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A Web-based Logistic Waste Management System for Guwahati City, Assam(India).

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Abstract :

Today, because of the exponential increase in population, fast urbanization, fast industrialization, increasing per capita income, changing lifestyles, technical advancements, etc., globally, waste management is becoming a subject of great concern. Apart from dealing with waste only, any waste management system has to encompass many other variants, including - environments, pollution, public health & hygiene, local eco-system, etc. So, it is difficult to frame a common global policy or a country's specific policy to meet all the requirements of the local service providers and customers. Preferentially, any waste management system needs to be developed as per the requirements of the local endeavors. In this report, the present waste management scenarios of Guwahati, the capital city of the state of Assam, India, which is the gateway of seven northeastern states of India, are studied and analyzed with reference to its local endeavors. The limitations and deficiencies of the existing waste management system in the city have been critically analyzed with suggestive measures. As a part of the measures, a waste collecting and processing model has been suggested along with an App, "Smart GMC App" which has been developed for better transparency between the service providers and customers(respondents) and monitoring the waste management, from collection to processing and disposal. It is expected that the App, named: "Smart GMC App" would help the service providers: Gauhati Municipal Corporation(GMC) and NGOs, to improve their performances in coordination with the respondents and to meet any eventuality during an emergency.

Key Words: Waste management system; Waste collecting and processing model; Web-based-Smart GMCApp.

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1.0 Introduction :

Materials or products that the generators have no further use or requirement in terms of their own purposes of –production, transformation, or consumption and want to dispose, of are termed as Waste[http://www.unep.org/ietc/our.work/waste]. It is mainly a by-product based on consumer lifestyles. With the advancement of technology, fast urbanization, increasing per capita income, changing lifestyles, etc., waste, particularly solid waste (SW), is becoming a serious universal issue that matters to every individual in the world [Caruso, et al., 1993] This issue has a strong linkage to many other global challenges like: human health and livelihood, global climate change, global poverty reduction, security of food and resources globally, sustainable production and consumption, and overall prosperity - in terms of an individual, in terms of any society or a country. This issue has been further fuelled by the advancement of technology, particularly in the IT sector. To fix the issues arising out of waste, we have to stop our old "Throw away culture". There must be proper global/local legislation to enforce proper waste management systems.

2.0 Waste: Global scenarios:

As per the reports of Global Waste Management Outlook(GWMO), the International Solid Waste Association(ISWA), and the International Environmental Technology Centre(IETC), Bardran, M.F et al(2006), about 7-10 billion tonnes of urban solid waste generated from households, commerce, industry, and construction & demolition, etc. It is further predicted in the report that the Municipal Solid Waste(MSW) generation will double in the next 15 – 20 years in countries with lower-income cities, like Asia, and Africa. As per the World Bank report (2012) during 2002-2003, globally, there were nearly 2.9 billion urban residents generating about 0.64 kg of MSW per person per day(0.68 billion tonnes per year), which increased to about 3 billion residents and generating 1.2 kg per person per day(1.3 billion tonnes per year). This increase has been attributed to many factors like the increasing rate of urbanization, an increase in income level in the urban areas, an increasing population at a faster rate in the urban sectors, an increase of waste per capita, migration from rural to urban areas and thereby causing the increase of the number & sizes of cities etc. Globalization has also played an important role in the global waste generation scenario. The generation of huge

industrial and hazardous waste in developing countries can be also thought of as a consequences of globalization. As per the Global report, [Bardran et al., 2006], annually about 1.3 billion tonnes of food waste are generated causing nearly 9% of Greenhouse gas(GHG), which is a matter of serious concern. Globally, about 2 to 3 billion people are not accessible to waste collection and disposal services, which are mostly from urban areas.

