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A Study of Development of Smart Cities Using Internet of Things

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Abstract: Smart cities as well as the unique services they provide by using current technology and innovative solutions are taking on a major role in the development of the information society. The Internet of Things is the most important factor in enabling and driving smart cities (IoT). In this article, the researcher has investigated potential Internet of Things-based smart city services by conducting a systematic literature analysis and reporting their findings. The researcher has developed the protocol for the review in order to specify the research topic or issues, the research methodology, the selection process, the criteria for evaluating the reliability of the research, as well as the method for information gathering. The following is the main study issue that the researcher has defined: In the context of the advancement of smart city services, what kinds of applications have been identified for the Internet of Things? The studies were organised into groups according to the smart city services they either described or suggested. The researcher has identified the following categories: transportation and traffic, environmental monitoring, accessibility and medical care, management of trash and resources, public lighting, management of energy resources, municipal infrastructure, and many other.

Keywords**:** *Smart Cities, Internet of Things (IoT), Smart Parking, Smart Metre and Billing, Smart Medical Care.*

1. Introduction

IoT-enabled smart city use cases include a wide range of applications, from promoting a healthier environment and strengthening public safety to enhance traffic and improving street lighting. The most well-liked use cases that have already been put into practise in smart cities throughout the world are outlined below.

1.1 Road traffic

Smart cities make it a priority to move their residents from point A to point B as quickly and securely as feasible. Municipalities use IoT development and smart traffic systems to do this. The number of cars, their position, and their speed may be determined by intelligent traffic solutions via the use of a variety of sensors as well as the retrieval of GPS data from drivers' smart phones. At the same time, smart traffic lights that are linked to a cloud administration system make it possible to monitor the length of time that the green light is on and automatically adjust the timing of the lights to account for the flow of traffic in order to reduce congestion[1]. Smart systems for traffic management may also foresee where the traffic might go and take efforts to minimise prospective congestion by analysing past data. This is an additional benefit of these solutions.

Los Angeles, one of the most congested cities in the world, uses a smart traffic system. A central traffic control platform receives real-time traffic data from road-surface sensors and CCTV cameras. Desktop user applications notify platform users of overcrowding and traffic signal faults after data analysis. The city is also using smart controls to alter traffic signals in real time.

Fig 1 Smart City using IoT

1.2 Smart Parking

A real-time parking map can be generated by smart parking solutions with the assistance of GPS data from drivers' smartphones. This information is then used to ascertain if the parking spots in question are currently inhabited or vacant. Instead of aimlessly driving about in circles, drivers get a message on their phones the instant parking place that is nearest to them becomes available[2]. They can then use the map that is stored on their phones to locate a parking spot more quickly and easily.

1.3 Public transport

The information collected by sensors connected to the internet of things may assist in illuminating trends in the

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ways in which residents use various modes of public transportation. The operators of public transportation systems may make use of this information to improve the travelling experience, as well as attain improved levels of safety and timeliness[3]. Smart solutions for public transportation may incorporate data from numerous sources, like sales of tickets and information on traffic patterns, to carry out more in-depth analyses.

Some railway operators in London, for example, estimate the number of passengers that will be travelling on their trains during the journeys to and from the city. They incorporate the information obtained from movement sensors, CCTV cameras, and ticket sales that have been set along the platform. Train operators are able to make accurate projections about how people will load each car owing to the analysis of this data[4]. Train operators try to get passengers to disperse themselves evenly throughout an arriving train so that as many people as possible may be accommodated. Train operators may minimise delays by making the most of the capacity they have available.

1.4 Utilities

Smart towns that are connected with IoT make it possible for inhabitants to save money by providing them more command over the utilities in their homes. IoT provides multiple methods to smart utilities:

1.4.1 Smart meters and billing

Municipal governments may provide residents with an efficient and low-cost connection to the information technology systems of utility companies if they have a network of smart metres. Now, smart linked metres are able to transfer data directly to a public utility through a telecom network, therefore giving the utility with accurate readings from the metres[5]. The installation of smart metres enables utility providers to generate correct bills for the quantity of water, electricity, and gas that are used by individual households.

