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Article

A Structural Approach on Enablers of IoT for Sustainable Development of Smart Cities

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Abstract: Smart cities will undoubtedly be the distinguishing characteristic of human geography in the twenty-first century. Throughout 1.3 million people move to cities every week around the world, and it is estimated that by 2040, cities will house 65 percent of the world's population. While the world's largest cities now contribute for 60% of global GDP, this percentage will continue to climb as cities get larger and smarter. According to experts, cities will account for up to 80% of future economic development in developing regions. Smart cities are no longer the wave of the future; they have here and are rapidly expanding as the Internet of Things (IoT) grows. With dozens of towns throughout the world, the smart city sector is expected to grow into a massive business as time goes on. Cities have been an increasingly crucial engine of the global economy and wealth over time. As a result, it is critical to guarantee that they are optimized to maximize efficiency and sustainability while also ensuring that each citizen's quality of life is improved. We can describe the need for smart cities through this project, and it also shows us how IoT technology and smart city enablers may be deployed in urban settings to help cities perform better for their residents and achieve overall sustainable growth. This initiative will educate urban planners, researchers, ICT professionals, and other city officials about the facilitators of IoT for smart cities and their long-term growth.

Keywords: Enablers of IoT; Interpretive Structural Modeling; Smart Cities; Sustainable Development

1. Introduction

Among numerous definitions of a smart city, in general terms, we can define a smart city as a city that utilizes IoT sensors, actuators and technology to connect components across the city that impacts every layer of a city which is from underneath the streets to the air that citizens breathe.Data from all segments is evaluated, and patterns are then created from the information gathered. A smart city is a framework made up mostly of information and communication technologies (ICT) that is used to position, advance, and promote sustainable development methods in order to track and address urbanization's progress and issues.

1.1. IoT in Smart City

Since the concept of a smart city was first established, Internet of Things (IoT) technology has been a major pillar of smart city growth. As technological advancements evolve and more countries adopt next-generation connectivity, it will continue to increase and have a greater impact on how we live.

"By 2025, there will be more than 75.44 billion linked IoT devices," according to the Improving Internet of Things (IoT) Security with Software-Defined Network (SDN) research. The Internet of Things is predicted to evolve into one of the brightest collective and collaborative systems in history, with over 7.33 billion mobile users by 2023 and over

1,105 million connected wearable device users by 2022. Cities must comprehend the benefits and prospects of the Internet of Things for Smart Cities since there is so much promise and opportunity across a wide variety of sectors, including urban transportation, security, sustainability, maintenance, healthcare, and management."

In a smart city, the Internet of Things is one of the main components that binds everything together. From sophisticated interconnectedness to becoming one of the key building elements of next-generation, smart city development, residents and governments will be connected in unprecedented ways.

1.2. IoT for Sustainable Development of Smart City

Urbanization is a continual phenomenon, and cities now house more than half of the world's population. By 2050, this percentage is predicted to be much higher. Over the next three decades, the overall population growth and growing urbanization will add many billions more people to cities. To keep up with the fast development that is stressing our cities' resources, environmental, social, and economic sustainability has become a requirement. Therefore, according to the UN, "in September 2015 at the United Nations, 189 nations agreed on the Sustainable Development Goals (SDGs) agenda."

Smart cities using IoT are using analytics and data from sensors to design better civic amenities and deliver better standards of living and cost-effective public services. With the rise in population in cities and the corresponding increased stressors on the natural and civic resources, civic administrators are coming up with interesting ways to utilize their data, IT infrastructure and using IoT applications in smart cities to deploy advanced models that will help them solve the challenges of urban planning efficiently and effectively.28 percent of people worldwide will be concentrated in cities with at least 1 million inhabitants due to which Smart cities leveraging technological advances to deliver a superior quality of living to the residents have become a critical public policy planning element. With the rise in the global population, it has become imperative for governments to design a sustainable and environmentally friendly future, to ensure the well-being of the people and curtail global warming. Major global cities have pledged to adopt sustainable practices and ensure significant cut-downs along critical dimensions and support the UN Sustainable Development Goals progress.

Following a comprehensive analysis of numerous literatures relevant to our research, we discovered that there are few attempts to link the enablers of IoT for smart cities and sustainability together. Furthermore, numerous frameworks and roadmaps have been offered to attain their desired goals, but no study has utilised ISM methodology to determine the driving and dependent capabilities of the selected enablers. With this research gap in mind, the goal of this study was to determine the structural link between IoT enablers for Smart Cities for Sustainable Development.

Following an exhaustive literature research and expert consultation, we have come up with 11 IoT enablers for Smart Cities and their link with sustainable development. The study used Interpretive Structural Modeling (ISM) to investigate the relationships between the extracted factors and their interdependencies, leading to the creation of a driver-dependence diagram to access the factors' driving and dependence power.