From the global perspective, as per the Global Waste Management Outlook (GWMO) report, around 15-20 million people got new jobs in the informal waste management sector during 2000-2010. As an urgent and essential measure, against the global waste generation and management scenarios, the GWMO, an international body under the shed of the United Nations Environment Programme(UNEP) and IETC, vide governing council decision: GC 27/12, directed all the national policy planners across the globe, for developing a global outlook of challenges and policies for waste prevention, minimization, and management [Nganda 2007]. The GWMO further highlighted the cost that has to be paid for not paying attention to the serious consequences of waste products. The international organization, particularly, stressed on two odd impacts due to inaction of waste, which are : (i) Public health impact of uncontrolled waste: causing gastrointestinal & respiratory infections, particularly in children, blocking drains and aggravating artificial floods and causing spreading of infectious diseases, and (ii) Environmental impact of open dumping and burning: which causes severe land, fresh water, and groundwater pollution apart from causing local air pollution and climate change, [Chang et al.,1996; Costi, et al.,2004; Mahajan et al., 2016].

In view of the above-cited global waste management scenarios, it is clear that waste, particularly, solid waste, is posing a serious threat to our planet, and to the entire global community. The issue is of many folds. It should not happen in a way that – lets one problem be resolved first before the beginning to address the next. However, it is not possible to do everything and resolve all waste-related issues with very high standards at once, particularly, when the resources are limited. To address all the issues related to waste, it is imperative to evolve some efficient solid waste management system via a series of intermediate steps. Many countries have already evolved suitable mechanisms and technology, as per their need, to address the waste-related issues. Developed countries like - the USA, UK, France, Germany, and Japan (also other developed ones), claim their success in solving the waste-related issues to their level of satisfaction [Mahajan, et al ., 2016] Some of the developing countries, for example, China, India, Singapore, Thailand, etc.,

have also evolved their own indigenous technology to resolve the waste-related issues in their respective countries.

3.0 India - Waste &waste management scenarios:

India is the second most populous nation in the world comprising 133.92 crores (2017) which is about 17.86% of the world's population. Area-wise, India is the seventh largest country in the world. In India, about 32.8% of people live in urban sectors. According to a report by ASSOCHAM and Price Waterhouse Cooper (PwC) (2017), [Gogoi, 2013], the increasing rate of urban population in India is 3.3% per annum against the total population growth of 1.19%.

It is expected that the population in India will reach nearly 1.53 billion by the end of 2030. It is further estimated that by the year 2031, about 600 million people will be living in urban areas. The fast-growing population coupled with urbanization and industrialization, is a matter of serious concern, particularly in the waste management sectors. Owing to the growing population, the volumes of waste generated are also increasing every day. So it is now becoming an urgent call for the country as a whole to embark upon efficient waste management practices to reduce the potential and harmful impact on urban population, public health, and hygiene. It is estimated that the present volume of waste generation in India, which is about 62 million tonnes per year, will be boosted to nearly 165 million tonnes by the year 2030.

In this context, we can attribute the seriousness of the waste generated in the country, to the multifaceted factors due to fast urbanization, such as fast migration from rural to urban areas, growing economic activities, industrialization, changing lifestyles, introduction of new technologies to urban environment, and fast urbanization. Presently, the Ministry of Environment, Forest and Climate Change, Government of India is the supreme authority for monitoring the entire waste management scenarios of the country. As per the reports available [Caruso, et al., 1993], out of about 75- 80% of the municipal waste collected, only 22 %– 28% of the waste is processed and treated. However, the scenario has changed since then . The Ministry of Environment, Forest and Climate Change, Government of India classified the types of waste generated as follows:

- Municipal solid waste,
- Industrial waste,
- Bio-medical waste,
- Hazardous waste,
- Plastic waste,
- E-waste,
- Construction & demolition waste.

As per the solid waste management (SWM) regulation 2016, the Government of India, the municipal SWM value chain includes the following stages executing in a sequential manner: [http://www.downtoearth.org.in/news/solid-state-waste management(2016)]

1. Primary waste collection,
2. Secondary waste collection,
3. Transportation,
4. Intermediary storage in a transfer station,
5. Process & Treatment,
6. Disposal in an environmentally sound & acceptable manner

As per the Central Pollution Control Board(CPCB) report (2012-2013), Govt. of India,[Swarup, et al.,1992] , the total volume of MSW generated in India is about 170,000 metric tonnes per day (TPD) and annual generation is about 62 million tones (population census, 2011). About 31.16% population (about 377 million people) live in the existing 4,041 municipal authorities. Considering the seriousness of the population growth rate, rate of urbanization, and industrialization, the Govt. of India has initiated some programs, to deal with possible havoc due to municipal solid waste, such as:

- Jawaharlal Nehru National Urban Renewal Mission(JNNURM),
- Swachh Bharat Mission,
- Smart City Mission.

