International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

Towards an Analytical Approach for Sustainable Smart City Services Management:

Waste Management as a Case Study

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Abstract- The application of innovative Information and Communication Technologies (ICTs) in Smart City outlines emerging possibilities for optimizing existing services and developing new services based on key concepts such as the Internet of Things (IoT), Big Data, information sharing, and smart applications. These ICT-based services have the potential to: change the demand for physical assets and infrastructure; take part in requalification procedures; and have an impact on the built environment's sustainability and metropolitan regions' economic worth. Including these, this paper deals with the key factors towards smart city sustainability by identifying, analyzing and linking Smart Cities (SC) domains and sub-domains, related smart services and the various levels of enabling ICT technologies involved with SC solutions at the urban scale and virtuous cases of cities that have implemented smart solutions, allows to collect, allocate and process information, in a unified way and finally implemented in the field of smart waste management as a case study.

Keywords- Smart city, Big Data, IoT, ICT infrastructure, Sensitive Data, Quasi-sensitive Data, Route optimization.

I. INTRODUCTION

The ongoing century have been characterized by the rising of two major phenomena, the increasing urbanization and the spread of Information and Communication Technologies (ICTs).The growth of urbanization has been dramatic over the past two decades, we have witnessed the progressive abandonment of rural areas towards cities which can offer many opportunities in terms of education, work opportunities, social life and quality of life in general. Previous analysis states that urbanization is nowadays a continuously growing phenomenon that it is expected to further intensify and moreover, it is expected that the 70% of the population will live in cities[02].This phenomenon has two main implications; on one hand it causes an increase of the cultural level and a growth of the economic conditions of the city, on the other hand the concentration of people within the city causes a variety of technical, social, economic and organizational problems that undermine the economic and environmental sustainability of the city.The increase of urbanization implies increased levels of traffic, pollution, gases emission and waste and social inequality which generate negative implications both for people and environment. Consequently, the impacts of the concentration of people within cities are reflected in higher energy consumptions and pollution levels, increased volume of urban waste, fewer adequate infrastructure, decrease of social cohesion and so on[05]. More in general, the urbanization process has impact of different nature and intensity on the main issues related to the economic development, the social development and the environmental protection. As a consequence, cities at the global scale started to seek for optimal solutions in order to efficiently handle and face new

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challenges. In the nineties, the urgency to successfully face these challenges and these impacts began to animate the debate of policy makers and urban planners and managers around the world, triggering them to find smarter way to manage cities. In parallel, the exponential development of the Information and Communication Technology (ICT) sector in those years led policy makers, urban planners and urban managers to pay a great attention to technological solutions, investigate their potential contribution in facing these issues. In this context the term Smart City started to be introduced and used by the stakeholders of the sector, recognizing the support of the new ICTs in enhancing the planning and management of cities contributing to the reduction of the aforementioned urbanization impacts by offering [04]:

- advanced capability of monitoring, analyzing and interpreting city and citizens' behaviors;
- innovative solutions for integrating physical and digital infrastructures for improving services;
- advanced techniques and procedures to exploit information both to optimize the decision-making processes and to improve the operational coordination of activities;
- ICT-based solutions to enhance the responsiveness of the city to changes in context conditions;
- supporting collaboration between municipalities, business community and citizens.

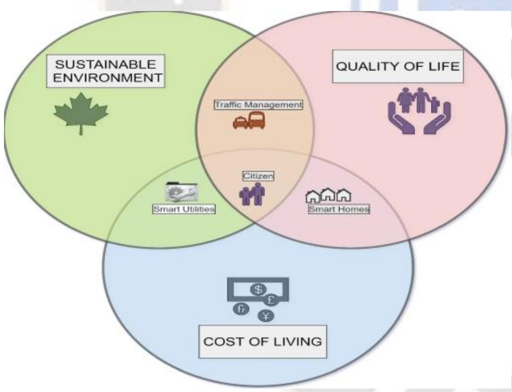

Figure 1. Goal of smart city initiatives
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Thus, the concept of Smart City as testing ground to investigate ways to exploit and take advantage of new ICT-based solutions, as well as new approaches to urban planning and living became to spread globally. In the late nineties, the Smart Growth Movement, which promote new policies for urban planning, introduces and formalizes the paradigm of a smart development of urban areas, understood as conscious development careful to the issues of environmental, economic and social sustainability, and moreover it initiates the gradual diffusion of Smart City projects around the world. In particular, the concept of Smart City begins to spread by finding its foundations in the creation and management of intelligent infrastructures, advanced digital services and in the creation and support of human connection [24]. The concept of smart city growth, understood as above, includes three main axes: sustainability understood in its three meanings (social, environmental and economic); governance and intelligent control of the territory, its infrastructures and physical assets and the services offered by and for them; social inclusiveness and territorial cohesion. Therefore, a Smart City has the objective of achieving these objectives using ICTs, thus digital technological infrastructures and solutions based on technological solutions declined and applied in the various areas of interest in urban planning and management. Despite a great spreading of ICT experimentations for an advanced urban planning and management, over the years, this diffusion was not followed by a common practice in the design and implementation methods[07].Therefore, the different approaches to the paradigm of Smart City concretized by the various countries have led to dissimilar initiatives and policies according to the different features, properties and needs of the different countries. Thus, these different ways of understanding the city makes it difficult to identify nowadays a common and unambiguous definition of Smart City that is consolidated and shared at a global scale. Over the years, only a limited number of studies have systematically investigated, analyzed and described the nodal points, issues and key impacts related to this new urban phenomenon of Smart Cities. To date, there are many definitions of Smart City, evidence that currently there is not a clearly and unanimously established Smart City vision and probably the achievement of a comprehensive definition of Smart City is still far . Obviously, this is also due to the fact that the concept of Smart City itself is still emerging and therefore the work of definition and conceptualization is still on-going. Indeed, nowadays the notion of Smart City is expressed through different definitions, shades of meaning, nomenclatures and contexts all over the world and, moreover, there is also a wide range of adjectives largely used - properly and improperly - as variants of the term "smart" as, for instance, intelligent, advanced, sustainable, digital, livable, etc[24].