1.4.2 Revealing consumption patterns

The installation of a network of smart metres gives utility providers the ability to improve their visibility and monitor the energy and water consumption patterns of their consumers. Utilities providers may analyze demand in real time using a network of smart metres and reroute resources as required or urge customers to use less electricity or water during times of scarcity.

1.4.3 Remote monitoring

Citizens may also benefit from the utility management services that can be provided by IoT smart city systems. Citizens are given the ability to remotely monitor and adjust their energy use via their smart metres by using these services. By way of illustration, a homeowner may switch off the central heating system in their home by utilising their cell phone[6]. In the event that a problem arises, utility providers are able to alert residents of their homes and dispatch technicians to address the issue.

1.5 Street lighting

Because they are based on the IoT, smart cities make the management and maintenance of street lighting more simpler and more cost-efficient. It is possible to better adjust the lighting plan to the lighting zone by installing sensors in streetlights and linking those lamps to a cloud administration service.

In order to optimise the lighting schedule, smart lighting systems collect data on illuminance, the movement of individuals and vehicles, as well as contextual and historical information, and then evaluate the combined set of information[7]. As a consequence of this, a smart lighting system "tells" a streetlight to dim, turn on, brighten, or switch off the lights depending on the circumstances that are externally present.

1.6 Waste management

The majority of those who work in garbage collection empty boxes in accordance with predetermined timetables. This strategy is not very effective since it results in the useless usage of garbage containers and the excessive consumption of gasoline by waste collection vehicles. Solutions for smart cities that are enabled by the Internet of Things assist to optimise garbage collection schedules by measuring waste levels. These solutions also provide route optimization as well as operational analytics to help improve municipal operations[8-9]. Each garbage container is equipped with a sensor that collects data on the amount of waste that is currently contained inside that container. The waste management system will get a sensor record whenever it is getting near a specific threshold. After processing the record, it will then send a notice to the mobile app that truck drivers use. As a result, the truck driver only empties full containers, eliminating the need of emptying containers that are only partially filled.

1.7 Environment

Solutions for smart cities that are powered by the Internet of Things make it possible to monitor parameters that are essential for a healthy environment in order to keep them at the ideal level. For the purpose of ensuring safe drinking water, for instance, a municipality may instal a system of sensors everywhere throughout the water grid and then link those sensors up to a cloud-based management system[10]. The pH level, the quantity of dissolved oxygen, as well as the ions that are dissolved are all measured by sensors. The cloud platform will initiate an output that the customers have specified in the event that there is a leak and a change in the chemical content of the water. For instance, if the quantity of nitrate (NO3-) in the water surpasses 1 mg/L, a water quality monitoring system will notify maintenance teams of potential pollution and will also immediately establish a case for field employees. These personnel will then begin working on resolving the problem.

Monitoring the quality of the air is another example of a use case. In order to do this, a network of sensors is installed along heavily used routes and all surrounding facilities. Sensors collect data on the amount of nitrogen oxides (NOx), carbon monoxide (CO), in addition sulphur oxides (SOx), as well as a central cloud platform analyses and visualises the readings from the sensors[11-12]. This allows users of the platform to view a map of the air quality and utilizes this data to point out regions where air pollution is particularly severe and formulate suggestions for citizens.

1.8 Public safety

Tools for real-time monitoring and analytics, as well as tools for making decisions, are made available by Internet of Things (IoT)-based smart city technology. Public safety solutions are able to identify possible crime acts by combining the information from acoustic sensors and CCTV cameras that have been distributed across the city with the data from social media feeds and then evaluating the combined data. Because of this, the police will be able to effectively prevent prospective criminals or hunt them down.

For instance, a technology that detects gunshots is used in more than ninety percent of the cities in the United States. The technique makes use of interconnected microphones that are strategically placed all across a city. The information collected by microphones is sent to a cloud platform, where it is analysed together with the other noises to identify the sound of a gunshot[13]. The platform determines the position of the gun based on the amount of time it takes for the sound to get to the microphone and measures this time. Cloud software will notify the police through a mobile app as soon as the location of the gunshot is determined once it has been detected.