3.1 Challenges in MSW Management in India

The Govt. of India promulgated guidelines for efficient management of municipal waste by the MSWM Rules, 2016,[http://www.downtoearth.org.in/news/solid-state-waste management,2016] by amending specific Bye-Laws and waste management projects, like - JNNURM, Swachh Bharat Mission, Smart City, etc. But, in ground reality, these MSWM Rules and Bylaws fail to address most of the existing waste-related issues faced by urban masses. Some of the MSWM issues yet to be addressed include:

1. Necessary clauses for effective & efficient implementation guidelines of the MSWM within the Regulatory framework for Urban Local Bodies (ULB), which are designated as the legal entity to manage waste in its jurisdictions. For example rules for financial implications for non-compliance of the Rule by ULB, Rules supporting the sale of compost & RDF, and purchasing of power from West –to – Energy plants.
2. Clear guidelines on the course of action on the latest technologies(already used in developing countries)to be used for MSWM, such as – Pyrolysis, Gasification, Waste–to–fuel oil, Mass burning or incineration, etc.
3. Proper directions to ULBs for collection of revenues from users and clear-cut policy on Govt. subsidies etc.
4. Proper guidelines to facilitate the private parties, accessing market-based/debt finance for the MSWM projects.
5. Estimating the contingencies based on a realistic risk assessment model.
6. Formulating proper guidelines for treating and disposing the mixed waste in an environmentally acceptable manner.
7. Lack of proper and strict policy on “segregation of waste at source”.
8. Lack of dry/wet collection system. In most cases, the wet waste mixed with dry waste creates problems like the generation of higher leachate at the disposal site.

The Price Waterhouse Cooper(PWC), based on the population growth rate and volume of waste generation, divided Indian urban/city areas into 4-clusters: cluster-1A(> 5 million population), Cluster –1B(1.0 to 5.0 million population), cluster-1C(0.1 to 1 million population), cluster-II(0.05 to

0.1 million population), cluster-III(0.02 to 0.05 million population) and cluster-IV(< 0.02 million population. As per this classification, Guwahati city, where the present work on MSWM is undertaken, is of category 1C.

4.0 Waste Management Scenario in Guwahati City.

In the Republic of India, Assam is a state with Guwahati as the capital city. The location of the city, in terms of geographic latitude, is: 26^0 5' N to 26^0 12' N and, Long 92° E. With a varying altitude of 49.5m to 55.5m above the mean sea level. Guwahati is the gateway to all the northeastern states of India. As per the 2011 census, the present population of the city is about 9, 62,334, which is nearly 3.19 % of the state population.

With the growth of the population in Guwahati city, which is estimated at0.0984 million increase every year, together with the development of markets and industries, the city waste management scenario is gradually becoming more and more crucial and complex. One of the major issues related to citizens' health and hygiene in Guwahati City is the improper disposal of municipal waste. Owing to improper disposal system municipal wastes heap up on the roads. This causes biodegradable materials to decompose under uncontrolled and unhygienic conditions.

The Gauhati Municipal Corporation(GMC), the local Urban body is responsible for resolving all the issues related to municipal waste including waste generation to treatment and disposal. As a part of the responsibility, the GMC divided the city area, which is about 216.79 sq. km, into 31 municipal wards, which are again divided into 2, 3, or 4 area sabhas. There are a total of 90 area sabhas. For waste management, from collection to transporting the waste to the treatment site and finally, to the landfill site, the GMC authorizes 58 NGOs for the city's waste management. Depending on the area and households, a ward is again divided into 2 0r 3 parts. In total, the city area is divided into 58 sectors, and for the management of waste in each sector, NGO is authorized. The primary responsibilities of the NGOs are:

(i) primary collection of waste(Door to door collection)& street sweeping

(ii) Deposit the waste to nearby secondary bins.

