean. However, wasting of food comes from a variety of sources [6].

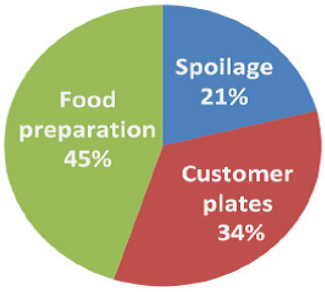

Fig 1. Types of food waste management

- out of date and spoiled food
- Trimmings and Peelings
- Inedible products
- Kitchen error
- Plate waste

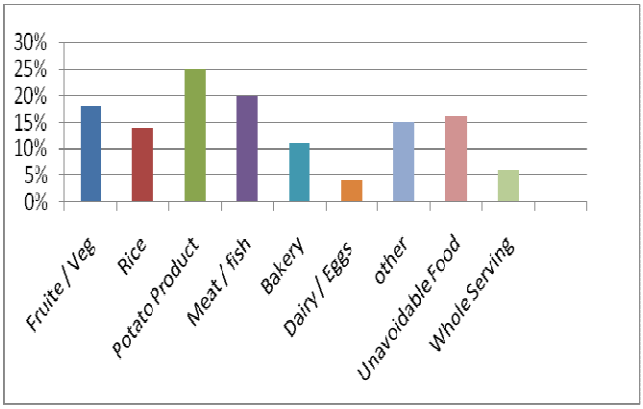

Fig 2. Comparison of food waste products

In case of best-run kitchens there will be some food waste. The priority is to reduce quantity of wasted food in your property, for that, how best is dispose of unavoidable waste. Food waste is major problem and how it is reducing from lawn and hotel is a typical task so be prepared and follow various step first is food waste measurement. Collection of food waste starts with three separate bins (one each for preparation, spoilage and plate waste), to understand why and where this waste arises and to find out where the most food waste is being generated [7]. Food that would otherwise have ended up in the sink disposal unit. This is going to present a challenge to staff to do things differently so preparation is key– make sure staff understands why you are doing this and get on board. Second is Development of an action plan to reduce food waste. Planning and ordering. Using some pre-prepared frosted or dried ingredients will help to reduce wastage; we can freeze most foodstuffs – even eggs.Be familiar with reservations forecasts over-prepare. Locate the menu for slower-moving dishes. Choices don't need choices for customers and keeping the menu simple reduces the possibility of waste. Be creative with menus we have, Consider what perishable creations or ingredients will be used in various ways, e.g. bones adornment or fish adornment for stock, bread for breadcrumbs, pate used for soups, ingredients etc. and menus have planed accordingly to these ingredients use [4]. Third is Review progression on the plan each month. Discuss with your staff and get feedback from progress being made. This will keep people motivated and involves on work. Measure the amount of waste produced regularly and work out how much money is being saved [6]. And final step is sharing your good work with consumers, staff and industry. Don't forget to thank staff and also keep them motivated. Recompense is excellent to recognize the efforts they have made.

III. SOLUTIONS FOR TREATMENT AND DISPOSAL OF WASTE

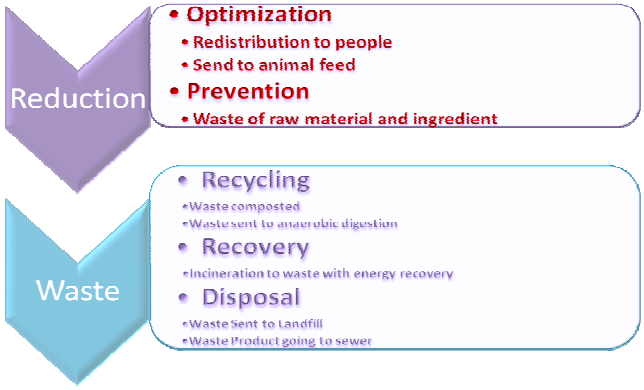

Fig 3. Solutions for disposal of waste

Legislation and availability of local services will affect your choice of options so check locally and apply the best option according to the food recovery hierarchy above.

The best method to use excess amount of food is to feed the hungry people. Many charities around the world are collecting excess food, including prepared food, to provide for the poor people, though note there may be various legal issue and health precautions and safety requirements to check with legal team and with the charity in questions [3].