1.9 Iterative approach to implementing smart city solutions

The spectrum of possible applications for smart cities is quite broad. The strategy that will be used to carry it out is something that they both have in common. Municipalities that want to automate garbage group or improve street lighting should begin with the foundation, which is a basic smart city framework[14]. This is true regardless of the municipality's plans. It will be feasible to modify the current structure with new technologies and tools so that it does not need to be rebuilt if a municipality decides in the future that it would want to increase the range of smart city services that it offers. In order to construct an Internet of Things architecture that is effective and scalable for a smart city, the following implementation methodology consists of six steps.

2. Review of Literature

In the context of the smart city idea, the use of intelligent devices and internet technology represents a novel approach to municipal governance. There is a broad spectrum of interpretations that may be applied to the term "smart city." It is distinctive owing to the various contexts and situations that are present in each instance of the deployment of smart cities. On the other hand, this has established the groundwork for smart city definitions. They determined that an instrumented, linked, and intelligent metropolis was the definition of a smart city. When a city is said to be instrumented, it indicates that it has a collection of instrumentation equipment that permits the acquisition and processing of live data from the actual world. If a city is said to be linked, it indicates that it has the capability to incorporate the data obtained from the monitoring equipment into a computer platform and to send the data to a variety of municipal services.

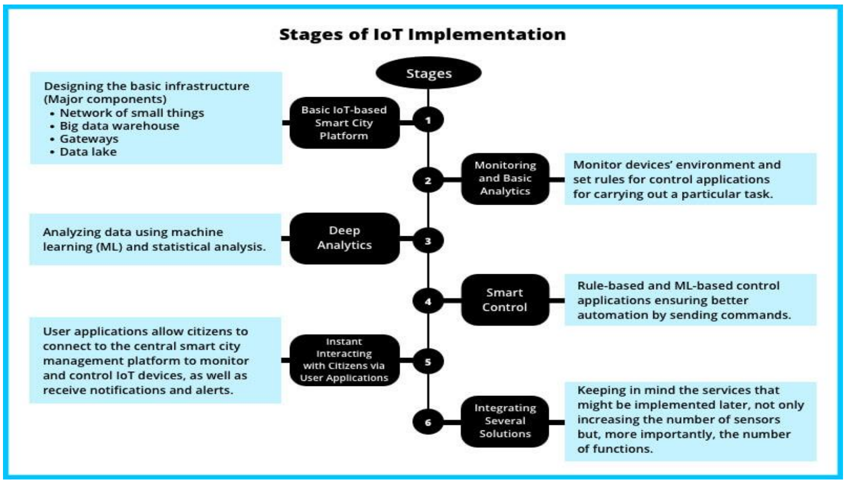

Fig 2 Stages of IoT Implementation

In addition, build a framework for the smart city with five layers. In this system, sensors acquire live, real-world information needed in the study in the top levels to help or digitise municipal function choices or activities. This data improves city functions. Because of this framework, interrelated sensors, which are more commonly referred to as the IoT, are unavoidably needed as an inherent characteristic of the smart city[15]. This is because the IoT has the capability to automatically share information, interact with one another, and incorporate services whenever and wherever it is needed to do so.

IoT is a system of connected items that gathers information from the world to become an information source for analytical tools, applications, as well as services in certain domains. This network is a development of the traditional internet. There is a concept for the Internet of Things that does not confine in any standard of communication procedure. This definition makes it possible for smart technologies to be created and implemented utilising any existing protocol that is considered modern at any particular moment in time. The explanation is as follows: "Interconnection of actuating and sensing devices offering the capacity to communicate information across platforms by means of a unified framework, hence establishing a common operating environment for the purpose of allowing creative applications." This is accomplished by integrating data analytics, large-scale sensing, and data depiction in a seamless manner via the use of cutting-edge ubiquitous sensing as well as cloud computing.