The research is divided into five components. To begin, Section 2 gives an overview of the link between IoT and its enablers based on a review of the literature and expert perspectives. Section 3 discusses the suggested ISM approach. The results of the ISM technique are interpreted in Section 4, and the management implications are discussed in Section 5.

2. Literature Review

Simon Elias Bibri explains how the Internet of Things (IoT) is one of the key components of the ICT infrastructure of smart sustainable cities as an emerging urban development approach due to its great potential to advance environmental sustainability in his paper "The IoT for Smart Sustainable Cities of the Future: An Analytical Framework for Sensor-Based Big Data Applications for Environmental Sustainability." His paper aims to review and summaries relevant literature in order to identify and discuss futuristic sensor-based big data applications enabled by the Internet of Things for environmental sustainability, as well as related data processing platforms and computing models, in the context of smart sustainable cities of the future. His paper also identifies the major challenges associated with the Internet of Things and big data analytics. Furthermore, it has also looked into the possibility of using big data applications to supplement the informational landscape of smart sustainable cities in order to reach the requisite level of environmental sustainability.

The proposed framework was tested in empirical research to add depth to studies in the field of smart sustainable cities, allowing the paper to inform urban planners, scholars, ICT experts, and other city stakeholders about the environmental benefits that can be gained from implementing smart sustainable city initiatives and projects based on IoT-based smart and sustainable city applications. An intelligent network of connected items and equipment that continuously transfer data utilizing wireless technology and the cloud is an important aspect of the ICT framework. Individuals, society, and industries can use cloud based IoT apps to receive, analyse, and manage data in real time to help them make better decisions that improve their quality of life. We interact with smart city ecosystems in a variety of ways, including through smartphones and mobile devices, connected cars and homes, and by combining these devices and data with a city's physical infrastructure and services, we can save money and increase sustainability. As a result, smart city solutions are divided into the following categories in order to transform the urban landscape:

1. Infrastructure

All of the core elements associated with a smart city, including smart people, smart transportation, smart economics, smart living, smart government, and smart environment, are built on top of smart infrastructure. A smart infrastructure is a cyber-physical system that allows for the integrated management of all of its components using various technology tools to assemble and analyse data in order to achieve efficiency, sustainability, productivity, and safety goals. It is a system that monitors, measures, analyses, communicates, and acts on data acquired by sensors and uses a data feedback loop to improve decision-making. This infrastructure receives data, interprets information, and takes necessary action totally autonomously, that is, without the need for human involvement, and adjusts to changing situations. Smart networks, smart buildings, smart public infrastructure, and smart beaches are typically included in this category. Smart buildings are those that have been constructed with modern installation and technological systems, allowing for the automation of various internal activities such as heating, ventilation, lighting, security, and other building systems. Most of these components have one thing in common: they are connected, and they provide data that may be used intelligently to ensure the best use of resources and increase performance.

2. Governance

One of the hallmarks of smart cities is smart governance, which has its roots in e-government, good governance principles, and the concepts of citizen participation and involvement in public decision-making. It's about the future of government services, increased efficiency, community leadership, mobile working, and continuous improvement through innovation and the use of technology to assist and promote better planning and decision-making. It's all about enhancing democratic procedures and altering the delivery of public services, which includes e-government, the efficiency agenda, and mobile working.

3. Utilities

Sensors, improved metres, renewable energy sources, digital controls, and analytic tools are used in smart energy management systems to automate, monitor, and optimise

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energy distribution and usage. By balancing the interests of the various stakeholders involved, such systems optimise grid functioning and usage (consumers, producers and providers). Distributed renewable generation, microgrids, smart grid technology, energy storage, automated demand response, virtual power plants, and demand-side developments such as electric vehicles and smart appliances are all examples of smart energy infrastructure advances. Such advances enable community-based energy monitoring programmes and improve building energy efficiency by extending a network of intelligent energy devices across a city and providing a thorough view of energy consumption patterns. Smart grids are an important part of smart energy infrastructure. A smart grid is a "electricity delivery system connected with ICT from point of generation to point of consumption for increased grid operations, customer services, and environmental benefits."

4. Mobility

Smart mobility is best defined as methods for reducing traffic congestion and promoting faster, greener, and less expensive transportation solutions. Most smart mobility solutions employ data about mobility patterns gathered from a range of sources to assist enhance traffic conditions holistically. Individual mobility systems, such as bicycle sharing, carpooling, vehicle sharing, and, more recently, on-demand transportation, are examples of smart mobility systems. New disruptive business models based on sharing, convenience, and technological use are emerging. To assess the influence of such models on traffic congestion and car usage in cities, more research is needed. Intelligent transportation systems integrate a city's complete multimodal transportation options, including both individual and group mobility. Intelligent transportation systems efficiently integrate a city's whole multimodal transportation options, including both individual mobility and mass transit. A network of sensors, GPS-tracked public transportation, dynamic traffic lights, passenger information panels, automatic vehicle registration plate readers, closed-circuit television systems, navigation facilities, signalling systems, and, most importantly, the ability to integrate live data from most of these sources are all common features of modern intelligent transportation systems. Safety, network management, transportation congestion, environmental performance, accessibility, convenience, and public perception can all benefit from this.

