REPUBLIC OF TURKEY

ALTINBAŞ UNIVERSITY

Institute of Graduate Studies

Electrical and Computer Engineering

KEY PERFORMANCE INDICATORS AND THE MODEL FOR ACHIEVING DIGITAL INCLUSION FOR SMART CITIES

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Master's Thesis

Supervisor

Asst. Prof. Dr. Mesut ÇEVİK

Istanbul, 2022

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2022

The thesis titled KEY PERFORMANCE INDICATORS AND THE MODEL FOR ACHIEVING DIGITAL INCLUSION FOR SMART CITIES prepared by KHALID OBAED MAHMOD MAHMOD and submitted on 17/8/2022 has been **accepted unanimously** for the degree of Master of Science in Electrical and Computer Engineering.

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I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Khalid MAHMOD

Signature

DEDICATION

He is a person who supported me in all stages of my life and studies. He is a person who gave me all the support, strength and assistance, my beloved father

PREFACE

Before every thanksgiving, I thank God for His grace and help. Thanks to my supervisor Asst. Prof. Dr. Mesut Cevik, I am proud that this thesis by his supervision. You are a true teacher, and many students' lives will be changed forever because of your kindness and passion. Thanks must be given to my mother and my father. Thanks to my brothers and my sisters. Thanks to my beloved wife Mariam and my children. Thanks to my colleague Ahmed Qasim Abdulgani You really were my brother and friend, and you helped me a lot. Friends and comrades and everyone who helped me, I am forever indebted to you all.

ABSTRACT

KEY PERFORMANCE INDICATORS AND THE MODEL FOR ACHIEVING DIGITAL INCLUSION FOR SMART CITIES

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Date: 08/2022
Pages: 73

The term smart cities has many definitions, but as a clear and simplified definition of the smart city, it is the site in which public services are provided to the community as in other cities, but it has gained flexibility and efficiency in providing its operations to the population through the use of networks, information technologies, and communications.

In general, smart cities are cities that use technological means in all areas of life In order to provide good services to citizens and visitors. Smart cities rely on (IoT) technology in order to connect the various components of the city and form a network, thus cities will be able to collect data from this network that covers all parts of the city. This data is the basis for providing technological solutions to manage services and resources in this city, such as the electric power network, the water network, roads and parking lots. The work presents the concept of smart cities, the reasons that prompted the world to move towards its establishment, performance evaluation criteria and indicators for smart cities, and the main pillars on which smart cities depend. It also provides a simplified hypothetical way to measure the ideal smart city model by identifying some of the key pillars and indicators on which smart cities depend, simulating these pillars with logical circuits and testing them to determine whether the city can be considered an ideal smart city or not.

Keywords: SMART CITY, PILLARS, INDICATORS, LOGIC GATES, FACTORS

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ABBRVIATIONS

IOT: internet of things

3D: Three-dimensional

RFID: radio frequency identification

DSL: Digital Subscriber Line

UMTS: Universal Mobile Telecommunication System

Wi-Fi: Wireless Fidelity

Wi-Max: Worldwide Interoperability for Microwave Access

GPS: Global Positioning System

GIS: Geographic Information Systems

CAS: Computer-Aided software

G2G: Government to Government

G2E: Government to Employees

G2B: Government to Business

G2C: Government to Citizen

B2B: Business to Business

B2C: Business to Consumer interactions

B2G: Business to Government

C2C: Consumer to Consumer

ICF: Intelligent Community Forum

MSC: Multimedia Super Corridor

LIST OF SYMBOLS

M : Meter

MB: Mega Byte

KM: Kilometer

1. INTRODUCTION

1.1 Introduction

Since the advent of the twenty-first century, the world has witnessed technical development and a wide digital revolution that has reflected its effects on the ways of performance of systems and the form of daily life. This led to the emergence of societies that depend entirely on digital knowledge and technologies to perform various activities instead of the usual means, which are called digital societies. [1]