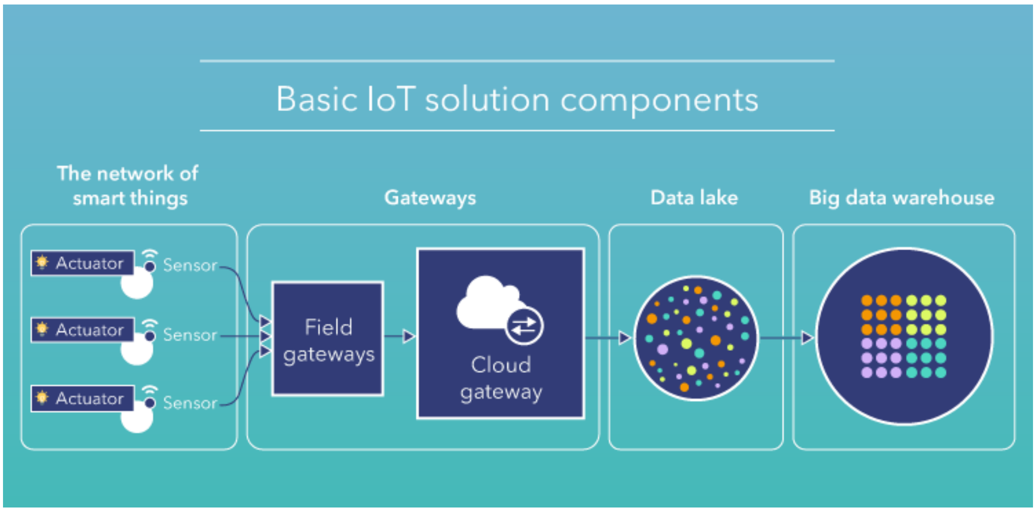

Fig 3 Basic IoT Components

In light of the concept presented above, the Internet of Things may be broken down into the following three categories: Devices, Middleware, and Presentation.

Internet of Things devices that are implemented in municipal infrastructures generate a massive quantity of data, also known as big data, which may then be put to use in a variety of applications that assist city operations. Managing the flow of these large amounts of data needs orchestration from specialised parties, often known as Internet of Things operators, so that the data may be used in an effective and safe manner. In the context of smart cities, IoT ecosystem should include at least four layers, particularly in respect to massive data flows[16]. The city infrastructure as well as the residents themselves serve as the objects as well as operators that turn out to be the facilitators of the smart city ecology. This layer is the first of three layers.

The utilities of a city are operated inside a city's infrastructure, and inhabitants are the end-users of the many different smart city services that improve the quality of their lives. From this 1st layer, Internet of Things equiments deployed in the 2nd layer may harness information, which middleware solutions can collect in the form of standardised APIs to engage with data created by these devices as well as saved in an open data model at the third layer. At the 4th layer, a public private partnership organization is established as the Internet of Things service hand to manage the data distribution to third-party developers[17]. This entity is developed based on the open data that is given through standardised APIs. IoT service operators often use a paradigm that is analogous to an app store when they provide API access to third-party developers so that these developers may create their own applications, analytical tools, including services. After the applications have been produced, they will be made available to consumers via app stores such as the Apple App Store and the Google Play Store. Regulated accessibility by the operator of the Internet of Things service may be advantageous to people since it will lead to the creation of services that have a constructive effect on the citizens' quality of life. On the other side, service providers of utilities will also gain from increased control over their own infrastructure[18]. Several municipalities all around the globe have already implemented smart city programmes that are supported by

Internet of Things technology. These programmes are using smart technology in order to improve municipal services such as energy distribution systems, transportation infrastructures, and natural resource management.