The main goal of a smart city is to optimize city functions and promote economic growth while also improving the quality of life for citizens by using smart technologies and data analysis. The value lies in how this technology is used rather than simply how much technology is available[07].

The success of a smart city relies on the relationship between the public and private sectors as much of the work to create and maintain a data-driven environment falls outside the local government remit. For example, smart surveillance cameras may need input and technology from several companies[07].

Using tools, policies, and technology to improve economic efficiency, all sectors must work together to tap into the huge

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amounts of data a smart city generates, analyze data, and put insights into action[07].

Sustainability is an important aspect of smart cities as they seek to improve efficiencies in urban areas and improve citizen welfare. Creating sustainable solutions could deliver environmental and societal benefits. However for all of the benefits offered by smart cities, there are also challenges to overcome. These include government officials allowing widespread participation from citizens. There is also a need for the private and public sectors to align with residents so that everyone can positively contribute to the community. This paper highlights the smart waste management in a smart city as a case study towards sustainability as a key factor[07].

II. BACKGROUND

Abraham Maslow a psychologist suggested that the first and most basic need people have is the need for survival: their physiological requirements for food, water, and shelter. People must have food to eat, water to drink, and a place to call home before they can think about anything else. If any of these physiological necessities is missing, people are not motivated enough to meet the growth needs. Maslow has identified seven categories of basic needs common to all people. Maslow represented these needs as a hierarchy in the shape of a pyramid [01].

A hierarchy is an arrangement that ranks people or concepts from lowest to highest. According to Maslow, individuals must meet the needs at the lower levels of the pyramid before they can successfully be motivated to tackle the next levels. The lowest four levels represent deficiency needs, and the upper three levels represent growth needs [02].

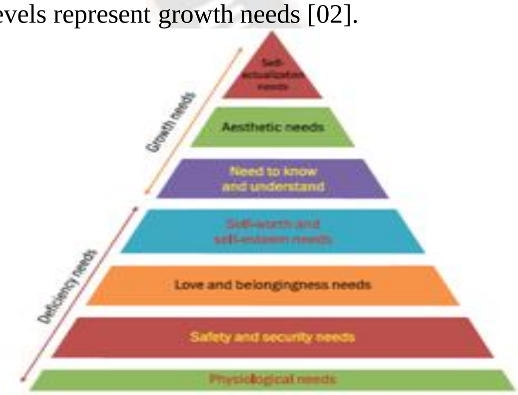

Figure 2. Maslow's hierarchy of needs

One will need to fulfill growth needs once their deficiency needs are fulfilled. In India, any cities have the infrastructure where deficiency needs are fulfilled and Smart City concept will fit in, while in other cities citizens are even struggling for their deficiency needs to be fulfilled. Due to dense population and lack of streamlined civic facilities and processes, such deficiencies remain unattended leading to complex problems in cities. To overcome this difference, the Government needs proper strategy that helps in successful implementation of Smart City concept[03]. India is at a point of transition where the pace of urbanization will speed up. The relatively low base allows us to plan our urbanization strategy in the right direction by taking advantage of the latest developments in technology especially in Information and communication Technology (ICT)[04].

A. *Smart city characteristics*:

As per the Smart City concept, none of the cities are well prepared to be termed as Smart City. Existing cities are facing several challenges starting from urban governance to internet penetration[04].

In Smart City concept, ICT plays a key role in integrating different components. The data reveals that most of the cities are lacking infrastructure, social awareness, and skills to upgrade into the Smart Cities. Further to this, while some of the cities have ICT infrastructure, they are not utilized up to its optimum. There need to be an effective plan or layout by the city governance and government implementing agencies to build awareness, skills, and infrastructure to develop existing cities into future Smart Cities [04].

The idea of building 100 energy-efficient, ICT-enabled, and transit-oriented cities sounds promising. Experts at the recently concluded Smart Cities India Expo have called for focus on making these people oriented and socially inclusive because, even with excellent infrastructure, several global cities have failed to retain people and businesses. Technology is important but so are the economy and people. Research states 60% jobs can be generated within these sub-cities. There can be many opportunities for decentralized production and related services [24]. They should act like a sponge where money comes in and keeps circulating. There has to be a business model. It also requires citizen's participation in planning.