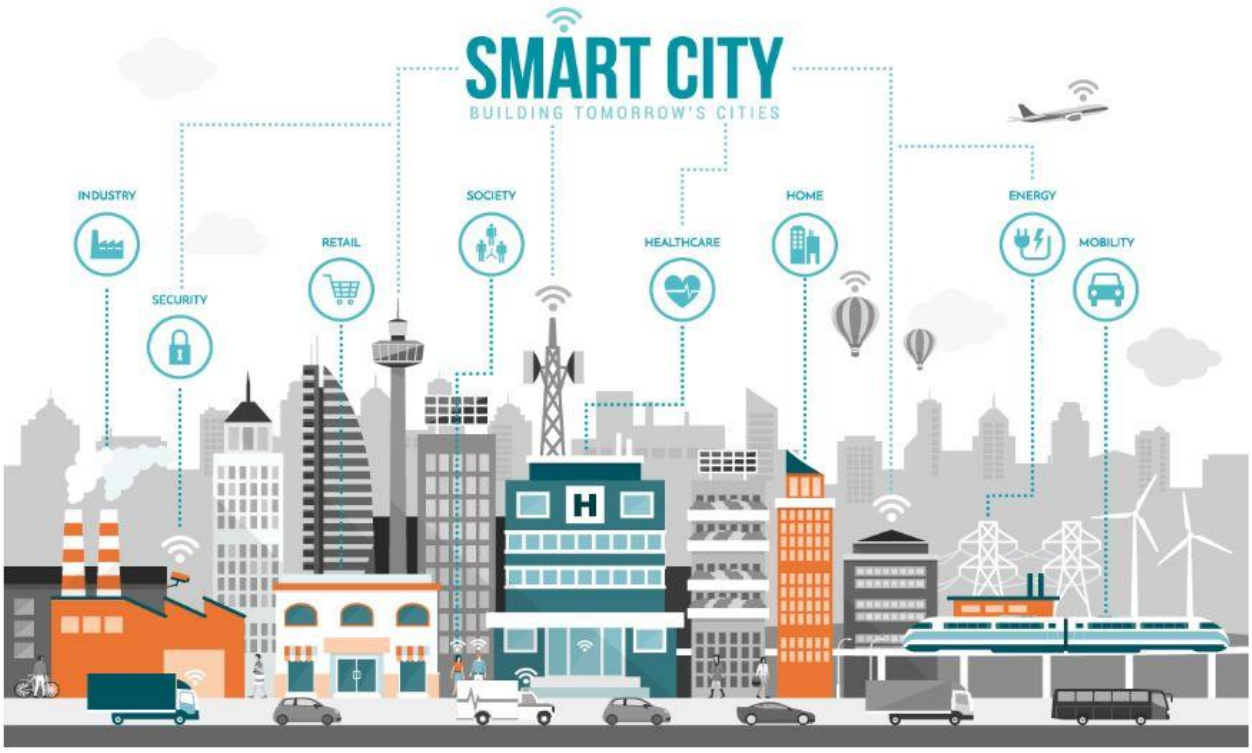

Figure 1.1: Smart City.[2]

Because of social development and progress in scientific fields, the concept of the city has developed and names for cities that use existing technologies have appeared, such as "digital city", "electronic city", "virtual city", "knowledge city", and "smart city". The basis for the emergence of this type of cities is the society's dependence on digital technology, communication and knowledge. [3]

The goal of these cities lies in providing an infrastructure in which electronic services are available with high efficiency, eliminating the spatial dimension of the city's components, and shortening the time element.[4]

although the tremendous progress in technology and the use of advanced communication means, and the efforts of cities and governments to provide all means of luxury for citizens and visitors, yet, cities could not reach the ideal level as a 100% smart city. [5]

Moreover, the proportions of cities may vary depending on many indicators that cities are measured with it, and basic pillars that cities can rely on to reach the Degree of idealism. [6]

1.2 Motivations

In light of the increase in population density and the resulting waste of natural resources, and the continuous need for housing, sanitation, food supplies, and health care services, all these pressures led the world to benefit from the technological development intertwined in all aspects of life to establish smart cities. [7]

A smart city is a populated area supported by networks and digital technologies that connect all components of the city in order to provide interactive electronic services in various fields. It is also characterized by social and environmental sustainability. A smart city has the power to solve problems by investing in technologies, smart people, and organizations.[8]