3. Methodology

3.1 Database in addition to the search terms

The Scopus database was searched to find publications that had been published on the IoT and the smart city. This database is well-known for its comprehensive inclusion of journals produced by reputable worldwide publishing houses including as Elsevier, Springer, Taylor & Francis, EmeraldInsight, as well as IEEE. It also has a solid indexing system for these publications. Only journal articles were taken into consideration for selection in order to ensure that the retrieved sources were of an academic character and of a high quality. In the body of work devoted to meta-analysis, choose a certain kind of publication to scrutinise as part of an investigation is somewhat of a contentious issue. For example, despite the fact that some academics choose to read just journal papers, others concentrate on both journal articles as well as books, or some specifically remove editorial material, amendments, and conference abstracts from their research[19]. Only publications from peer-reviewed journals were considered for inclusion in our analysis because researchers wanted to ensure that the information they collected represented high-quality Internet of Things research applicable to the topic of smart cities.

3.2 Preliminary article analyses

Researcher was successful in retrieving all of the bibliographic entries that were associated with the authors, titles, keywords that were submitted by the authors, as well as other document information. The key features of Internet of Things and smart city articles may be seen in Table 1, which was derived from the Database search. According to the information shown in the table, a total of 1,802 articles, which demonstrate a cooperation index of 4.12, were produced by 5,789 writers. These papers earned a mean of 16.81 citations per document[20]. According to Ajiferuke, the cooperation index is a measurement of fractional productivity. According to this index, a number that is near to 0 indicates that the majority of the articles were written by a single author.

4. Result and Discussion

Following the collection of the list of relevant documents, the papers were further arranged according to the smart city services that they either suggested or described. Because the papers were not limited to just one kind of smart city service, one will find that several papers appear in more than one category. In addition, the borders between each category were not strictly enforced. This is due to the fact that a single smart city service may cross over into many categories. When this occurred, researcher took into consideration the goals and positioned the service into the category that they determined to be preeminent. Following is a list of the categories that they have identified: (1) transportation and traffic, (2) environmental monitoring, (3) public accessibility as well as healthcare, (4) trash administration, (5) public lighting, (6) energy resources, (7) municipal infrastructure, and (8) other issues. The Internet of Things is the primary catalyst and facilitator of smart city services. It provides the tools for sensing the city and the people that live there, as well as gathering massive volumes of data on the activities and occurrences that take place in the city.

This is shown by the large number of suggested solutions for traffic monitoring, the environment, energy consumption, major events and crises, as well as the infrastructure of the city. The monitoring of the city's vital signs is just one use of Internet of Things technologies. Instead, they examine the data, do analysis on it, and then go on to intervening in specific instances. Papers that have been peer reviewed may provide illustrative instances of IoT's active engagement. Some examples of these types of systems are intelligent road lane management systems, dynamic and adaptive traffic signal systems, garbage collection efficiency systems, dynamic street lighting, evacuation and emergency systems. It is quite clear that the Internet of Things has discovered the most fruitful ground in the enhancement of current services and the provision of new services in the categories of traffic, transportation, and parking. It should not come as a surprise that this is the case given that traffic is one of the most significant characteristics of contemporary cities. It has an impact on people's time, health, productivity, and safety, in addition to the number of pollutants and energy that is used.

As a consequence of this, it is not at all unexpected that a number of publications have focused on the optimization of lighting systems. The assistance for several other kinds of municipal infrastructure aspects, like water, gas, heating, electricity, as well as irrigation systems, has also been investigated as a possibility. It is possible that security has never been more vital on a global scale, and cities, which are the locations where people and things are concentrated at the highest densities, are particularly susceptible to a variety of natural and man-made hazards. The Internet of Things (IoT) provides assistance in forecasting, recognising, avoiding, and controlling occurrences of this crucial nature via the use of various disaster management and surveillance systems.

Table 2: smart city project in India.