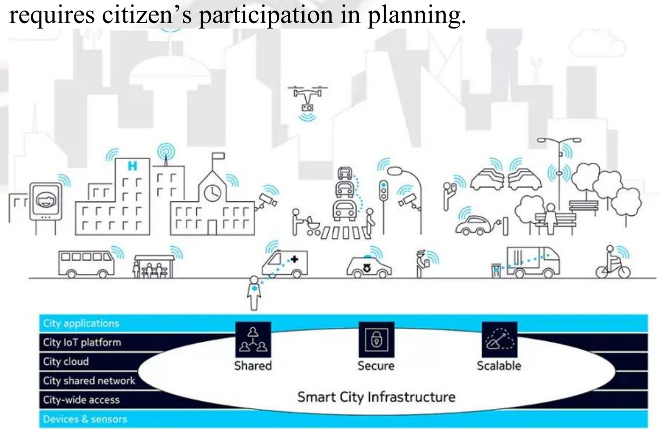

Figure .3. Smart City Infrastructure

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Smart Cities integrate society with their management, identifying the needs of citizens and offering solutions that improve the quality of life with the least environmental impact. To do this, let's look at the keys that make a city stop being traditional and become what we call a smart city[04]:

- Use of information and communication technologies
- Building and control automation
- Efficient urban planning
- Urban mobility and sustainable public transport
- Smart waste management
- Improving environmental sustainability
- Concern for the social environment
- Technologies applied to education
- Health technologies
- Advanced e-commerce system
- Transparency between governments and citizens
- Data sharing

The success of a smart city relies on the relationship between the public and private sectors as much of the work to create and maintain a data-driven environment falls outside the local government remit. For example, smart surveillance cameras may need input and technology from several companies [04].

Aside from the technology used by a smart city, there is also the need for data analysts to assess the information provided by the smart city systems so that any problems can be addressed[04].

Smart cities follow four steps to improve the quality of life and enable economic growth through a network of connected IoT devices and other technologies. These steps are as follows:
1. Collection – Smart sensors gather real-time data
2. Analysis – The data is analyzed to gain insights into the operation of city services and operations
3. Communication – The results of the data analysis are communicated to decision makers
4. Action – Action is taken to improve operations, manage assets and improve the quality of city life for the residents

The ICT framework brings together real time data from connected assets, objects and machines to improve decision making. However, in addition, citizens are able to engage and interact with smart city ecosystems through mobile devices and connected vehicles and buildings[04].

B. *Smart City Sustainability:*

Sustainability is an important aspect of smart cities as they seek to improve efficiencies in urban areas and improve citizen welfare [24].

However for all of the benefits offered by smart cities, there are also challenges to overcome. These include government officials allowing widespread participation from citizens. There is also a need for the private and public sectors to align with residents so that everyone can positively contribute to the community [24].

Smart city projects need to be transparent and available to citizens via an open data portal or mobile app. This allows residents to engage with the data and complete personal tasks like paying bills, finding efficient transportation options and assessing energy consumption in the home[24].

It can be inferred that cities are not considered only as an object of innovation, but also as ecosystems that enable collective intelligence and capacity of co-creation of citizen communities for the design of innovative lifestyles and work scenarios . Moreover, the application of the service system to the smart city confirms this vision, highlighting common aspects between the smart city and the service system. These aspects allow configuring the smart city as a service system [04].

The first aspect is linked to the regard toward the human factor and the collaborative features among the elements of the city, linked to a reticular view of the relationships among stakeholders, in which everyone is a bearer of knowledge, including citizens who are becoming more and more powerful and important. The overcoming of the internal virtualization of the administration, in favor of a landing towards a horizontal dimension of government allows understanding in a unitary and harmonized way the different vertical functions (for example the sectors of smart energy, smart house, smart building, etc.) on the market. The overcoming of old management logics allows all the actors of the system to have equal rights[24].

The second aspect in common between the two systems is the organic and holistic approach to the reorganization of the territory and the context in which a company operates in general that allows integrating, enhancing and directing towards common objectives, solutions and interventions. In particular, both the objectives of the service system and the smart city are: effectiveness, efficiency and sustainability. To make this integration happen it is necessary that all the resources within the city or the system enjoy equal rights and power and those they are placed on the same level. The resources exchanged by citizens take on the same role as those exchanged by organizations, for this reason, it can talk about democratization of the role of resources[24].

Lastly, the third aspect in common is the interacting between human and technological components. Specifically, while the human component is linked to the creation of knowledge and innovation, the technology is the mean by which knowledge is exchanged faster. The main role of ICTs, indispensable both in smart cities and in service systems, generates e-government

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stands as a connecting point between the two concepts. From the moment the whole city becomes an integrated system of resources that interconnect with each other in order to co-create value, and then the smart city can be seen in all respects as a service system [04].

Through integration of all the resources available within a city, deriving from the collaboration of the citizens themselves, it is possible to frame the whole city as a huge service system within which public value is co-created and in which citizens become central actors contributing to the value co-creation. Figure 4 summarizes this process, defining the key elements of the service system and qualifying for each of them the types of resources exchanged, used technologies, and interacting actors [04].

This all requires a solid and secure system of data collection and storage to prevent hacking or misuse. Smart city data also needs to be anonymised to prevent privacy issues from arising[24].