The establishment of smart cities helps in the prosperity of the economy, creating competition between societies, the quality of life, and providing well-being for citizens, and distributing wealth equally. [9]

We also find that the use of smart traffic systems and smart investment are solutions to reduce the use of personal cars and thus reduce traffic congestion that causes pressure on road infrastructure and increases natural pollution.[10]

1.3 Previous Reports and Studies

To review a group of previous studies and benefit from what it has reached and present its conclusion.

i) The Architecture of Intelligent Cities: "Integrating Human, Collective and Artificial Intelligence to enhance knowledge and innovation"

International Conference on Intelligent Environments, Athens/ Greece, "Nicos Komninos", 2006.

The research provided a definition of smart cities as regional systems with an innovative level, bringing together institutions and their knowledge-based activities to develop creativity, education and digital technology that provides interaction and communication. Determine the most important characteristic of smart cities is high performance and creativity in order to increase the ability to solve city problems.

The research discussed the general structure of the city, as it emphasized that smart cities consist of three levels; the first level includes creative individuals, the second level is related to the population, collective intelligence and institutional mechanisms that regulate operations within the city, and the third level includes the communication and information infrastructure.

The research ended with identifying a set of functions that smart cities perform, which are information exchange and local community development. [11]

ii) A Smart World: "A Development Model for Intelligent Cities", The 11th IEEE International Conference on Computer and Information Technology, "Azamat Abdoullaev", Cyprus, 2011.

The research explained the justifications and reasons that led to the trend towards smart cities, the challenges they face, strategies and standards for developing smart cities, in addition to models for smart cities that exist in the world.

The research provided a theoretical explanation about the general concept of smart cities and pointed out that there is no smart city integrated between the economy, technologies and sustainability.

The research considered that the establishment of smart cities is the turning point into a smart sustainable world.

The research showed that the establishment of smart cities must be consistent with the Adoption of knowledge in the development of the economy, increasing the efficiency of resources, and increasing social and regional cohesion. [12]

iii) "Smart cities-Ranking of European medium-sized cities", the research was carried out in collaborative work of persons from the Centre of Regional Science at the Vienna University of Technology, Vienna/ Austria, October 2007.

The research clarified the role that smart city evaluation plays in creating competition between cities. The research also presented a set of foundations and criteria for classifying and evaluating smart cities.

The researcher described the smart city as a well-functioning city based on six pillars; smart government, smart people, smart economy, smart transportation, smart environment, and smart life.

The research presented a methodology to determine the cities to be evaluated, as it addressed medium-sized European cities and identified the challenges in each of them, and the selection was made based on a set of indicators, including: ease of access to data, population and the availability of a university at least in the selected cities, and based on these criteria, 13 cities were selected.

It also identified a set of factors and indicators for evaluation, which were selected based on the general concept of smart cities.

The research presented a set of graphics and analytical statistics for a set of data collected with the aim of determining the factors that determine the performance of medium-sized European smart cities, and through this assessment, each city is given a value for intelligence.

By presenting these results in relation to the dimensions of the smart city, it is possible to identify the strengths and weaknesses of each city, and thus define future development goals and strategies. [13]

iv) "Smart cities: Definitions, dimensions, performance, and initiatives "Albino, V., Berardi, U., & Dangelico, R. M. (2015, *22*(1), 3-(21).

The research reviewed the justifications for establishing smart cities, namely; Reducing energy consumption, the effects of population density on the environment, and insufficient services and communications.

The research discussed the concept of the smart city, where the researcher believes that the term digital city expresses the smart city, and identified two areas of digital empowerment in cities; the first is called digital community initiatives and includes the promotion of participatory service interfaces. The second is the strategies of digital cities, which include e-government, service infrastructure, and digital empowerment in the field of transportation, health, education, services and buildings. The researcher emphasized that smart cities enhance economic, social and environmental sustainability. The researcher considered that one of the most important challenges facing the implementation of smart cities is the extent to which they are compatible with the existing political and strategic initiatives of any government, and the management of cooperation for digital networks, applications and infrastructure data. [14]

v) "Smart cities in Europe", Andrea Caragliu, Chiara Del Bo, Peter Nijkamp", Slovak Republic, 2009.