This process mainly depends upon the market and capabilities of the food bank. Identify food banks or agencies that can accept prepared food and then identify hotels in the area they operate that might want to

participate. The food agency can then operate with the hotel to determine the types of food they can take and the process for storing and distribution. In many situations it is easier to freeze and schedule regular pick-ups. Some organizations may be able to pick up the same day and maintain the heated or cooled product directly to the end recipient but arranging logistics for small regular donations can be difficult task. Note that the available food banking the best, most cost-effective and environmentally friendly solution is to stop food becoming waste or surplus in the first place - being eaten is always the best option for food! [6].However, food you cannot use does not always need to become waste. Distinguish between 'surplus food' and 'waste'. Even the best-run kitchens generate some food waste, so what you can't reduce, priorities for treatment as per the above diagram.

infrastructure/economics is set up to maximize large amount of non-perishable things from donors like grocers or manufacturers, so accommodating relatively smaller donations and perishable food can be challenging, but it is worth exploring and is a very rewarding work[4].

A. Optimization

(a)Optimization - animal feeds:

Conversion of food waste to safe animal feed is an option to the some parts of the world. Impenetrable air, hygiene, cleaning a globally leader, packaging solutions with including food safety programs, has been leading several CSR programmed such as Hope used in Soap and Linens for Life in the industry. They now pilot a scheme to collect food waste from hotels to convert it to dried food pellets for distribution to poor farmers as animal feed [3].

(b)Recycling – composting:

Synthesizing is nature's way of recycling. For the development, organic waste, such as food wasting and garden clippings, is turned into valuable fertilizer due to biodegradable. The advantages to composting are reduces the amount of solid waste in your trash and when used in a garden, it fertilizes the soil. If our property has greenhouse, composting may be an option at on-site, instead of, seek a composting contractor in your area [8].

B. Energy recovery from food waste

(a)Anaerobic digestion:

Anaerobic Digestion is the process of breaking down of ecological material without the presence of oxygen by methanogens the micro-organisms, this process of anaerobic digestion is a source of renewable energy, since the food waste is demolished down to produce bio-gas (a mixture of carbon dioxide and methane) which is useful for energy production. The bio-gas can be used to generate heat and electricity to power on-site equipment and the infrastructure, the remaining electricity will be transported to the national grid [3][6].

(b)Biofuel from waste cooking oil:

Biofuel generation from cooking oil waste is important process. There can be much waste of cooking oil. Gathering of such waste is done and by proper recovery/recycling process we can generate biofuels. This can be used in vehicles as addative substance for petrol. IT can also be used for electricity generation [5].

C. Optimization Food Recycling Program

(a)Multiple Bins:

Traditionally we have only one type of bin which is used to collect all type of waste. But this can be hectic process to separate different types of waste. So we can put multiple bins which can collect degradable waste, food waste or spoilage waste. This can reduce time to separate wastes. Also proper placing of bins is required to cover up sufficient area. And frequency must be good to collect these wastes [8]. And number of collection bin can be calculated by given equation(1) [9].

$$N = W / (D*S*AF*CF) \quad (1)$$

Where, N = Number of collection bins
W = Total quantity of waste generated per Day in Kg
D = Density of waste in Kg/m3
S = Size of bins in m3
AF = Average filling rate of bin. (Generally 80 %)
CF = Collection Frequency

(b)Choosing appropriate Waste Management Solution:

There are different kinds of waste. Each one can not be manage by one solution. For example, plastics can be recycled in factories or food waste can be decomposed bio-degradable way.So choosing appropriate waste management solution plays vital role in this program. We can recycle, recover or degrade the waste [6].

(c)Data Collection:

In this phase, we need to track all the details regarding how much waste has been collected or how much waste has been recycled/reuse. All this information must be given to waste management controller. By using this information we can do future planning about number of bins and its placing. Using this data different solution can be incurred [9].

(d)Work together:

Consider working with neighboring businesses to buy up food waste and recycling collections, where appropriate. There may be adaptability/austerity of scale to be made by working together. Where larger scale is essential, see what you can do on a national or industry scale [1].