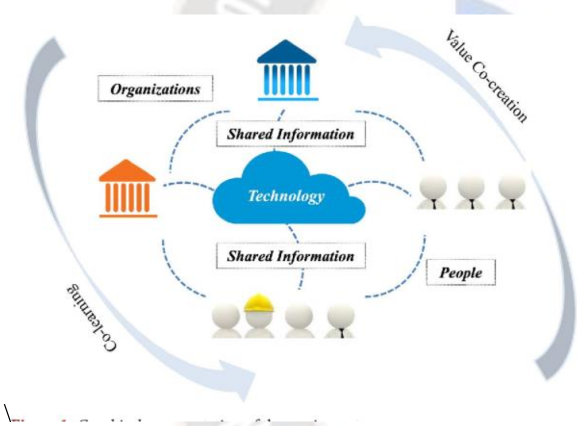

Figure 4. Smart City Service System

The largest challenge is quite probably that of connectivity, with thousands or even millions of IoT devices needing to connect and work in unison. This will allow services to be joined up and ongoing improvements to be made as demand increases[05].

Technology aside, smart cities also need to account for social factors that provide a cultural fabric that is attractive to residents and offer a sense of place. This is particularly important for those cities that are being created from the ground up and need to attract residents[04].

Smart cities offer plenty of benefits to improve citizen safety, such as connected surveillance systems, intelligent roadways and public safety monitoring, but what about protecting the smart cities themselves?

There is a need to ensure smart cities are protected from cyber attacks, hacking and data theft while also making sure the data that is reported is accurate[04].

In order to manage the security of smart cities there is a need to implement measures such as physical data vaults, resilient authentication management and ID solutions. Citizens need to trust the security of smart cities which means government, private sector enterprise, software developers, device manufacturers, energy providers and network service managers need to work together to deliver integrated solutions with core security objectives[24]. These core security objectives can be broken down as follows:

. Availability – Data needs to be available in real time with reliable access in order to make sure it performs its function in monitoring the various parts of the smart city infrastructure

. Integrity – The data must not only be readily available, but it must also be accurate. This also means safeguarding against manipulation from outside

. Confidentiality – Sensitive data needs to be kept confidential and safe from unauthorized access. This may mean the use of firewalls or the anonymising of data

. Accountability – System users need to be accountable for their actions and interaction with sensitive data systems. Users logs should record who is accessing the information to ensure accountability should there be any problems.

To cope with long-term urbanization, smart cities must start today to deploy services based on the Internet of Things (IoT) to enhance their livability, sustainability, mobility and overall efficiency. Even if the concept of the “smart city” is now broadly understood, many cities still have an unclear view of where and how to get started. Smart cities applications are making an impact in four main domains: mobility, environmental sustainability, public services and livability. But to quickly and fully benefit from these services, an end-to-end approach is needed combining applications, connectivity and platforms[05].

C. *Smart City Management:*

Smart city services are major solutions for reducing costs and solving urban problems by using information technology (IT) for housing matters, traffic problems, and crime prevention caused by rapid urbanization. For this reason, the Smart city is becoming one of the most compelling tools for local governments who are seeking to meet sustainable development goals, achieve a higher quality of life for residents, improve government efficiency, and bring about collaborative governance. In addition, smart cities can improve quality of life, save time, increase economic benefit, and consequentially maximize value by applying advanced technologies to cities. With the development of smart cities, the services that are being provided in cities are also diversifying, and as many smart technologies are developed to provide services, the smart city-related industries and markets are also growing significantly [24].

Smart City Management is the productive utilization of advanced projects and services through information and communication technologies (ICT) to provide various applications and strategies for better operation of the city. In every smart city, a new project is like a brick which assists in the development of the city and bestows it with useful services. The reference models and managerial practices together create an intelligent vision of the smart city's future[04].

Smart city management is a series of planned actions, monitoring and governance based on the use of advanced information and communication technologies. At the core of this type of innovative management there is the digitalization of all areas of public administration which are interconnected through smart city data management platforms. These city management systems are able to analyze a large quantity of data and interact directly with the infrastructure. This type of management eases governance while guaranteeing citizens a better quality of services and a more sustainable city[24].

To develop an efficient management of the smart city all sectors of the public administration must also be smart.

- Smart Payments - an economy based on digital payments which guarantees safe and rapid transactions, both for customers and for the public administration.
- Smart Mobility - smart and sustainable mobility solutions such as bike-riding or car-sharing. But also smart city traffic management tools and electric charging infrastructure.
- Smart Governance - improving sectors, from heath to education and security, using open data management systems and city analytics to make more efficient decisions based on updated and accurate information.
- Smart Living - contribute to the well-being of citizens and the environment thanks to smart LED lighting which can be monitored remotely or waste management platforms based on IoT.

Smart City management benefits:

- *Absolute Scalability, Modularity, and Compatibility:* All governance operations can be carried out easily and quickly. The management systems can be efficiently applied to small local government bodies to large private sectors too as per the specific features and requirements[04].
- *Citizen Relationship Management*: Technology gives an excellent opportunity to look after the policies, campaigns, and procedures for the citizens and delivers them a better experience. With e-government, the management can track, measure, and implement programs as per the smart city plan over multiple networks[04].
- ***High Data Security:*** Every bit of data and information transmitted in the smart city environment is effectively authorized and secured. This ensures the complete safety of the resources and provides details on the possible defects or errors too[04].
- ***Automated Information and Working Systems:*** All the operations tasks related to the citizen and government, integrated metropolis services, database systems, geographical information systems, etc. owing to the digital technology are automated with ease. This further ensures that the functioning of the smart city infrastructure is smooth, with no bottlenecks at all[24].
- *Public-Private Sector Integration:* With the streamlined integration of public and private sectors, the services to be provided and the amendments to be made both are managed in a much better way. The initiative offers the maximum mobility to the working structure and improves the economy of the system too[24].