The research provided a simplified definition of the smart city, and the research confirmed that the city's performance does not depend on the city's infrastructure only (the physical structure), but increasingly depends on the quality of the available communication networks as well as on knowledge (the social structure).

The social structure is a critical factor in achieving competitiveness at the general level, and on this basis, development is a strategic tool that demonstrates the importance of technology and information in enhancing competition within the city.

The study concluded with conclusions and recommendations, the most important of which are the presence of the creative class, the quality of the environment, and good education, in addition to the use of technology and information in the field of public administration, which are mainly related to achieving prosperity for the city in urban areas. This requires reformulating the new strategies of smart cities in Europe to achieve sustainability and development.

Previous studies and reports clarified various concepts of the term smart city, and defined criteria and strategies for evaluating smart cities and determining their levels, considering smart cities as a turning point into a smart world.

The research relied on the incoming studies to describe smart cities and the foundations and pillars on which smart cities depend, and to determine the dimensions and criteria for use in formulating a strategy to measure smart cities and tell them about their idealism. [15]

1.4 Research Problem

In the first place, the research problem lies in the concept of smart cities, and the reason for the delay in establishing them and using their applications in poor countries, as well as limiting the set of pillars on which smart cities depend. The right way to achieve all the pillars at the lowest cost and impact on the city's population.

Accordingly, the research problem can be determined by asking some questions.

i) What distinguishes smart cities from other cities and what is the general concept of a smart city?

ii) What are the main pillars and performance indicators on which smart cities depend?

iii) Smart cities use many applications. Are these applications compatible with real cities?

iv) What are the practical applications to transform existing cities into smart cities?

v) How do you get the perfect smart city?

1.5 Research Aim

The research aims to know the characteristics of smart cities and sustainable cities, their concepts, the main and sub-sectors, the reasons that prompted the world towards their establishment, the steps taken towards the transformation into smart cities, and how to benefit from information technology in achieving the sustainability of cities.

The work reviews the concept of smart cities in a simplified form, the concepts associated with smart cities and the basic pillars on which smart cities depend, and the performance evaluation criteria and indicators, in addition to the sub-divisions of those pillars. The research attempts to find a low-cost and easy-to-apply method by which the ability of current cities to become smart cities can be measured, as well as the degree of intelligence that existing cities have reached and by how much. The knowledge and development that a city can have to transform it into a smart city.

1.6 Research Importance

The importance of the research comes in that it sheds light on the general concept of the smart city, its requirements for its establishment, and the applications of city, in light of the development of digital technology at the present time. [16]

The research also attempts, through reports and studies related to smart cities, to collect the quantity of pillars and performance indicators for smart cities and how to achieve them to obtain an ideal smart city that provides an easy and advanced life for citizens.

1.7 Research Areas

a) The field of scientific research: The research falls in the field of future planning for cities based on technological development and the wide spread of technological applications and technologies. The research deals with the concepts of smart cities as a basic orientation for current cities in the age of technology and information. It deals with all concepts of the smart city as a basic orientation for all the cities.

b) The locational field of research: The research depends on any realistic city and the possibility of turning it into a smart city by achieving the basic pillars on which smart cities depend.

1.8 Research Methodology

The research relied on a working mechanism and methodology represented in a set of steps that stem from the theoretical foundations and concepts about smart cities and their applications, global standards and indicators to assess their performance, the requirements for their establishment and the basic pillars on which smart cities depend.

The research relied on the results, theoretical studies and global experiences in determining the most important pillars and performance indicators on which smart cities depend, and the proper ways to achieve these pillars to create a sustainable city that relies on knowledge and technical methods to provide comfort and luxury in live to residents and visitors.

1.9 Research tools

To achieve the required of the research and answer the questions presented about smart cities, the methods of establishing them, and the pillars of smart cities , the research relied on a set of tools represented in;

a) Arabic and foreign books, references, and literature related to the research topic

b) Local and international official websites as a source of statistics and information

1.10 Search Components

This thesis consists of six chapters. As shows in the following lines:

Part one: introduction to the thesis.

Part two: presents some of basic Smart Cities Concepts.

Part three: Shows Requirements, pillars and applications of smart cities.