IV. METHODOLOGY

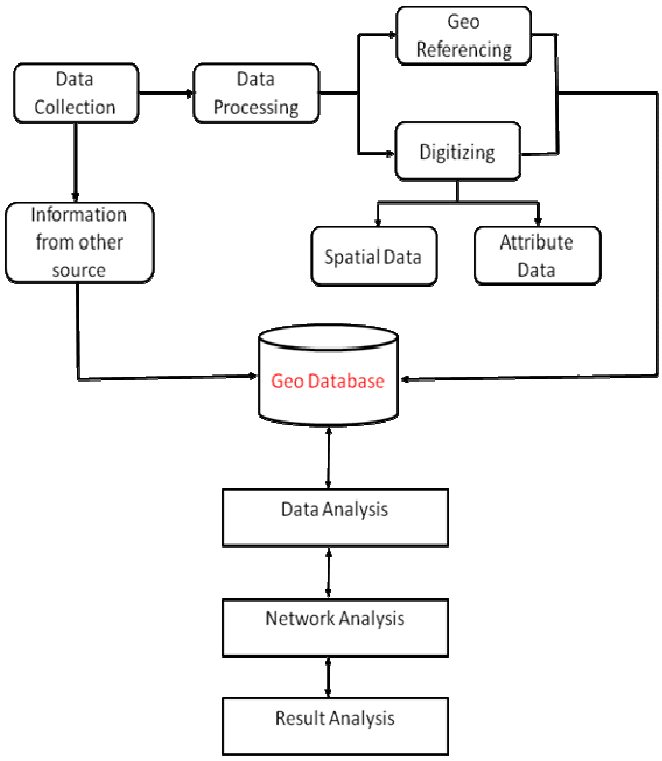

Fig 4. Methodology of proposed work

A. Data collection

(a) Study area:

It is the first step chooses a study area for project. Toposheet of city can be taking from government office which show the scale trace and scan for consider as a base map for further work. Find out the coordinates of given city in the form of latitude and longitude. Creation of map data collected in the form of spatial and attributes data, spatial data can obtain by digitizing the base map of city along with its attribute data.

(b)Data Processing:

In data processing both spatial as well as attribute data getting merge together to form new GIS database. Spatial data shows the map and attribute data shows the necessary information about the task and this can be use for next steps for further work.

B. Geo-referencing

The geographic data can be integrated with other GIS data and it is essential to align with the existing geographic referenced data called geo-referencing. It is more important stage for obtaining high accuracy or precision in measurements it is known as rectifying map. Geo-referencing allows us to register the base map with respect to the earth's surface. Geo-referencing can be done by selecting the four ground control points on the corners of the scanned map and placing that point by giving appropriate latitude and longitude values and it is very important to perform this step with minimum RMS error in order to gain maximum accuracy. The RMS (Root Mean Square) error can be calculated by using following equation (2).

$$\sqrt{(Xact - Xest)^2 + (Yact - Yest)^2} \quad (2)$$

(Where Xact and Yact are the x and y value of the actual location, Xest and Yest the x and y values of the estimated locations [1]. RMS error measures the deviation between actual and estimated locations of control points. In arcgis

(a) Digitizing:

Digitizing is a process to convert paper map features into digital format. It can be creates spatial data and allows the attribute data to be stored in together.

(b) Shape files creation:

Shape file creation is next step after geo-referencing. Select the folder in which you will create your new shape file, so select that folder and right-click on it. Go to New and select shape file and give an appropriate name. Click on Edit to see the coordinate system of the file. In the Spatial Reference Properties window click Import to use the projection of the Toposheet layer. Click OK and OK again to create the shape file [10]. Two separate shape files created. Point shape file used for storing object data and polyline for storing road network data.

(c) Creating Personal Geo-database:

It is a first step for the data processing stage. Geo-database stores all the information about the projection of maps,

spatial data and attributes data. After the creation of geo-database, the external/personal database is joined together by database connection.

C. Data Analysis

Data analysis can be perform for creating network analysis and use for find out the shortest paths and closest facility of desired location on a network.

(a)Creating network dataset:

The creation of network dataset incorporates the model which show multimodal network for transportation. Network dataset are collection of feature classes that posse's connectivity among the road network. It is used for creating shortest path using network analysis tool and find the closest facility available from location of client.

(b) Shortest path analysis:

Shortest Path problems are a key issue in network analysis. Travelling is part of daily life of every people. As the traffic condition among a city changes from time to time and there are usually a huge amounts of request occur at any moment, it needs to quickly find the solution [11]. Network analyst tool of ArcGIS uses a number of shortest path algorithms.

(c) Closest facility analysis:

The closest facility solver displays the best routes between incidents and facilities.For finding the closest facility; we have to specify constraints, like a cutoff cost beyond which ArcGIS Network Analyst will not search for facilities. In this example, the hospitals are facilities, and the accident is the incident. ArcGIS Network Analyst allows performing multiple closest facility analyses simultaneously. This means you can have multiple incidents and find the closest facility (or facilities) for each incident. This uses a multiple-origin, multiple-destination algorithm based on Dijkstra's algorithm. Single-origin-to-single-destination route planning service provides travel route from one origin to one destination. In contrast, the single-origin-to-multiple-destinations [17]. route planning service plans the routes from one origin to a final destination through one or multiple waypoints for multiple given source vertices (origin nodes) and one common destination vertex (destination node) in the graph. This algorithm finds a suitable rendezvous-point in which the total cost of paths from each given vertex via the rendezvous-point to the destination vertex is the approximate lowest.