II. RELATED WORK

We may use the Internet of Things (IoT) and cloud computing to organize the dustbins in real-time at various locations throughout the city. The smart clean dustbin is linked to the internet to keep track of its current status. A set of ultrasonic sensors are placed at the top of the dustbin to eliminate inaccurate measurement and are coupled to microcontrollers [04]. The weight sensor is attached to the base of the dustbin and is linked to the controller in order to determine the amount of garbage that has been deposited in the dustbin. These sensors send signals to the controller, and the radio frequency transmitter encrypts data from the microcontroller and sends it to the receiver unit, which then sends it to the radio frequency collector connected to the receiver unit . The receiver compiles the information gathered by the collector and uploads it to the web server. This system has been set up by connecting these sensors to the Private Cloud Data Management Infrastructure [04].

The smart dustbin is taken with the data parameters of weight, capacity, and cross section according to its data types, such as sensitive, quasi(semi)-sensitive, or public data. One side of the dustbin has ultrasonic sensors at the top, and the other side has a load cell [04]. A web Application Program Interface (API) is developed for remote monitoring of the real-time status of the data parameters that are stored or available

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on the web server. This web server manages all the integrated resources effectively and also operates (accesses and stores) the required on-demand data as and when required with respect to the anonymization of the data. The API gives all operational information (sensitive, semi-sensitive, or public) about the proposed Waste Management System, as well as information about the consumer, such as the location of the dustbin, the name and contact information of the coordinator, and the status of the dustbin in that particular area.The API shows the current status of the collected garbage. When the dustbin is full, an SMS is sent to the coordinator through the GSM module[04].

A. Hardware Specification:

CPU	1-GHZ, Broadcom BCM2835
RAM	512MB
Wireless (Pi Zero W only)	802.11n / Bluetooth 4.1 / LE
Ports	Micro USB, mini HDMI
I/O	40 GPIO Pins, CSI camera connector (not on version 1.2)
Size	2.6 x 1.2 x 0.2 inches (66.0mm x 30.5mm x 5.0mm)
Weight	0.31 ounces (9 grams)

B. Circuit Block:

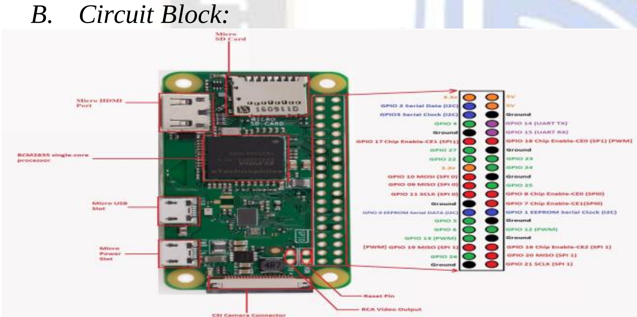

Figure 5. Circuit Block

. *Long-Range IR Sensor Specification:*

Figure 6. LR-IR Connector

- Input Supply Voltage: 5V DC
- Load current: 100mA
- Sensing range: 3 cm to 80 cm adjustable
- Sensing object: Translucency, opaque
- Output operation: Normally Open (0)
- Output DC: three-wire system (NPN)
- Model No.: E18-D80NK-N
- Diameter: 18 mm
- Length: 45 mm
- Guard mode: Reverse polarity protection
- Material: Plastic
- Appearance: Threaded cylindrical
- Ambient temperature: -25 to 70 deg C
- Brown: +5V, Black: Signal, Blue: GND
- Output: 1- No detection 0 - Object detected

. *Ultrasonic Sensor:*

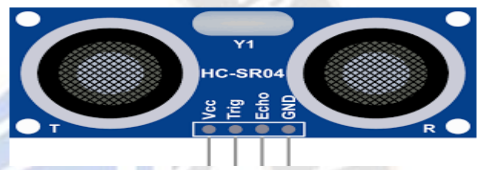

Figure 7. Ultrasonic Sensor

- Power Supply: DC 5V
- Working Current: 15mA
- Working Frequency: 40Hz
- Ranging Distance: 2cm – 400cm/4m
- Resolution: 0.3 cm
- Measuring Angle: 15 degree
- Trigger Input Pulse width: 10uS
- Echo Output Signal: TTL pulse proportional to the distance range
- Dimension: 45mm x 20mm x 15mm

. *Servo Motor:*

Figure 8. Servo Motor

- Dimension: 40.7mm X 19.7mm X 42.9mm
- Weight: 55g
- Stall Torque: 9.4 kg-cm (4.8V); 11 kg-cm (6V)

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- Operating Speed: 0.20sec/60degree (4.8V); 0.16sec/60degree (6.0V)
- Operating Voltage: 4.8V ~ 6.6V
- Gear Type: Metal gear
- Temperature Range: 0℃ - 55℃
- Dead Band Width: 1us
- Servo
- Wire Length: 32cm
- Current Draw at idle: 10mA
- No Load Operating Current: 170mA
- Stall Current: 1.2A Servo Arms and Screws included