5. Environment

Smart systems for controlling environmental quality, irrigation, garbage, photovoltaics, lighting, weather stations, and water supply are among the smart solutions for the environment. Its goal is to increase energy efficiency and environmental quality in cities. The rate of waste generation is outpacing the rate of urbanisation. 18 Cities are finding it increasingly difficult to source, separate, and utilise various types of waste that may be returned to the consumer life cycle. Waste management usually entails waste collection, transportation, processing, recycling, and disposal. Smart waste management systems decrease waste at the source, classify waste types, and establish procedures for proper trash disposal. Such devices could be utilised to turn garbage into a resource and generate electricity. Closed-loop economies can be created by converting waste into a resource using such technologies. Their main advantages are increased garbage collection, pickup, separation, reuse, and recycling efficiency.

6. Life

Citizens' smart solutions entail optimising the services provided to them, with the understanding that cohabitants are essential in co-constructing a better city for all. Informational MUPIS, citizen cards, citizen Apps, and social Wi-Fi are examples of these solutions. Its goal is to improve communication between the various parties. Regarding the sustainability of urban areas and their supporting ecosystems, the health and well-being of urban dwellers is of special relevance. Smart cities can improve their ability to employ technologies like big data to make predictions or detect population health hotspots (such as epidemics or health impacts during extreme weather events). Digital health records, home health services, and remote diagnosis, treatment, and patient monitoring are all examples of smart health-care management, which translates health-related data into clinical and business insights.

Digital health records, home health services, and remote diagnosis, treatment, and patient monitoring technologies are all examples of smart health-care management, which translates health-related data into clinical and business insights. It also makes it easier to provide health care by utilising intelligent and networked devices that monitor residents' health. With the recent pandemic, smart health approaches such as crowdsourcing to collect data on epidemics, predict epidemic outbreaks, and take necessary precautions, remotely collecting patient health vitals and data for diagnostic purposes, and setting up automated alerts for patients regarding medications and health check-ups are all examples.

Aside from people and traditional urban infrastructure, the following four aspects are critical for smart cities to thrive:

1. Ubiquitous wireless connectivity
2. Open data
3. Steadfast Security
4. Flexible monetization schemes

2.1. Past Literatures concerning IoT Enablers for Smart Cities

In their article, Yonghee Kim, Youngju Park, and Gwangsuk Song[5] employed ISM to determine the enablers influencing IoT service acceptability. Their research concluded that international cooperation and the security of objective data are more important than ever in laying the groundwork for effective IoT services. In addition, efforts should be made to expand and develop IoT services by undertaking research and development and implementing projects through public-private partnerships and the formation of a consultative group. Furthermore, both the government and the business world should concentrate on them.

Pooja Gupta and Vijay Kumar Jain [7] developed a structural model of several enablers that are required to execute G-IoT. From a literature study and expert perspectives, they identified a variety of G-IoT enablers and constructed a structural model of G-IoT enablers using the Interpretive Structural Modeling (ISM) approach.

2.2. Enablers of IoT for Sustainable Development of Smart Cities

1. AIoT

A term used to describe AI in conjunction with the IoT. This is often used when thinking about IoT in an analytics and data collection construct. When adding AI and IoT to make AIoT together, those IoT devices can analyze data used within equipment or devices and make proactive, intelligent, and accurate decisions without the involvement of humans. Eventually, these devices will become smart, communicative, and powerful devices that can process data and make decisions faster and more accurately than ever. Humans are understandably more trusted, and the switch to being more dependent on machine intelligence is not easy. In essence, AIoT, can bridge this gap and make the transition from trusting humans to trusting technology as seamless as possible.AI and IoT also interact with smart office buildings. Companies install sensor technologies that help to manage energy and lighting. Buildings also pick up on the physical movement of people, something essential for security management. Smart buildings can also control access of people through facial recognition. Another way AIoT is being used today is through autonomous vehicles using radars, GPS, and cameras to make real-time decisions based on current driving conditions.

2. Big Data

In a smart city, big data plays a vital role. Cities can discover trends and requirements by analyzing data from IoT devices and sensors. The analysis can assist drivers find a

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parking place and minimize the amount of road accidents and congestion. Data may also help with crime reduction, smart city lighting, and water and energy systems.