In the entire GMC area, presently, there are two function transfer sites: namely, RadhaGobindaBaruah (RGB) road, near Ganeshguri, and the other one situated near the Gauhati Medical College &Hospital(GMCH), Bhangagarh. West Boragaon, nearly 15 Km from Guwahati city, is the only official disposal site or dumpsite. The municipal vans carry the wastes to the

dumpsite and dispose of them with any processing. This method of waste dumping is now a major issue of concern as the dump site, which covers an area of about 108 bigha and is almost exhausted. Daily, nearly 85 to 90 % of the collected waste is transported to the dumping site (Boragaon) [Gogoi,2013]. The local people around this dumping area complain of air pollution, water pollution, the biodegradable materials so dumped decompose under uncontrolled and unhygienic conditions, and thereby producing a foul smell, breeding various types of insects and infectious organisms, and spoiling the aesthetics of the surrounding environment [Gogoi, 2013]. The existing waste management system within the Gauhati Municipal Corporation (GMC) area can be represented as shown below:

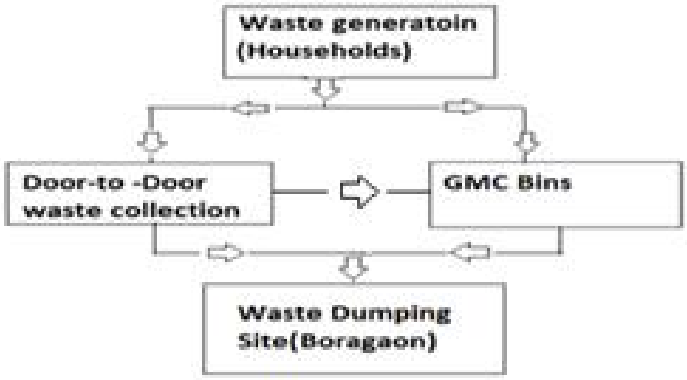

Figure 1.0: A block representation of the Waste Collection and Disposal System

.4.1 Issues with Plastic Wastes:

Plastic is one of the major constituents of the waste generated. Globally, about 300 million metric tonnes of plastics are produced annually. Out of this volume, about 50% can be used for disposal applications. Discarded plastic products can act as both a boon and a bane (Singh and Sharma, 2015).

According to the report of the subgroup on plastic waste management (2009) and plastic waste management rule (2016),[http://www.downtoearth.org.in/news/solid-state-waste management 2016], Govt. of Delhi, about 10 thousand tonnes of plastic waste is generated every day, constituting about 9% of the total waste. In India, about 5.6 kg per capita plastic waste is generated, growing by nearly 8 – 10 % per year.

In Assam, about **3 lakh kg** of plastic is generated every day. Guwahati, the capital city of Assam, generates about **37,000 kg** of plastic every day. At present, there is no processing plant or facility for either recycling or reuse of the generated plastic waste in the city. This seems a very vital issue on the part of GMC, both in terms of revenue generation and effective use of waste plastic products. In the following figure (Figure 2), a systematic methodology has been suggested for the best reuse of waste plastic in Guwahati City under the GMC authority.