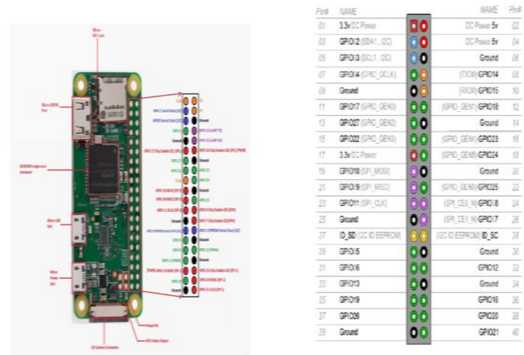

Figure 10. RPi editor

. *Moisture sensor*:

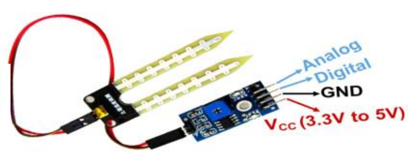

Figure 9. Moisture Sensor

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- Output Digital - 0V to 5V, Adjustable trigger level from preset
- Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
- LEDs indicating output and power
- PCB Size: 3.2cm x 1.4cm
- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- Small, cheap and easily available

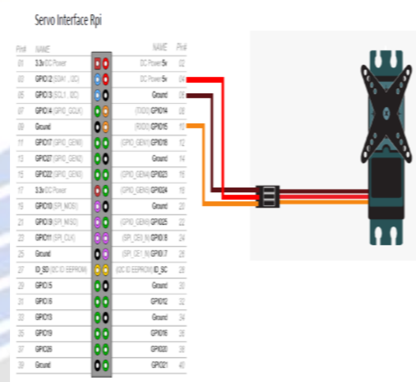

Figure 11. Servo- RPi editor Interface

C. Software Specification:

Frontend: HTML, CSS
Backend: Python (Django)
Database: SQL Lite
RPi OS: Raspbian buster 32bit
API call: json RPi editor: Geany (Pythoneditor)

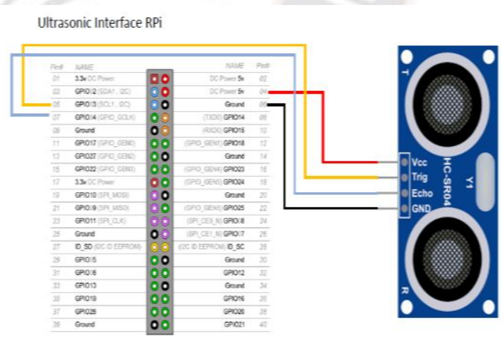

Figure 12. Ultrasonic- RPi editor Interface

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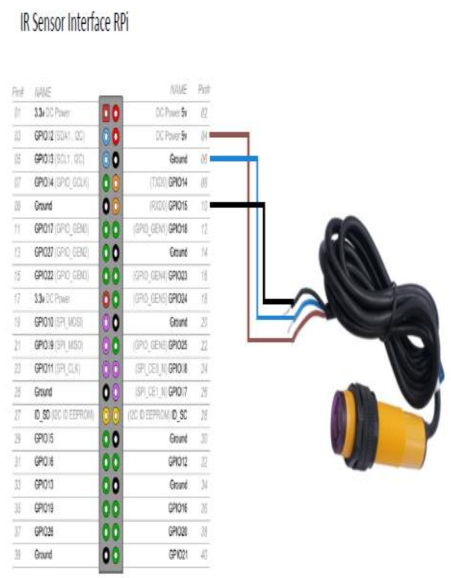