3. Cloud Computing

For analytical reasons, smart cities require a vast volume of data. In their data centers, cloud data systems employ solid-state drives, delete redundant data, and secure data transfer. Payment choices for cloud-based systems are frequently more flexible than those for on-premises data centers. Clouds are essentially low-maintenance and secure for those who utilize them.

4. Predictive Maintenance(PDM)

PDM and wireless power have the potential to make Smart Cities even more intelligent. There are several applications for anything from putting a variety of sensors in metropolitan settings to monitoring traffic patterns, air quality, and the health of key infrastructure. A key challenge of installing strain sensors on a bridge or highway overpass is sourcing the power required for them to operate. Nikola Labs technology can address this challenge by harvesting power from nearby power lines, radio and TV towers, and cell phone communication hubs. When consistent power is provided, long-lived sensors can provide the rich streams of data necessary to generate PdM insights; thereby avoiding catastrophic failures and permitting municipal departments to focus their attention on infrastructure most in need of repair.

5. Preventive Maintenance(PVM)

Similar to predictive maintenance, the goal here is to reduce equipment failures. However, with preventive maintenance, maintenance is performed regularly on the machine to reduce the likelihood of failure rather than doing maintenance when the machine begins to exhibit abnormal behavior . Due to the high-risk nature of manufacturing operations, the only solution for never fail situations has been to over-ensure uptime with redundant equipment and too many parts on hand. While these systems track performance of various components using sensors, there’s typically no proactive way to trigger maintenance to avoid downtime.

6. SDGs (Sustainable Development Goals)

The United Nations adopted the 17 Sustainable Development Goals in 2015, which form a comprehensive global framework for ending poverty and protecting the environment by 2030. A recent study found that 84 percent of IoT deployments address the SDGs in some way. The private sector was responsible for 70% of these deployments.

7. Smart Buildings(SB)

Building automation has progressed far beyond HVAC and lighting management systems in recent years. While the notion of smart buildings has been around for a while, with the advent of the Internet of Things and a new generation of intelligent edge devices, the term "smart" has taken on a whole new meaning in the context of building automation. Residential and commercial buildings of all sizes and uses are becoming networked smart ecosystems in which systems monitor and manage far more than just temperature control and lighting. More than merely collecting point data will be done by intelligent edge devices. They'll also collect, analyse, and feed data to edge computing, where powerful predictive analytic engines will allow new levels of management and security while vastly enhancing the overall user experience in the building. These brand-new They'll also collect, analyse, and feed data to edge computing, where powerful predictive analytic engines will allow new levels of management and security while vastly enhancing the overall user experience in the building. These new systems will be more intelligent, self-learning, inventive, and complex.

8. Quality of Service(QoS)

A Quality of Service (QoS) measurement indicates how well a service is delivered. The phrase refers to network performance in the context of IoT connection. In the Internet of Things, quality is a critical aspect in ensuring service quality. The QoS requirements will differ from one application to the next. While framing the application, the quality of service is regarded a vital aspect in the service process.

The relevance of QoS in IoT has been discussed by Ravi et al. [1.] The authors have summarized the QoS parameters and metrics that must be taken into account at each tier. The authors have organized the available IoT literature into numerous study themes such as standardization, system design and performance, and quality of service, among others.

9. Telematics

A telematics platform is a computer system that handles data transfer across great distances. Many vehicles include consoles that can give GPS and satellite radio services, as an example. In simple terms, it is the use of telecommunications networks to send and receive data from assets located at a distance. Telematics is a vital and lucrative sector of the Internet of Things. Vehicles may be augmented with electronics, connections, and hardware that allow them to talk and interact with other devices when IoT and telematics are combined. Telematics IoT applications are making our roads safer, making driving more fun, and assisting companies with vehicle management. As a result, drivers who use these apps claim a variety of advantages, including theft prevention, decreased insurance costs, and enhanced safety. Telematics IoT applications are making our roads safer, making driving more fun, and assisting companies with vehicle management. As a result, drivers who use these apps claim a variety of advantages, including theft prevention, cheaper insurance costs, and better driving behavior.

10. Range of Applicability

The variety of IoT applications is one of the most fascinating aspects of the technology. While equipment performance should be tailored to a given property type, other IoT devices may be broadly installed at a reasonable cost. Leaks from packaged terminal air conditioners (PTACs), for example, are a regular and costly problem for many real estate firms. Operators are also responsible for maintaining the space temperature of tenant sections. It is unnecessary for real estate businesses to have to hire two different vendors to monitor leaks and space temperature.

11. Network Effect

The network effect is a phenomenon in which the value of a commodity or service increases as the number of persons or participants increases. The network effect may be seen on the Internet. As the internet—one of the most visible examples of the network effect—becomes a more significant part of our lives, it will become increasingly vital for both service providers and users to understand the network effect and its advantages.