Part four: Presents A Standards and an Indicators Performance evaluation for smart cities

Part five: reviews Arab and international examples of smart cities.

In the end Part six summarizes the presented basic pillars and factors of building smart cities with a description of a logical circuit to test the achievement of all pillars and ways to reach an ideal smart city

2. CONCEPTS IN SMART CITY

2.1 The General Concept of Smart City

The concept of cities has evolved during different ages, and this development has been reflected in various human activities. With the advent of the twenty-first century, the unprecedented expansion of information technologies transformed the world from industry to the information age very quickly. [17]

The development in communications and information technologies led to the development of all human activities, causing the emergence of concepts and terms that became part of the daily life of society, for example; the term electronic government, electronic university, electronic shopping, and email. All this transformation caused the emergence of the information society.[18]

Since the city is the place where people practice all their different life activities, which has become increasingly dependent on information technologies, changes have begun to occur in the city's structure in response to the requirements of those activities. [19]

After the rapid economic, electronic and social development, and impact this development on the natural environment. The world's attention has been directed to find alternatives and solutions that reduce and processing these impacts on the environment. Also, the increase in population density in attracted cities during the 20th and 21st centuries resulting from internal and external migration led to the formation of large cities (cities with more than ten million inhabitants) such as Mexico City, Tokyo and New York. Where, noticed that the high population density is not commensurate with the available resources and services provided to citizens. [20]

From here, the trend towards establishing smart cities began, as they were classified using many terms, including “digital cities”, “electronic cities”, “flexible city”, “information city” and later on the term smart city emerged, which is an application of the concept of the Internet of Things (IOT). [21]

However, the rapid growth of population and increasing requirements for life remained a real challenge for these cities. To overcome this challenge, cities had to walk in two directions.

The first one is to be a sustainable, livable city, as a smart city means smart economy, smart transportation means and a smart environment. The second trend is to focus on technological means and communication in designing aspects of life. [22]

2.2 The Concept of Artificial Intelligence

The concept of intelligence is the mental ability to plan, analyze, solve problems, collect and coordinate ideas, and draw conclusions. It is also defined as the adapting to the environment in which he lives by changing the environment, changing oneself, or creating a new environment.[23]

The concept of artificial intelligence is the characteristics and features of computer programs that enable them to simulate the mental ability of humans and the way they work. One of the most important of these characteristics is the ability to draw conclusions about situations that were not programmed. Artificial intelligence systems work to link with human perception to know the requirements of individuals and users. Success in artificial intelligence leads to eliminating redundancy, saving time and getting rid of routine in business.[24]

Figure 2.1 : Artificial Intelligence.[24]

2.3 Technical Cities

Due to the dependence of the contemporary economy and societies on the methods of knowledge and innovation, many cities called technical cities have appeared in the recent period, which depend on electronics and networks and have acquired several names .Which considered information technology the main catalyst for its development. [25]

In addition to the spread of many repositories that depend on technologies and digital technology, and they are entirely composed of networks that include user data, applications and electronic services. To understand the general term smart city, it was necessary to establish a link between it and the rest of the terms used to describe the smart city.[26]

2.3.1 Electronic City

The electronic city is the city with communication and network links, which is managed by the information technology part to implement information exchange operations. Most of the activities are carried out through electronic systems and the Internet, as they depend mainly on information technologies, which in turn help citizens to access data on a continuous and reliable basis.

Among the reasons that led to the emergence of electronic cities is the speed and growth of innovations in the field of computer technologies, large-scale communications, and the development of networks that contributed to linking population centers with each other.

Electronic cities consist of sections and components that unite with each other to form the electronic environment and these components; information, electronic government, electronic infrastructure, electronic organization. [27]

From the functions of the electronic city

a) Social information sharing

b) Exchange of information with other cities in the same country or with the rest of the countries

c) Providing information about the weather forecasts, first aid, and traffic information

d) Providing direct services such as government transactions

e) Providing fixed information such as city maps, shopping malls, prices, citizen's information, hotels and tourist areas information. [28]

2.3.2 Digital City

A digital city is that relies on the Internet to carry out the usual functions of its residents in an electronic way, and ordinary people can implement them in any city.