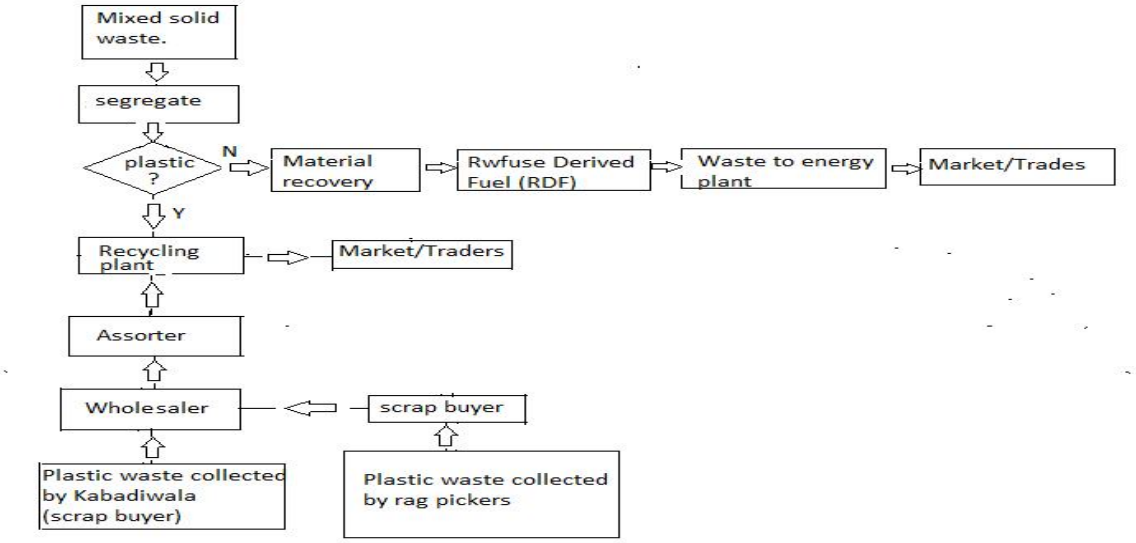

Figure 2: A proposed Mixed waste (including Plastic) processing scheme

4.2 Proposed ICT-enabled Waste Management System for the Guwahati City :

Globally, many developed and developing countries prefer ICT-based waste management systems for effective management and monitoring the various wastes. The various components of the ICT-based facilities are :

* Real-time status of waste clearing/collection from any specified location(s).
* Tracking the waste collection efficiency.
* Viewing and tracking the vehicles on duty.
* Monitoring the waste disposal to the pre-assigned destination or disposal site(s).
* Monitoring the citizens' or the household's complaints etc.

In India, the Municipal Corporation of Greater Mumbai (MCGM), which has to look after huge junk of waste generated in the city, nearly 9,000 tonnes per day, engaging nearly 1,234 municipal

and private vehicles for collection of waste and requiring nearly 1,396 trips per day. To operate manually is a very complex and complicated task. The MCGM, started the web–based ICT-enabled waste management project called Vehicle Tracking & Monitoring System(VTMS) equipped with GPS based navigation device and its tracking ability. The MCGM highly appreciated the ICT-based system for benefiting the organization in many ways: for example – by monitoring the waste-carrying vehicles or vehicles deployed for the purpose effectively and efficiently by the waste management officials.

4.3 Designing and Developing of Smart Guwahati Municipal Corporation (GMC) App

The app which has been developed for management and monitoring the Guwahati Municipal wastes is named as **SMART GMC APP.** The Three-layer architecture of the App is given below(Figure 3).

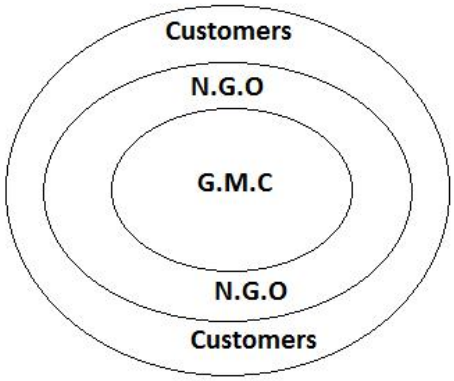

Figure 3: Three-Layer Architecture of GMC Waste Management System

The different facilities provided by the **Smart GMC App** for the NGOs and Customers are listed below:

1. List of GMC-approved NGOs : (i) Already engaged by GMC(ii) New/Substituted NGOs
2. List of Wards
3. List of localities within wards and associated NGOs.
4. List of Households in a locality under a particular NGO.
5. Complain registered by customer(s) to NGO(s), which will be simultaneously updated in the GMC database to monitor the status of the service registered by the customer(s).
6. Managing the job request made by the customers (which may be for a specified period of

time or new permanent customer(s) (shifted from another locality/place)). This job request to NGOs must be approved by the GMC.