3. Methodology

To begin with our research, we identified IoT enablers for smart cities and sustainable development; we analysed previous work and solicited various expert viewpoints and inputs into organised self-interaction matrices (SSIMs). For assessment, we also studied and analyzed related publications and research papers.

Following that, we utilized ISM to create a baseline model of crucial factor connections and MICMAC analysis to categorise the variables. Our ISM looks for connections between items recognised as a concern or a problem through literature study and expert opinion. We used a combination of brainstorming, nominal group tactics, and face-to-face interviews to get expert opinions on how to build a contextual link between crucial components.

We've looked at the IoT enablers for smart cities while keeping sustainable development in mind. A literature study was used to identify variables, and there was no restriction on the number of factors.

Table 1 lists the 11 enablers identified. **Table 2** lists the ISM step followed by the flowchart of the factors as shown in **Figure 1**.

Table 1. Numbers of enablers evaluated in various reports.

S No.	Factors

F1	AIoT(AIoT)
F2	Big Data(BD)
F3	Cloud Computing(CC)
F4	Predictive Maintenance(PDM)
F5	Preventive Maintenance(PVM)
F6	Sustainable Development Goals(SDG)
F7	Smart Buildings(SB)
F8	Quality of Service(QS)
F9	Telematics(TM)
F10	Range of Applicability(RA)
F11	Network Effect(NE)

Table 2. ISM steps.

S.No.	Steps	Focus
1	**Establishment of a Structural Self-Interaction Matrix (SSIM)**	"The Driving pairwise relationships among identified critical dimensions of Enablers of IoT and Smart City with Sustainable Development"
2	**Create a reachability matrix**	"To Determine driving and dependent factors"
3	**Level partitioning**	"To Define structural levels (factors level partitioning)"
4	**ISM modeling**	"To Develop an ISM model using a reachability matrix and level partitioning"
5	**MICMAC Analysis**	"To Classify critical dimensions of the enablers of IoT into four factors: drivers, dependents, autonomous factors and linked factors via MICMAC Analysis"

3.1. ISM

ISM is a traditional and extensively used technique utilised by strategic decision makers in numerous businesses. It is used by researchers in various disciplines such as supplier selection, knowledge management, green supply chain management, and energy conservation. When a problem develops, the goal of ISM is to detect and create relationships between aspects influencing decision-making. The problem is then solved by taking

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into account each factor's driving and dependence capabilities. Experts identify the relationships between components, which finally comprise the research framework.

Table 3 lists the various applications of ISM.

The following steps are involved in modelling: (1) identification of relevant factors based on previous studies and expert opinion; (2) development of an SSIM, then a reachability matrix; (3) creation of a partition level table using the reachability matrix; (4) characterization of relationships between various factors; and (5) identification of uncertainties and subsequent moderations.

Table 3. Applications of ISM.

Techniques	Application
ISM	Interpretive Structural Modeling in the Adoption of IoT Services [**5**]
ISM	Analyzing the factors influencing integrated clean sustainable system [**17**]
ISM	The IoT for Smart Sustainable Cities of the Future: An Analytical Framework for Sensor-Based Big Data Applications for Environmental Sustainability [**1**]
ISM	Factors Affecting ESG towards Impact on Investment: A Structural Approach [**18**]

3.1.1. The SSIM

The SSIMs were completed after extensive investigation and provided us with ISM inputs. The contextual correlations among the 11 criteria that were identified were determined using most opinions on various web platforms. After evaluating the nature, the purpose, and the majority view of the linkages of each difficulty between the variables, we arrived at a conclusion that finalized the contextual relationships.

The contextual interconnectedness between two components I and t) is expressed in one of four ways: (a) if I affects t, "V"; (b) if t influences I "A"; (c) if I and t influence each other, "X"; and (d) if I and t are independent, "O."For example, AIoT, F1(AIoT), has an impact on Predictive Maintenance, F4(PDM), hence the symbol used is V.Because Sustainable Development Goal F6 (SDG) affects Sustainable Buildings Goal F7 (SB), the symbol used is A.The symbols X represent the interaction between AIoT F1 (AIoT) and Big Data F2 (BD).

Table 5 shows the summary of the SSIM. The SSIMs' reachability matrix is discussed in further detail below.