V. FOOD WASTE MANAGEMENT IN RS AND GIS

RS and GIS play an important role in food waste management. RS help in Site selection processing for study area we required a satellite image and it covers a large region with high resolution. GIS helps in creating geo database which is used to take a decision support making problem. It shows both the attribute data as well as map data. It is an effective tool for Geoprocessing [12] [13].

GIS integrates with both software and hardware for collecting, managing, querying, analyzing the data and displaying all forms of geographically information in a computer-based system. It helps to analyze data visually and look patterns, trends, and relationships that might not be visible in tabular or written form. A GIS is different from other information systems, because it integrates common database operations such as query and statistical analysis with the advantages of visual and geographic analysis through maps. Thus, GIS with the aid of control server, food waste collection can be detect and monitors [14] [15].

The role of GIS in food waste management is very large as many aspects of its planning and operations are highly dependent on spatial data. GIS is crucial in maintaining account data to facilitate collection operations such as food waste; analyzing optimal locations for NGOs; planning routes for vehicles transporting unserved food from hotels and wedding hall to NGOs and waste food to landfills; locating new landfills and monitoring the landfill, etc. GIS is a tool that imparts a digital data bank for future monitoring program as well as reduces time and cost [16].

Remote Sensing provides an opportunity to visualize the actual ground features. The Geographical Information System (GIS) can provide an opportunity to integrate the various field parameters with population and other relevant data or other associated features, which help in the site selection. These procedures can benefit from the appropriate use of GIS. The use of GIS in the site selection process will reduce the time and enhance the accuracy [17].

VI. OPTIMIZATION OF FOOD WASTE COLLECTION AND TRANSPORT IN GIS

The optimization of the decision system for collection and transport of food waste is a crucial factor of an sustainable and cost effective food waste management system. The development of optimal road scenarios is a very complex task, based on various excerpt criteria, most of which are geographical means spatial in nature. The common is of vehicle route in which each vehicle must drive and visit all

the desired location to collect food waste. It must be in a way that minimizes the total driving cost, most often defined on the basis of distance travel in given time but also reduce CO2 emissions and fuel consumption[18].

GIS can be effectively used to feature extraction, network analysis, designing thematic maps, access to several layers of data at a time. Also it will help in crossing attribute data with respect to topological and special relationship [19].

A GIS can be effectively used fot the new route identification with the help of various GIS layers to identify a shortest route which will cover less diatance and covers maximum waste bin locations with a less overlaps. GIS provides a solution to choose shortest route for collection of waste. The new suggested route will be cheaper by upto 50% of the old route [20].

Network and Transportation analysis within a GIS environment has become a common in many applications. A key problem is to compute the shortest paths between the different locations on a network. Many shortest path algorithms are used for finding out the shortest route of desired location. We compare the number of shortest path algorithm are given below [21][22].

Table No. 1: Comparison of Shortest path algorithm in ArcGIS

Sr. No.	Abbreviation	Implementation
1	DKQ	Dijkstra's Naive Implementation
2	DKB	Dijkstra's Buckets -- Basic Implementation
3	DKM	Dijkstra's Buckets -- Overflow Bag
4	DKA	Dijkstra's Buckets – Approximate
5	DKD	Dijkstra's Buckets -- Double
6	DKF	Dijkstra's Heap -- Fibonacci
7	DKH	Dijkstra's Heap -- k--array
8	DKR	Dijkstra's Heap -- R--Heap
9	BFM	Bellman-Ford-Moore
10	BFP	Bellman-Ford-Moore with Parent-checking
11	PAP	Graph Growth – Pape
12	TQQ	Graph Growth with Two Queues -- Pallottino
13	THR	Threshold Algorithm
14	GR1	Topological Ordering -- Basic
15	GR2	Topological Ordering -- Distance Updates

VII. CONCLUSION

The improper management of food waste produces many social and environment related issues. RS and GIS can be effectively used in the waste food management and waste collection and transport management for reuse, recycling and recovery. Bin size should be decided in consideration with the generation of amount of waste. On the basis of type of waste generated in particular area. GIS can be conveniently used in food waste collection to decide collection routes to reduce the collection cost and time.

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