Figure 13. IR Sensor- RPi editor Interface

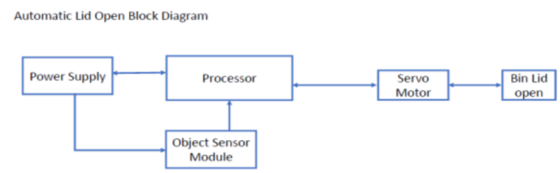


Figure 14(b). Smart Bin Block Diagram

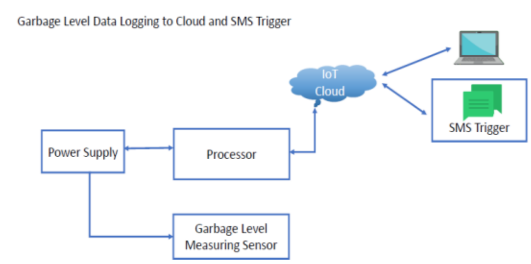


Figure 14(c). Smart Bin Block Diagram

D. Model Block Diagram:

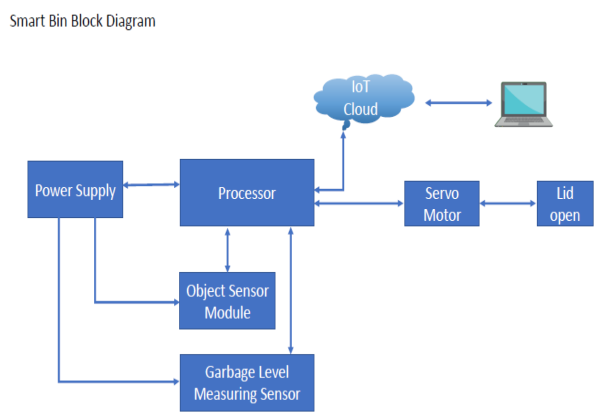
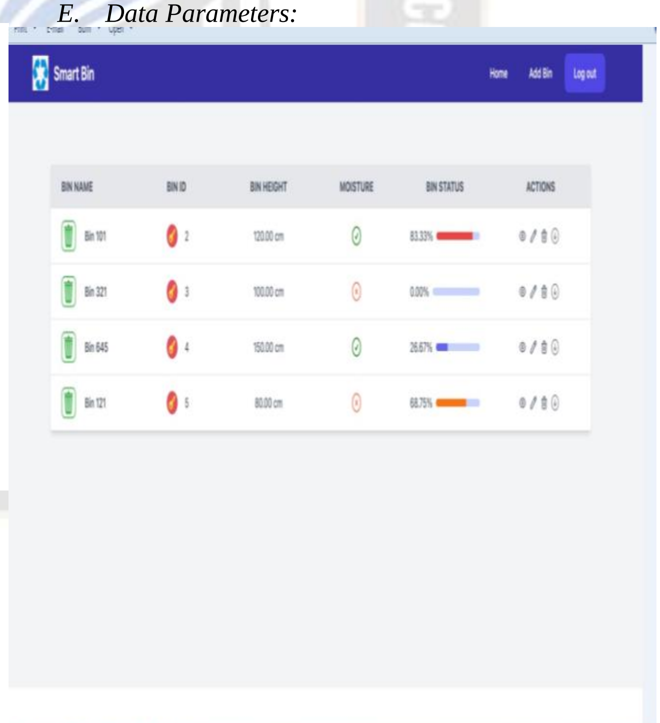


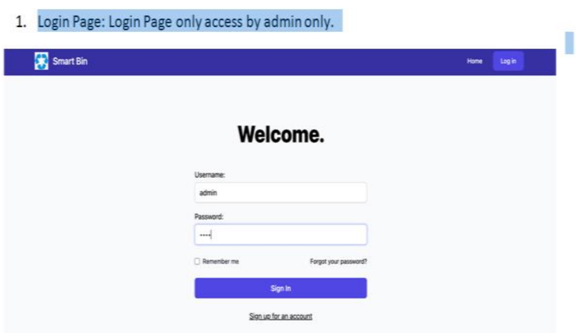
Figure 14(a). Smart Bin Block Diagram

E. Data Parameters:



International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

F. User Interface:



III. CONTRIBUTION

Most waste collection operators empty containers according to predefined schedules. This is not a very efficient approach since it leads to the unproductive use of waste containers and unnecessary fuel consumption by waste collecting trucks[05].IoT-enabled smart city solutions help to optimize waste collecting schedules by tracking waste levels, as well as providing route optimization and operational analytics[05].Each waste container gets a sensor that gathers the data about the level of the waste in a container. Once it is close to a certain threshold, the waste management solution receives a sensor record, processes it, and sends a notification to a truck driver's mobile app. Thus, the truck driver empties a full container, avoiding emptying half-full ones[05].

"Waste management or waste disposal is all the activities and actions required to manage waste from its inception to its final disposal [04].This includes amongst other things, collection, transport, treatment, and disposal of waste together with monitoring and regulation. The overall events conducted in smart waste management system are;

Smart sensors measure the level of waste

- Containers send the info to a data management system of the level of waste or last collection.
- Only certain bins are marked for collection.
- Vehicles only collect full or overdue containers.

Smart cities are leveraging the Internet of Things (IoT) to create an efficient system to save cities money and save the environment. A major way Smart Waste Management has been impacted by technology is route optimization [05].One of the greatest problems solved by Smart Waste Management Solutions is route optimization. Waste management is not the only industry affected by route optimization, also, trucking (logistics) is a major adopter of optimizing routes[04].

A. *Optimizing the Routes:*

Route optimization for solid waste collection involves making waste collection as efficient as possible for the waste vehicle. Cutting down on miles driven to complete a route of collection addresses is an important way to reduce carbon emissions but also reduce costs for the business[10].Route optimization for solid waste collection is challenging, requiring superb organizational systems. If we can do this then you will benefit from efficiencies that can transform your costs and you improve your fleet management operationally[10].Smart Routes route planner app works with some of the largest solid waste collection teams around the world to help them optimize the routes they drive to do their collections. Smart Routes is uniquely capable of managing waste collections as it consists of both web app and mobile apps that communicate in real-time to ensure anything that happens in the field is captured in the systems. For waste collection teams it is the perfect tool to get the job done right[10].

B. Proposed system Architecture:

The GIS-based route-optimization algorithm discussed earlier can be incorporated within an integrated smart waste collection solution, as shown in Fig15.The proposed system combines multiple hardware and software components, including smart waste bins, a control unit (with route-optimization and artificial intelligence (AI) algorithms), and Global Positioning System (GPS) navigation devices in collection trucks[04].While most of those components are typical in SCS, except for the AI machine-learning module, the overall system is customized to fit the local operating conditions[05].The system utilizes real-time sensory data obtained from waste bins, along with live traffic data, in the decision-making process. The optimized collection routes are wirelessly transmitted to the GPS-navigated collection trucks. The route-optimization algorithm is continuously tuned based on the system performance feedback by means of AI machine-learning. The following sections describe the main components and processes of the proposed system[04].