Table 4: Structural Self Interaction Matrix

Factor	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**

s											
F1		X	X	V	V	V	V	V	V	V	V
F2			X	V	V	V	V	V	V	V	V
F3				V	V	V	V	V	V	V	V
F4					O	V	V	V	V	V	V
F5						V	V	V	V	V	V
F6							A	A	A	A	A
F7								A	A	A	A
F8									V	X	V
F9										A	X
F10											V
F11											

3.1.2. Reachability Matrix

The four SSIM representations, V, A, X, and O were then replaced by 1 or 0 in the reachability matrix shown below in **Table 5**, as: (a) the symbol "V" in the (i, t) position of the SSIM matrix being substituted by 1 and 0 in the (i,t) and (t, i) positions of the reachability matrix; (b) the symbol "A" in the (i, t) position of the SSIM matrix being substituted by 0 and 1 in the (i, t) and (t, i) positions of the reachability matrix; (c) the symbol "X" in the (i, t) position of the SSIM matrix being substituted by 1 in both the (i, t) and (t, i) positions of the reachability matrix; and (d) the symbol "O" in the (i, t) position in the SSIM matrix being substituted by 0 in both the (i, t) and (t, i) positions of the reachability matrix.

After that, the reachability matrix's transitivity was tested. The term "transitivity" refers to the idea that if factor F1 influences factor F2 and factor F2 influences factor F3, then F1 influences F3. F1's location (I, t) has an effect on F3, and the value becomes 1. For the driving power (DVP), we may compute a factor by summing all numbers in the accommodating row, while V stands for the dependency power (DNP). Following the factoring technique, the final form of the reachability matrix is displayed in **Table 5**. The reachability matrix is also employed in the Level Partitioning process that follows.

Table 5: Reachability Matrix

Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**Driving Power**
F1	1	1	1	1	1	1	1	1	1	1	1	11
F2	1	1	1	1	1	1	1	1	1	1	1	11
F3	1	1	1	1	1	1	1	1	1	1	1	11
F4	0	0	0	1	0	1	1	1	1	1	1	7
F5	0	0	0	0	1	1	1	1	1	1	1	7
F6	0	0	0	0	0	1	0	0	0	0	0	1

F7	0	0	0	0	0	1	1	0	0	0	0	2
F8	0	0	0	0	0	1	1	1	1	1	1	6
F9	0	0	0	0	0	1	1	0	1	0	1	4
F10	0	0	0	0	0	1	1	1	1	1	1	6
F11	0	0	0	0	0	1	1	0	1	0	1	4
Dependence	3	3	3	4	4	11	10	7	9	7	9	

3.1.3. Level Partition

The reachability and antecedent sets for each element were then constructed using the previously prepared reachability matrix. The elements themselves, as well as factors influenced by other factors, are included in the reachability set. The antecedent set includes both the factors and the factors that influence them. The intersection set consists of components that are shared by both the antecedent and reachability sets. When the antecedent and reachability sets were equal, the technique was repeated, and the top factor was selected. Because the antecedent and reachability sets are equal, F6 occupies level I for Instance. When determining the amount of a factor, six iterations were used. **Table 6** depicts the level divide. There are six levels to each of the 11 criteria. The sixth level is occupied by F1, F2, and F3, while the first level is occupied by F6, and the remaining factors are located between these levels.

Table 6. Level partition.

Factors	Reachability Set	Antecedent Set	Intersection Set	Level
AIoT	1,2,3,4,5,6,7,8,9,10,11	1,2,3	1,2,3	6
BD	1,2,3,4,5,6,7,8,9,10,11	1,2,3	1,2,3	6
CC	1,2,3,4,5,6,7,8,9,10,11	1,2,3	1,2,3	6
PDM	4,6,7,8,9,10,11	1,2,3,4	4	5
PVM	5,6,7,8,9,10,11	1,2,3,5	5	5
SDG	6	1,2,3,4,5,6,7,8,9,10,11	6	1
SB	6,7	1,2,3,4,5,7,8,9,10,11	7	2
QS	6,7,8,9,10,11	1,2,3,4,5,8,10	8,11	4
TM	6,7,9,11	1,2,3,4,5,8,9,10	9,12	3
RA	6,7,8,9,10,11	1,2,3,4,5,8,10	8,11	4
NE	6,7,9,11	1,2,3,4,5,8,9,10,11	9,11	3

The digraph and level partition table were used to create the ISM depicted in **Figure 1**. This digraph shows the interrelationships between items at edges and nodes while excluding transitive interactions. The ISM was derived using the digraph's combinative information.