Sr. No.	State	Number of cities
1	A & N Islands	1
2	Andhra Pradesh	3
3	Arunachal Pradesh	1
4	Assam	1
5	Bihar	3
6	Chandigarh	1
7	Chhattisgarh	2
8	Daman & Diu	1
9	Dadra & Nagar Haveli	1
10	Delhi	1
11	Goa	1
12	Gujarat	6
13	Haryana	2
14	Himachal Pradesh	1
15	Jammu & Kashmir	1
16	Jharkhand	1
17	Karnataka	6
18	Kerala	1
19	Lakshadweep	1
20	Madhya Pradesh	7
21	Maharashtra	10
22	Manipur	1
23	Meghalaya	1
24	Mizoram	1
25	Nagaland	1
26	Odisha	2
27	Puducherry	1
28	Punjab	3
29	Rajasthan	4
30	Sikkim	1
31	Tamil Nadu	12
32	Telangana	2
33	Tripura	1
34	Uttar Pradesh	13

35	Uttarakhand	1
36	West Bengal	4

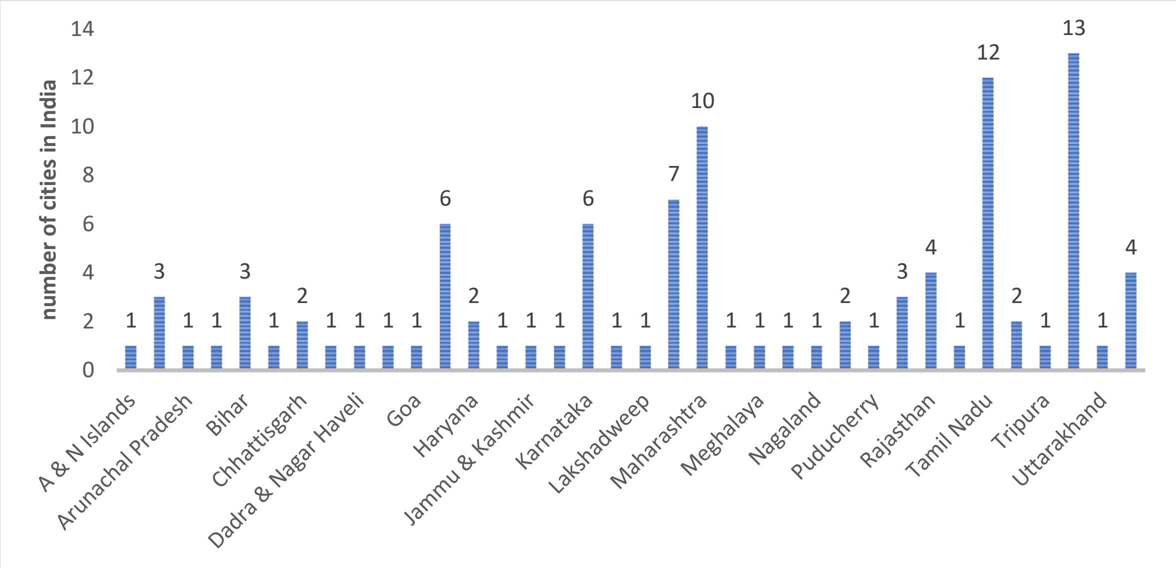

Fig 4 Selected cities from Indian State/UT for smart city project

Based on the geographical distribution, it can be seen that a significant proportion of the selected cities are located in big states like as Uttar Pradesh, Tamil Nadu, Maharashtra, Madhya Pradesh, Karnataka, and Gujarat (see Figure 4). Fewer of them come from Andhra Pradesh, Punjab, Bihar, and Rajasthan (three or four), while the other big states (Jharkhand, Kerala, Haryana, Odisha, and Telangana) only have one or two each. West Bengal, the only other major Indian state, is entitled to one such city: New Town, which is really an extension of Kolkata. The administration of that state had first distanced itself from the Mission on the grounds that it fostered unequal growth and development. Even in the state of Maharashtra, the opposition parties that are in power in the municipal corporations of Mumbai and Navi Mumbai have turned down the opportunity to take part in the programme because they disagree with certain conditions associated with it, most notably the requirement that participants form Special Purpose Vehicles (SPVs). They contend that the SPVs will result in a reduction in the powers held by the municipal corporation.

