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MSW as an IoT enabled service– A Case of Ekamra-Kshetra

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Abstract

Development in the field of Information technology has open avenues for diverse opportunities in the field of Municipal Waste management. Smart Waste management, employing IoT is one of the latest trends that most smart cities of India have been following. Owing to the growing urbanisation, municipal solid waste is an essential task of any urban local body and a major point of concern as well. However, since the littering still happens in small bins with collection strategies that are bound by time and availability of labour, it is almost impossible to achieve a solution to the threats that the waste in public areas pose to the well being of the humans. Bhubaneswar being the first smart city is an emerging tourism destination that has implemented smart city platform to engage various stakeholders. It is also the temple city and these precincts attract a substantial percentage of these tourists. This transition from temple city to smart city has witnessed a lot being ignored in terms of infrastructure in the Old town which houses all the temples. The objective of this paper is to identify smart waste collection methods that when implemented in the old town of Bhubaneswar will offer results that are sustainable. This paper uses precedence that is being conceptualised and implemented not only abroad but also in India. The method adopted is to review the literature available in the field of waste collection using smart strategies. In addition to this similar the MSW management of similar precincts like the shore temple at Mahabalipuram and temples at Varanasi, wherein smart technologies are being used have been referred to as a case study. The best practices are then recommended in the analysis section. The study area, the Old town of Bhubaneswar, requires proactive implementation in the said field to avoid any irreversible alarming situation in terms of cleanliness and hygiene.

Keywords: *Municipal Solid Waste, Smart City, IoT, urbanisation, pilgrimage tourism, garbage collection, sustainable*

1. Introduction

In the last 100 years the world population has quadrupled due to the gentrification of inhabitants from villages to the cities. As per the projections, the population in the urban areas is expected to increase to 70% by 2050 and in the current scenario almost 50% already lives there.According to the UN report of 2007, 40.76% of India's population will be in urban areas by 2030. The urban areas have been facing various issues related health, resources, traffic, pollution, electricity, waste disposal and sanitation. (Fertner et al,2007). Such issues coupled with many other were the primary reason as to why the Indian Government floated the concept of smart cities where a technology driven approach to resolve these issues was undertaken. However the standards, methodologies and best practices are yet to be resolved even after 4 years of the smart cities being announced. The whole process of garbage collection till its disposal is very big challenge for major cities. The garbage collection system is inefficient bringing with itself the economical challenges and discomfort to the city dwellers.

The old town of Bhubaneswar houses around 300 temples and the Lingaraj temple being the most visited one. It is a Shiva temple where all religious practices and rituals are still observed. As globalization accelerates, the expansion of pilgrimage has encouraged environmental cleanliness and Eco-development programme having commitment to protect our living planet sustainably and awakening ourselves though deeper experiences – from realization to revelation, ultimately that foster peace.(Singh,2016). The primary ritual in the Lingaraj temple is to offer milk or water on the Lingam present inside the garbha griha (Sanctum Sanatorium). As it is a living temple, daily more than 6000 people visit the temple as per data of the Temple Trust. On festive occasions, the number increases to ten thousand. Data from the temple trust reveals that on Shivaratri, which is the main festival of the temple, lakhs of people come to the temple. The aim of this paper is to identify the current pattern of waste collection in the Lingaraj temple precinct and propose smart methods using IoT to address the challenges that retard the overall MSW of this temple and its near vicinity.

Fig.1 The ongoing work for the plaza development at Ekamra Kshetra discussed later in the paper. This entire plaza has no means of garbage collection.

Fig.2 Current plan of the Ekamra Kshetra.

1.1 Theoretical Background

Smart city is defined as "a city well performing in a forward-looking way, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens"(Dirks and Keeling,2009) . In yet another definition, a smart city, according to IBM's vision 3 , is instrumentation, interconnection and an intelligent system. They have to optimize the resources which are otherwise finite in nature.(Medvedev et al,2015). According to Dirks and Keeling,smart cities are organic integration of systems. The relationship between the various core elements is studied to create system of systems smarter and intelligent. The systems don't act alone. Rather the smart systems infuses information into the physical systems to create and improve quality of life, air, water, mobility convenience, energy efficiency , quick addressal of issues and disasters, improved decision making and collaborative decision making by bringing together various entities of the system. A smarter city needs to behave like a linked system , rather than just independent intelligent units. In spite of the plethora of definitions, the academia is yet to find a consensus for defining the smart city.