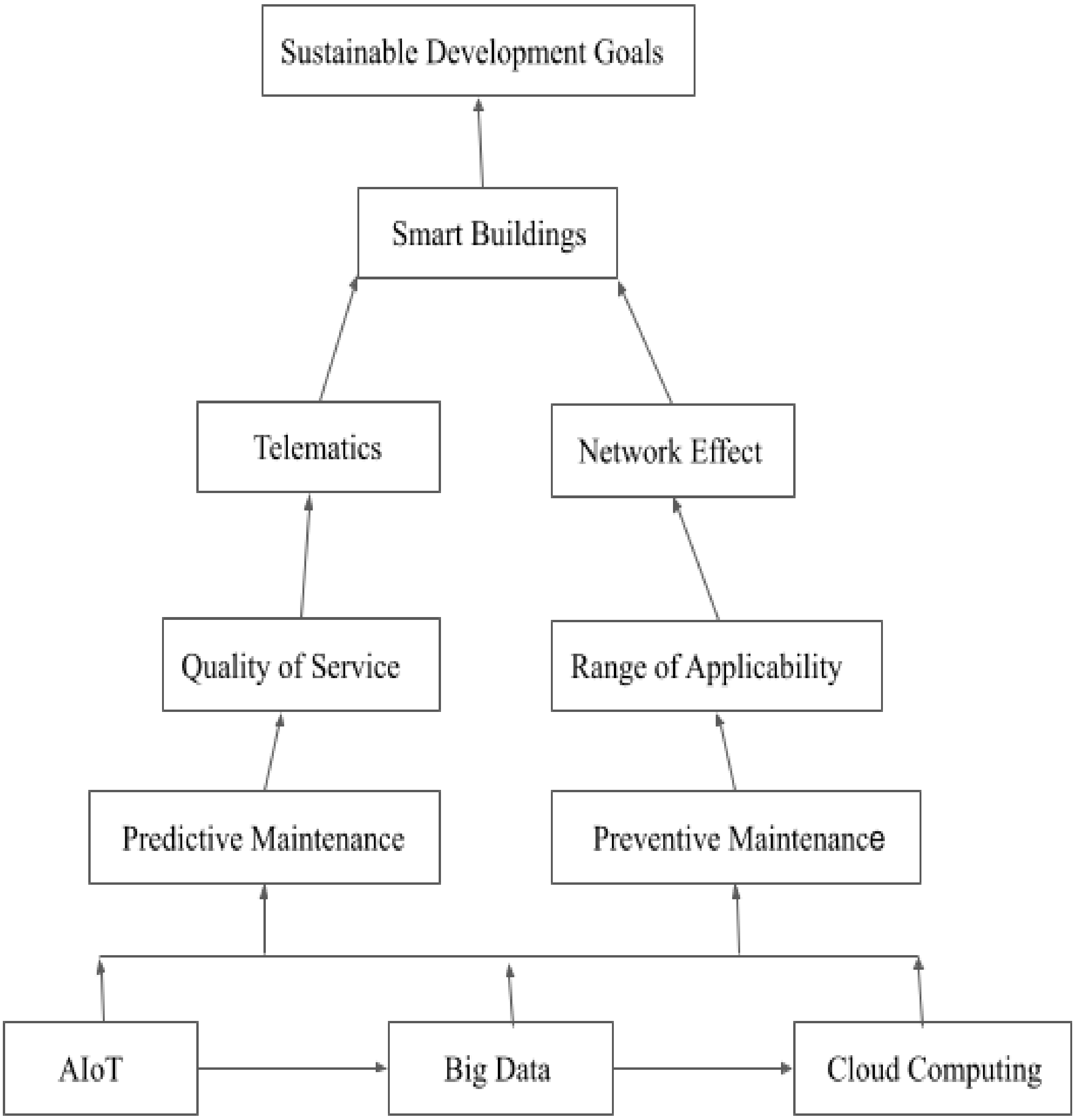

Figure 1 ISM Model

3.2. MICMAC Analysis

We need factor dependence and driving powers as inputs to perform the analysis, which then requires factor dependence and driving powers as inputs to categorise the factors into four types (**Figure 2**): Autonomous variables (weakly dependent and driving factors) are depicted in the first quadrant. Linkage variables (factors with strong dependency and driving powers) are displayed in the third quadrant, while dependent variables (factors with high dependence but weak driving capabilities) are displayed in the second quadrant. The third quadrant contains driving variables (factors with low dependency powers but high driving powers).