7. Fee collection and coupon generation (NGOs).

Incorporating all the provisions [1 to 7], as cited above, the functional flow diagram of the GMC's waste management via the Smart GMC App is shown below(Figure 4):

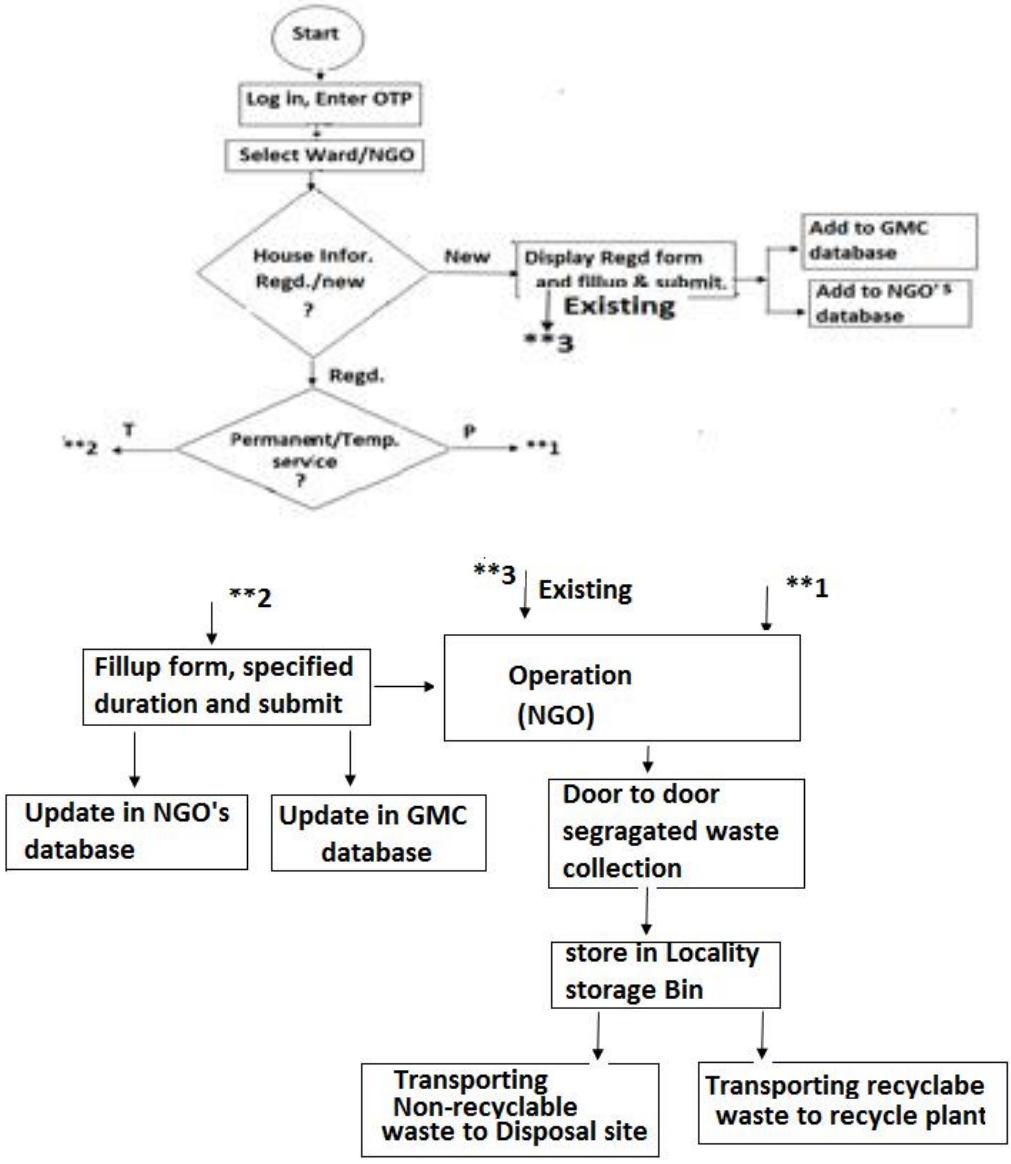

Figure 4: Functional diagram of GMC's waste management plan using the Smart GMC App

5.0 Conclusions :

The major issues related to waste management in Guwahati city under the supervision of Gauhati Municipal Corporation (GMC), Assam, India, lie on two prime tasks: (i) The waste collection from the households, segregation of waste and storing the waste in suitable place or location and (ii) the transportation of the segregated waste to the processing sites and final disposal sites.