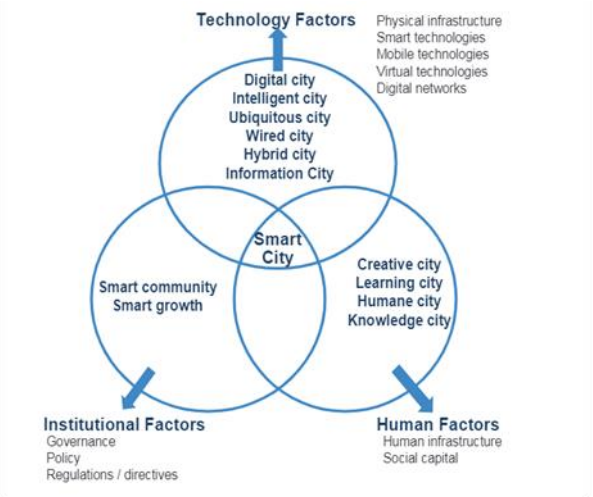

Fig.3 Fundamental Components of a smari city

The smart city initiatives was launched in India in 2015 with the aim of making 100 cities technology driven in terms of the habitability as well as sustainability. according to the smart city mission, the initiative is broadly divided in the field of construction, transport system, information and communication technology centric, governance and energy. Thus the initiative is very multidisciplinary in nature.

1.2Related Work

A substantial percentage of the smart cities in India have already started implementing smart measures in MSW management. Most of them are restricted to the collection and the transfer to the landfills. Also, not much has been witnessed of these strategies being implemented in the temple precinct areas. With the advances that has happened in IoT, monitoring of the garbage bins has become a lot easier than before. Firstly all overfilled dustbins can be tracked using the ultrasonic sensor which will raise an alarm when the volume exceeds the tolerance levels. This can be backed up by means to spray mosquito repellents and similar methods to keep off other rodents. Motion sensor detecting human presence should be placed in these dustbins to ensure that these dustbins detect human motion and open by themselves. However, the profile of our study area and the activity pattern of the temple complexes need more than just guidelines to achieve the envisaged outcome of sustainable waste collection. Many measures have been undertaken to solve the issue of solid waste disposal by using intelligent systems and techniques. Some solutions include the right placement of the waste bins, optimizing the frequency of garbage collection and the behavioral study of the users(Rossit et al, 2020).The incorporation of IoT (Internet of Things), the monitoring of the garbage bins has become a lot easier than before. IoT enabled smart smart garbage systems(SGB's) were introduced which share data by using wireless mesh networks, server and router. The

collected information is utilized for provisioning of the services and it has in the end resulted in reducing the food waste almost by 33%(Hong at al, 2014). Another such system is the utilization of decision support system for improvising the waste collection from areas which are otherwise difficult to reach (Medvedev at al, 2015). This system uses the block status of the bins and it is the job of the truck driver to find them and report its status. Another effort which is worth mentioning is a system which uses cloud integrated wireless garbage management system.In this system , the temperature, inflammable gas collection, garbage volume and fire detection.The bins are fitted with wireless nodes with sensors which send the status of the garbage bins across various parts of the city(Talha et at, 2017). However the main challenge is the energy consumption of such bins which is should not be more than the norms of the smart city. In yet another system, smart trash bins were used in an cost and energy efficient manner through dynamic routing of garbage collection where as ordinary smart dustbins work in static time intervals which reduces the efficiency as well as the battery life.(Kristano et al, 2016)

Most of these systems and researches however are based on mitigation strategies rather than avoiding the overflow of the bins . Avoidance and prediction of the waste bins can only be achieved using IoT and machine learning systems. The data collected through the sensors is evaluated and analyzed using machine learning to understand the user behavior. This helps in predicting the generation of municipal waste (Al Jabi and Diab,2017). The data collected through the sensor fitted on smart dustbins is read and studied through highly optimized algorithms which can be then used to handle the garbage collection in a more dynamic manner. (Shyam at al,2017)

In Seoul South Korea, an IoT based pilot study on food waste disposal system was done. In this system, they have decentralized monitoring by fitting the garbage bins with sensors and internet modules. It helps in real time monitoring of the status of the garbage bins in terms of its filling and collection. Though efficiency was achieved, but the challenge that was observed was in terms of battery based power consumption.(castro et al,2017)

Similar initiatives have been undertaken by K. Mahajan and J. Chitodewhere they have used Zig-Bee based garbage bin monitoring. In another system developed by S. Gupta and P. Kumar, where they have used RFID and GSM technology for monitoring the status of the garbage in the bins .