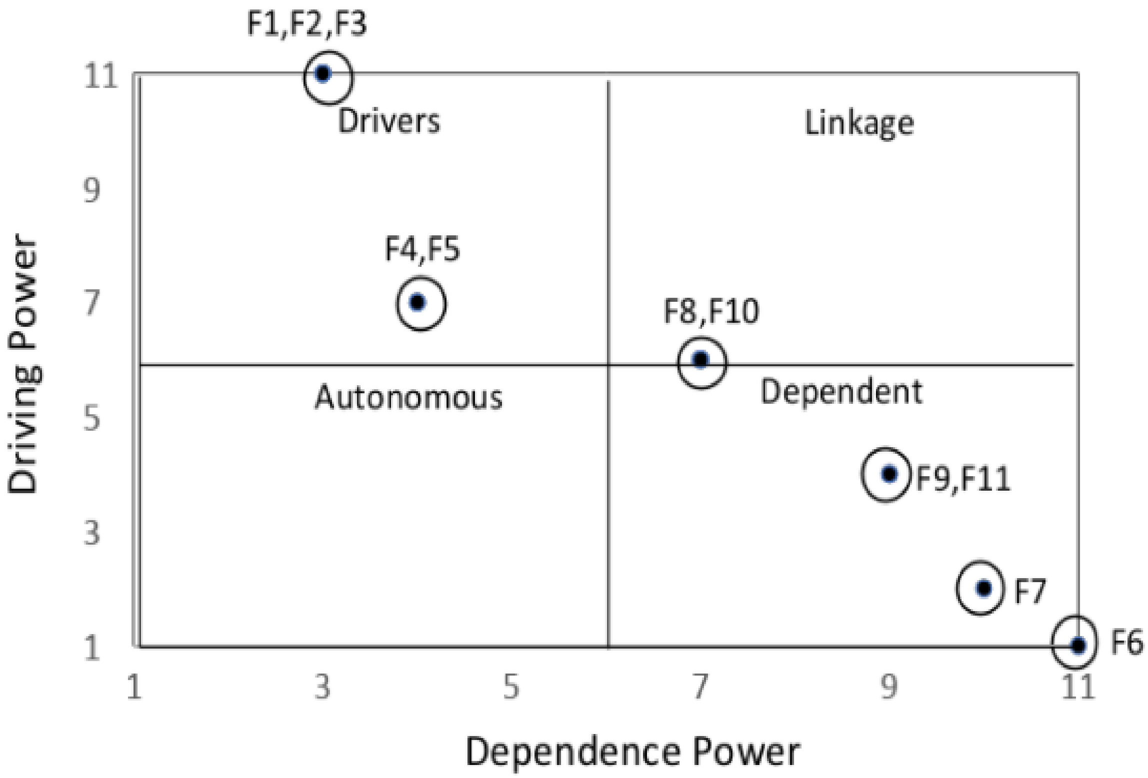

Figure 2. MICMAC analysis

5. Conclusion

Our system has systematically analyzed and constructed the relationships among enablers of IoT for Sustainable Development of Smart Cities. We first identified critical factors affecting the adoption through MICMAC analysis and have systematically analyzed and constructed the relationships among factors relating. We have derived factor dependence and driving powers through the analysis. The ISM split all factors into six levels. AIoT, Big Data and Cloud Computing were observed to be the key enablers as they are put up at the bottom in the hierarchy.

In **Figure 1** The ISM is split into six tiers. The consideration of AIoT (AIoT)(F1), Big Data (BD)(F2) and Cloud Computing (CC)(F3) are the fundamental parts of enablers of IoT (which were positioned at the bottom of the hierarchy) while Sustainable Development Goals (SDG)(F4) being on the top as it is the major goal to be achieved. The path from bottom is led to Predictive Maintenance (PDM)(F6) and Preventive Maintainace (PVM)(F7) in Level II. Which they drive to Quality of Service (QS)(F8) and Range of Applicability(RA)(F9). They further drive to Telematics (TM)(F10) and Network Effect (NE)(F11) at level IV and leads to Smart Buildings (SB)(F5) at Level V.

Our research looked into and created links between various factors that affect ESG investing. We used the MICMAC study to identify key aspects that influence ESG investment decisions, and then analysed and generated correlations between those elements in ISM. We were able to identify factor dependency and driving capabilities as a result of the inquiry.

Figure 2 shows how the MICMAC analysis splits the 11 identified IoT enablers into four parts. The first portion is the autonomous zone. It is based on reduced driving and power consumption. There is no autonomous component among the detected components, implying that there is no unfocused factor. The dependent zone is the second part. It is highly reliant and has minimal driving power. Predictive Maintenance (PDM)(F6), Preventive Maintenance (PVM)(F7), Range of Applicability (RA)(F9), and Network Effect (NE) are the major dependent components (F11). The linking zone, the third segment, is unstable and develops with strong driving and dependant powers. Quality of Service (QS)(F8) and Telematics (TM) were both unstable in our investigation (F10). Finally, AIoT (F1), Big Data (BD) (F2), Cloud Computing (CC) (F3), Sustainable Development Goals (SDG) (F4), and Smart Buildings (SB) (F5) are identified as important drivers in the fourth quadrant.

Through this project we can define the need for smart cities, and it also gives us the pathway of how IoT technologies and enablers of smart cities can be applied in urban settings to facilitate cities that work better for their citizens and achieve overall sustainable development. This project shall serve to inform urban planners or scholars as well as Information Commutation Technology experts, and other city stakeholders about the enablers of IoT for smart cities and their sustainable development.

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