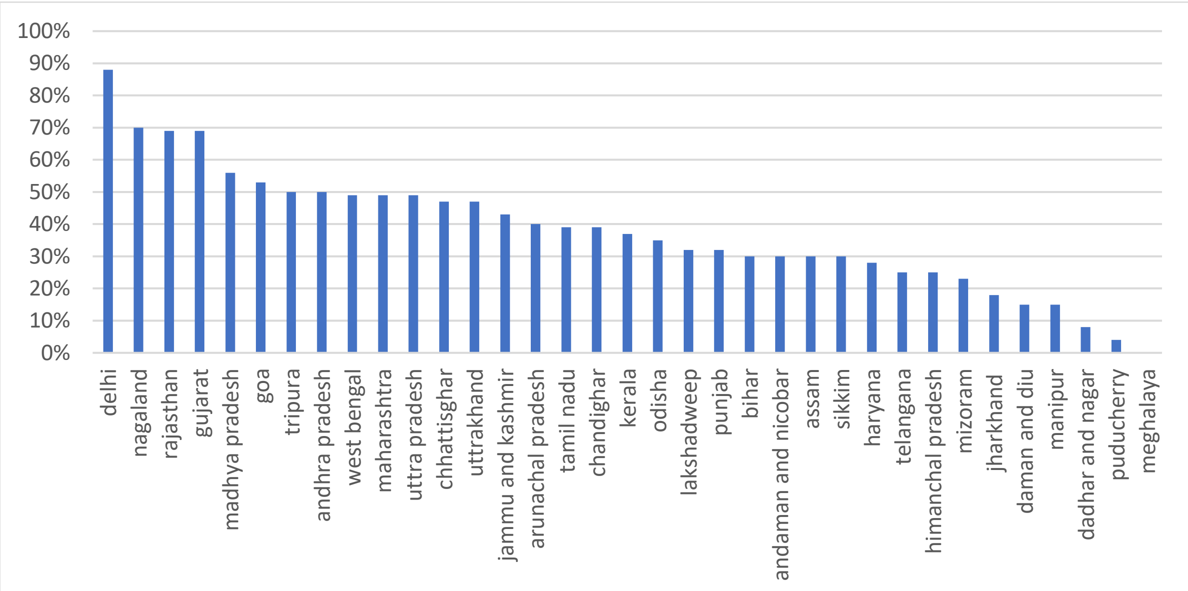

Fig 5 Project completed

Source: Ministry of Housing and Urban Affairs.

Note: Based on data up to 28 July 2021.

Delhi and Nagaland have finished more than 70 percent of their respective projects out of the total number of tenders that have been issued. Seven other states, including Gujarat, Rajasthan, Madhya Pradesh, Karnataka, Tripura, Goa, and Andhra Pradesh, have finished between 50 and 60 percent of their projects. However, a large number of additional states and territories are not doing very well (see Figure 6). Meghalaya has not been able to finish even one of its projects.

5. Conclusion

The purpose of this article was to conduct a comprehensive analysis of the services that are made possible by the Internet of Things (IoT) in smart cities. The performed review revealed that this study field is just a few decades old, and judging by the increasing number of papers published in the field over the last few years, it is presently at the hype phase of its development. According to the findings, the Internet of Things is, in fact, the most important factor in enabling and driving the various smart city services. It paves the way not only for the evolution of traditional city services into smart city services but also for the development of completely new smart city services. In order to do this, it works in conjunction with and supplements a number of other contemporary technologies, including big data and cloud computing. Even in the cities that are now the frontrunners in this field, the true use of IoT in smart city services is still in the early stages of development. However, the capability of the Internet of Things has been acknowledged, and it is not difficult to see the services discussed in this article being the standard in the not-too-distant future. Even more, new concepts for applications of the internet of things and smart services appear every day, and they will continue to have an impact on both our surroundings and our lives. Comparison of IoT-enabled smart city services from the standpoint of technology, maturity, validity, and other such factors etc. is one of the probable future works and improvements that might be made in this field. Developing a classification system for Internet of Things-enabled smart city services, - Integration platforms for Internet of Things and other relevant technologies, - Integration testbeds and simulation settings - The capacity for interoperability in the context of the smart city environment among the many different types of devices and middleware systems.

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Declarations

Author declare that all works are original and this manuscript has not been published in any other journal.

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