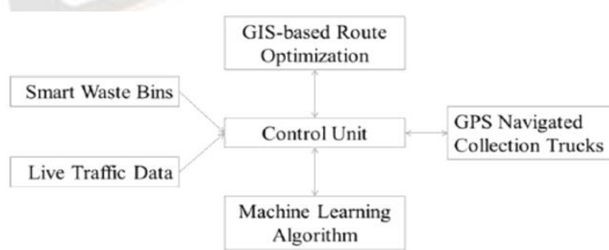


Figure 15. Smart Waste Collection System Architecture.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

C. *Determination of Shortest Path:*

In smart cities where IoT devices need to communicate and exchange data efficiently often have resource constraints, and finding the most energy-efficient or reliable path is crucial[05].The shortest path finding mechanism plays important role for the citizen of Bhubaneswar as a smart city and the Municipal Corporation (BMC) as well.

The citizen is interested to get prompted about the status of the waste bins, preferably the unfilled ones to be used by the citizen. Whereas for the municipal corporation, the detailed status of the smart bins placed city wide need to be monitored dynamically, so that the related services like sending the waste carrying vehicles to different locations of the city for collecting the waste[04].

To find out the shortest path (Unfilled or Partially Filled Bins for citizens) and the filled bins nearer to the waste carrying vehicles to reach using Global Positioning System (GPS) Bellman ford algorithm will work as the parameter in this and use from the initial node to target or source node. This algorithm efficiently calculates the shortest paths from a source vertex to all other vertices in a graph, even in the presence of negative edge weights[04].

D. *Applying the Algorithm:*

This algorithm follows a simple iterative process that gradually refines the estimated distances to vertices until it converges on the shortest paths. Here is a step-by-step breakdown of the algorithm:
Step-1: Initialize the distance values of all vertices in the graph as infinity, except for the source vertex, which is set to zero. Also, set the predecessor of each vertex as undefined.
Step-2: Relax all the edges in the graph |V|-1 times, where |V| represents the number of vertices in the graph. During each iteration, the algorithm examines every edge and attempts to improve the distance value of the target vertex. If a shorter path is found, the distance value and predecessor for the target vertex are updated.
Step-3: After |V|-1 iterations, perform an additional iteration to detect negative cycles. If any distance value further decreases, then a negative cycle is present in the graph as it can handle negative weight cycles.
Step-4: If a negative cycle is detected, the algorithm reports its existence. Otherwise, results the shortest path and its corresponding distances for each vertex.

. *Path detection using in GPS:*

1) Function (0,3)
2) for each node V in G
3) distance[i]□INFINITY
4) previous[i]□NULL
5) distance[s]□0
6) for each node V in G
7) for each edge(i, x) in G
8) alt□ distance[i]+length(i ,x)
9) if alt<distance[x]
10) distance[x]□ alt
11) previous[x]□u
12) for single edge (i, x) in G
13) if distance[i] + length(i, x)<distance(x)
14) return

System Block Diagram:

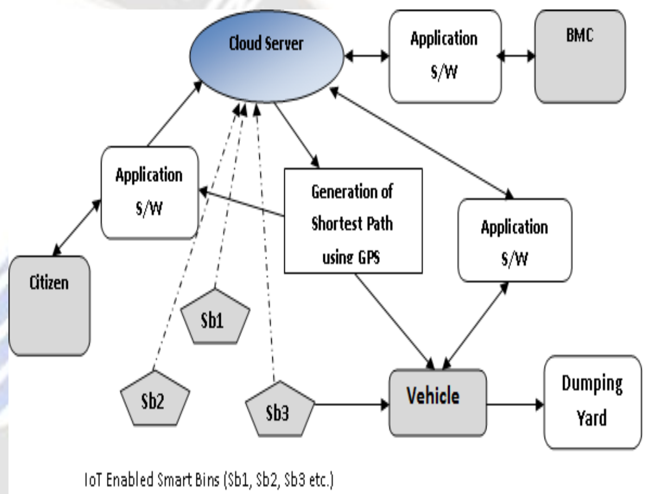


Figure 6. System Block Diagram

V. CONCLUSION

It is preferred that a sustainable city should reduce environmental impacts through its activities and promotes sustainable consumption and production patterns in accordance with its own territorial, geographical, social, economic and cultural conditions[04].

Sustainable management is the application of sustainable practices in the categories of businesses, agriculture, society, environment, and personal life by managing them in a way that will benefit current generations and future generations. This type of management eases governance while guaranteeing citizens a better quality of services and a more sustainable city[08].

In context of smart waste management, some of the limitations are need to be taken as big concerns such as power trade off for sensors, technological dependency, data security, avoiding Human computer interface (HCI), Lack of versatility, Limited or no autonomy and great influence of geographical differences[08].

The future work may be in the direction of upgrading the smart systems w.r.t. the technology in time and to overcome the these limitations, Artificial Intelligence (AI) and Robotics Technology can be a great move in managing a sustainable smart city[08].

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