(a) Waste segregation and Waste collection:

If the GMC authority seriously wants to implement the "**Waste to Energy**" conversion strategy in reality, both with speed and spirit, then the segregation of waste at the source is a must. But it is seen that the existing infrastructure, for example: human resources, waste collection mechanisms, transportation facilities, etc., have to be improved and restructure. In view of this the following suggestions have been made for effective waste segregation at source :

(i) It is felt that though the segregation process at source will need some homework practices by the households, the same can be made simple and easy through conducting some waste segregation programs by the GMC authority along with NGOs.

(ii) The GMC may direct the households through the concerned NGOs to segregate their waste at home and keep it in separate bags (with Tag marks) provided by the concerned NGOs. The bags with the identification tags, containing segregated waste, will be collected by the waste collectors in the garbage-carrying vans. There must be strict provision of penalty for the defaulters.

(iii) These vans will finally store these segregated wastes in the common GMC Bins, which are equipped with separate chambers to store the segregated items. The GMC must allocate the common Bins according to the volume of waste generated in a particular locality within a ward.

(iv) As per the available statistics, at present the GMC provides only 200 common Bins(3 cubic meters in size) for the entire GMC area, covering nearly 216 sq. km, serving about 9,62,334 population, and collecting nearly 673 tonnes per day. This is one of the major snags found in the waste management system of GMC.

(v) As the average waste generated /per person in the city households is about 0.7kg/person, and according to the present policy of GMC, nearly 16,574 people have to be served by one NGO, collecting about 11.6 tonnes of garbage per day, the allotment of 200 number of secondary waste collection Bins for 31 wards of the city which is divided into 58 sectors, is found inadequate.

(vi) To store the segregated waste, all the secondary waste collection Bins must be provided with separate chambers for storing segregated waste.

(vii) All the financial matters, including supplying bags, for collecting segregated waste at home, to households, must be settled mutually between GMC, and NGOs with required Govt. approval(if necessary).

(viii) Finally there is no mechanism or system implemented by GMC in its SWMS for evaluation performance of a particular NGO's in a ward.

(ix) The GMC must generate a mechanism to evaluate the performances of NGOs, both through feedback from the public and through its own machinery.

(x) In the existing SWMS of GMC, the GMC or NGO is not conducting any awareness program among the households to fix the mismanagement of their waste

This is a must. Once in every month the GMC along with NGOs should conduct an awareness program)(s) among the stakeholders/Households for the smooth functioning of its SWM program as per its commitment to both the Govt. and the Public.

(b). Waste Transportation Issues :

Waste transportation either to the recycling sites or to the waste disposal sites is a major issue with the GMC waste management system. As per the available statistics of the transport machinery and mechanisms used by the GMC for secondary waste collection and disposal, there are 22 garbage compactors, 200 push carts, 12 number Excavator cum loaders, 26 dumpers, and 200 garbage collection bins, to serve 31 wards of the city with 58 sectors, comprising total 9,62,334 people.

(i) Since the regular waste collection is a time-bound and time-fixed process, so to expedite the waste transportation process the GMC has to improve its transport infrastructure to mitigate existing deficiencies of the waste transportation mechanisms. It is suggested (considering the views of responsible citizens of Guwahati), that there needs to be at least one garbage compactor and one dumper for each sector under each NGO. Smaller transport mechanisms can be adjusted accordingly.

(ii) The delay in transporting the collected secondary waste to the recycling site or to the disposal site is a major lapse found in the GMC waste management system. In addition to the respondent's views on secondary waste transportation from the Secondary waste collection Bins. It is also physically observed that in some parts of the city (under GMC) the secondary wastes are getting

dumped for days together. This becomes a very honestly visible scenario within Guwahati city. This is a very crucial issue with the waste management scenario of the city which must be mitigated through proper transportation planning and enhanced transport infrastructure.