In another waste monitoring system developed in the city of Pune, the IoT and GIS based system was simulated for a period of one month. One the basis of the date received, it can be used to analyse waste collection of a area on the basis of the congestion, traffic etc and can be used to predict when the waste bins might start overflowing. (Shyam et al,2017)

In a large scale smart sewage disposal system experimentation, Campus of Lille University was chosen with more than 25000 users, 150 buildings and about 100kms of urban network. For this experiment GIS information of the campus was developed. Various types of sensors such as turbidity sensor, hydraulic sensors, water level and velocity sensors were used. The data collected from various vulnerable points fed into a data logger and the GSM network was used for transferring of the information. This experiment helped to identify various operational faults as well as the various challenges the sensors provided. It also helped generate numerical data of sewage flow during weekdays, weekends, dry periods and rainy seasons which could help monitor and regulate the sewage disposal better. (Abbas et al, 2017).

As discussed in the previous points Internet of things (IoT) helps in monitoring of the garbage bins, whereas machine learning helps in understanding the nature and behavior of the users and predicting the overflow of those bins based on their behavior analysis. But the role of the policymakers in this scenario can not be negated as they will decide what is the most optimal, cost effective and efficient solution. For example if certain number of bins are overflowing , it will be the decision of the policymakers to direct the disposal based on the severity. Thus the above examples highlight how various technological interventions have been undertaken to achieve better garbage disposal methodologies in various countries.

Please note that the properties of the equations must not be locked

2. Current state of waste collection in the study area

The data collected for this study is collected both from primary and secondary sources. The temple complex is protected by Archaeological Survey of India (ASI). Lingaraj Temple Trust is there to manage all the services in the temple and to coordinate among various service groups. ASI is also responsible for the waste management in the temple complex in coordination with the temple trust. There are definite collection hours in the temple complex and the waste. Also the waste can be categorized into recyclables and bio-degradable. However, in the current scenario there is no segregation at source.

In festive occasions about 100 baskets of waste is disposed. During the month of Sawan (between July **to August), the waste composition includes plastic** ware and earthen ware. The liquid waste composed of water and milk is drained from the sanctum sanatorium through a drainage channel to a open tank (paduka kunda) on the western corner of the temple. The waste is pumped out in every 30 days and drained into the municipal sewerage line outside. On festive occasions and rainy seasons more frequent pumping is required. Aggregating all the weight of the waste from various parts of the complex, almost 800 Kg of solid waste is generated, which is being disposed daily.

As per the literature, solid waste is generally classified as per its characteristics i.e. biodegradable, recyclable and others. The rules that govern are Solid Waste Management Rules, 2016 (—MSW Rules‖) . Flower waste, garden waste, fruit waste, vegetable waste, food waste, cattle waste etc is classified as bio-degradable. Plastic, glass, polythene, metal, paper etc. Is classified as recyclable waste (Tripathy,2018)The Other category includes biomedical waste, sanitary napkins, slaughter waste, electronic waste, construction & demolition waste. Hence,other residual waste will involve physical characteristics categorizationand include organics, paper, plastic, glass, metal, cloths (Medvedev et al, 2015) .The revitalization plan of the Ekamra Kshetra , wherein the Lingaraj temple is the most visited temple is under implementation. Sustainable infrastructure, urban design initiatives which include creation of plaza, parking solutions, barrier free interventions have all been proposed. But at the onset, waste management which poses to be a major health hazard in this area is not discussed in the strategy development plan. The project for Rehabilitation & Resettlement Policy For "Ekamra Kshetra Amenities And Monuments Revival Action Plan (EKAMRA) Plan" Bhubaneswar, houses temples that are a testimonial to the ancient built heritage of Bhubaneswar. As discussed earlier, over the years, because of the pressures of urbanization, Old Town Area has developed congested roads, crowded market-places, polluted water bodies, inadequate roadways, infrastructure, parking facilities and haphazard development around the historic structures. This unorganized development and encroachments around the temple in the last decade have led to the deterioration of the surroundings of Lingaraj and other national and state monuments. This has increased threats to the safety and security of the pilgrims, visitors, and residents.

As per the records, the major objectives of this revitalization shall be

- Revive and preserve the heritage value and grandeur of Lingaraj temple and its surroundings
- Enhance the living heritage, continuous traditions and a complete timeline of Kalinga architectural developments through strategic interventions
- Protect and strengthen the linkages between the area's natural and built heritage assets
- Highlight the experiential value of the place for pilgrims, tourists and residents.

In spite of objectives like augmentation of the experiential value of the pilgrims, waste collection does not see any place in this development plan.

With reference to the aforementioned sections of the related works in the field of IoT being implemented in MSW management and the current scenario of our study area the following analysis section makes an attempt to marry the two and makes recommendations which could be implemented to obtain the desired outcome.

At the onset, it should be mentioned that the area of the temple precinct being managed by IoT does not have any precedence in India. Although, Mahabalipuram and Coimbatore have made an attempt to implement effective measures but IoT has not been applied. Hence, the recommendations mentioned are purely generic in nature and not peculiar to a temple precinct. Having said that the stakeholders mentioned are common to any MSW management community.

3. Analysis

Based on the aforesaid activity pattern, a conceptual framework is prepared further in this paper to apply the measures available under IoT onto the current waste management scenario.

Providing software-as-a-service (SaaS) products for customers is the principal aim of the application of IoT on MSW collection. These customers range from the private agencies that collect the waste, the vehicle owners that collect and dispose the waste, and the urban local bodies that manage the entire show. Secondly, developing a system, which makes possible mutually beneficial communication between all the stakeholders involved in the chain of supplying goods and utilizing solid waste in smart city should be pursued.(Costantino,2014). A list of recommendation encapsulating the stakeholders and their needs is mentioned below.

A brief of the stakeholders and their needs, business norms, and requirements is presented in the following.

:•The additional fund that the urban local bodies need to lay out along with a formal budget. This should be backed up with the constant monitoring of the expenditure.

•The responsible urban local bodies that should constantly be checking the services that are being rendered in terms of the collection and disposal. In addition to this they should be checking for solving the disputes amongst parties to ensure the seamless operation.

- Waste trucks owning companies need platform for organizing and optimization of their business process in general without serious investments in developing, deploying and supporting their own systems. Such a system must include effective dynamic routing based on IoT data for the truck fleet. Besides, controlling drivers and tracking the fleet is also an important issue.
- The truck owners that collect and dispose the waste need a robust navigation system .
- Traffic police can get reports about inaccurate car parking that leads to impossibility of waste collection.
- Also, there is no compactor or composter in this vicinity. Although, IoT does not play any important role in the composter or compactors , however considering the sustainable plan that the municipal corporation wishes to implement, presence of a composter and a compactor is but inevitable.

Conclusion

Pilgrimage tourism is considered to be a economy booster for many countries, For the temple city of Bhubaneswar, it is therefore the need of the hour to stimulate this source income and propose pro active measures to confront the issues in this sector. The issues that impend the pilgrimage tourism in the old city of BBhubaneswar can be mitigated considerably by simple application if the aforementioned recommendations in the analysis.

Sustainable infrastructure interventions like the Mo buses and Mo cycles have received an overwhelming response from the temple city. These can be tracked by mobile applications. Similarly an application can also be developed in which real time information about garbage bin is shown in graphical form on map so garbage collector truck driver can go directly to the place where there is need to empty the bin.

Also,a driver can have active participation in whole system which isn't seen in current waste management system. In Google Map API can be used for finding efficient path to reach the desired bin in quick time. In order to give the system more eco-friendly touch and utilize the natural resources, one can explore the option of incorporating solar panel which is renewable and clean source of energy with the proposed system. Smell sensors(MQ-2) can be placed in the dustbins to manage the odour coming from the bins. With these endeavors, Ekamra Kshetra can not only be a visual treat but also cater to sustainable waste management (Chaudhuri et al,2018)

This paper proposes how, practically the collection and management can be done for waste in the old town of Bhubaneswar. Integrated sensing system can be designed using ultrasonic sensor and also a proficient system can be proposed to understand the status of the dustbin. However, it should also be understood that there is plenty of scope for future improvement even in the given proposals. Further studies can be made on the loading status perception of the dustbins based on the activity pattern of the pilgrims and temple users and also the time threshold. A few test runs can be made to understand the optimization of the power requirement which has not been discussed in the paper.

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