(iii) From the present survey of waste collection and transportation mechanisms under the GMC, it is found (Taking some peripheral samples areas under GMC) that almost 30% to 40% of residents of the GMC area are not accessible to the GMC's transport facility for waste collection. This is due to congested by-lanes, very steep lanes, muddy lanes, etc. Respondents are carrying waste bags to distant secondary waste collection Bins for disposal.

(iv) It is suggested that GMC should make suitable transport arrangements to reach their service to those people who are presently not accessible by their transport machinery. GMC needs to procure suitable vehicles that can play on these by-lanes and serve the people accordingly.

(v) All the NGO's waste-collected vans (Door to Door) and secondary waste-collected vans (GMC) must set fixed times of every day while plying on the roads, to avoid traffic jams on the road and Bye-lane. The time needs to be fixed either: Early morning when traffic rash on the road is quite less. This is found a very serious problem as of now.

It is observed in the present survey that the official time setting for collection of waste, primary and secondary, and the execution time by the waste collecting vans are totally different. This creates not only a large number of problems but also makes the process miserable for the households.

(c) Issues with Waste Disposal :

Waste disposal is found a major issue with the current waste disposal methods followed by GMC. Presently GMC is using Boragaon area, which is 15 km away from central Guwahati, as a permanent waste disposal site. This disposal site is next to or very near to Deeper Beel, which is one of the biggest ponds of the state, harboring verities of fishes and a hundred thousand types of migrated birds during particular seasons of the year. There are objections raised by huge sections of researchers, academicians, environmentalists, and nearby residents. On the other hand, GMC finds it very difficult to have alternate locations for waste disposal. There is constant pressure and objections from the public not to use Deeper Beel and its surroundings as waste disposal sites. Either for or against the use of Boragaon (Near Deeper Beel) as a permanent waste disposal site by GMC, but in principle the waste management must not be compensated at the cost of natural

resources. This is an open issue between GMC, the public in general, and the Government. The issue can only be settled by shifting the disposal site to remote unused Govt. land.

(d) Existing Status of Reuse, Recycle and Reduce (3R) of the waste generated :

Reduce, Recycle, and Reduce is a global policy for managing waste. Most of the developed and developing countries followed this waste management strategy adding some local variants. Many countries developed their indigenous technology to supplement global 3R policy according to their need and necessity. India is no exception to that. Department of Environment, Govt. of India, promulgated certain rules to meet the requirement of 3R policy in 2016 and directed all state and local bodies to abide by the waste management 2016 rules.

GMC must come forward, in association with Govt, with proper 3R policy. But the GMC has to visualize the ground reality of the Capital city, Guwahati, considering all the local variants. For example, why the Reuse and Recycle plants are not coming up in the city to the expected level? Why the local entrepreneurs are not coming forward? Why the NGOs are not coming up with a 3R policy for waste management in the city? How does the GMC conceive the usefulness of the 3R policy? How is the GMC coordinating with Govt. for implementing the 3R policy in the city? All these questions are to be analyzed by the GMC and concern the government body taking all contingencies of the local variants of Guwahati city. It is concluded that for any permanent solution to all the deficiencies presently prevailing in the execution process of the GMC waste management system, the 3R policy must be encouraged

(e) Management Transparency of GMC/NGOs :

In any system, coordinated functioning by different entities or attributes associated with the system is a must to make survive the system. This coordinated approach must be transparent. GMC is a coordinated waste management system, comprising: human resources, transportation machinery, processing mechanisms, etc. as entities or attributes.

So, for its long survival and to become effective to the best satisfaction of the customers, the GMC's waste management system needs to be transparent, including the service provider level, execution level, and customer level.

To achieve transparency, the "**Smart GMC App**" will render a good service to both the service providers and customers/households of the waste management system to their best satisfaction.

6.0 Future Scope :

The Smart GMC App would certainly help, both the GMC authority and NGOs, to render their services to the customers with transparency. However, the Smart GMC App lacks the facilities of waste collection vehicle tracking facilities, online videos of Waste collection Video conferencing facilities between GMC authorities, NGOs, and Customers. These facilities could be incorporated into the App , as an extension in the future, through satellite-based GPS.

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