This city includes a wide range of electronic applications and is linked to each other by wide networks and can provide many services in various fields; Commerce, health, education, and entertainment.

There are several types of digital cities, and they can be divided into four sections, depending on data and functions

a) The digital economic city: which is concerned with commercial information and trade exchange between individuals

b) Government digital city: which enhances communication between government councils and individuals

c) Virtual Digital City: Cities that provide the use of 3D technologies to provide virtual tours and conversations between service providers and the citizens in the city

d) Multipurpose Digital City: It provides various information such as; Traffic, weather and parking information.[29]

The digital city consists of four levels:

a) Administration: It is a tool for managing data and applications to ensure usage rights

b) Applications: which include digital content and electronic services

c) Database: which includes all digital content and information

d) User Interface: It is the final interface or web pages that provide services.[30]

2.3.3 Virtual City

Virtual City: It is a city opposed to the ordinary city with a virtual electronic reality in which residents and governments perform their activities indirectly through available technologies and digital media without the need for human intervention.

Virtual cities are classified into four sections;

a) Virtual cities in the form of websites: they are in the form of an electronic directory consisting of several windows and lists. Its purpose is to publicize and encourage tourism

b) Flat virtual cities: They contain maps of buildings and the city as an interface to display detailed information via the Internet

c) 3D Virtual Cities: Techniques are used to design models similar to the shapes of buildings and city areas

d) Real virtual cities: They are a representation of real cities in a digital image, as they provide a real sense of roaming within these cities. It also offers a variety of services and functions as well as provides support for social interaction. [31]

2.3.4 Knowledge City

Knowledge City: The cities whose main objective is to encourage science and knowledge, and this is done by providing knowledge tools to citizens, a network of public libraries, and the provision of cultural services.

It is also the cities that have an economy that depends on the sources of scientific research and the competencies of human cadres.

A group of knowledge cities has been established around the world, which is one of its advantages

i) Providing work for individuals.

ii) Adopts the idea of innovation and creativity as one of the main pillars of development.

iii) Continuous communication between scientific research centers and universities.

iv) Ease of delivering modern technologies to individuals.

v) Connecting schools, universities and research centers through networks.

vi) Improving the efficiency of individuals through awareness and guidance. [32]

2.4 The Concepts of Smart City

The multiplicity of technologies and collective activities that contributed to the emergence of smart cities also showed a set of definitions of the general concept of the smart city. The concept of smart cities was associated with virtual cities when they became a virtual simulation of the city, and the concept of digital, knowledge and electronic cities falls within

the concept of smart cities. It can be said that a smart city is an urban assembly that uses communication and information technologies to create an interactive environment between the virtual component of the city and the real component. [33]

The smart city consists of three basic elements, namely;

a) A technical component represented by information, communications, networks, sensors and all technological devices.

b) A social component represented by individuals with a high rate of education and creativity

c) An environmental component that provides for the distribution of available energy and the use of renewable energy resources. [34]

2.5 Smart City Levels

The smart city consists of three integrated levels:

Human intelligence: It is considered the basic level of the smart city, and it includes the productive groups in the field of manufacturing and services within the city, and it is represented by the people who determine the organization of work and the mechanism for developing the city, in other words, it includes the layer of creative individuals. Information is exchanged between individuals. [35]

Collective intelligence: The second level of the smart city is the collective intelligence, which is represented by cooperative institutions and the collective intelligence of the population, as it includes the institutional mechanisms that regulate the flow of knowledge and cooperation in the field of education and creativity, training centers, the exchange of technologies, and intellectual property.

Artificial intelligence: This level consists of communication and information infrastructure and digital tools, which create a virtual environment based on interactive technologies and multimedia tools.[36]

2.6 Smart City Components

The main components of a smart city can be identified

a) Networks: a group of broadband or narrowband networks, as well as wired or wireless networks, which provide linking the components of the city with each other and provide continuous and reliable communication

b) Database :they are stores that contain user information and are a source for all the information required for various activities within the smart city

c) Applications :a set of programs that are prepared and usable and provide activities for citizens and visitors

d) Electronic services :Each electronic device provides a service and can be connected through the city's network. [37]

2.7 Smart City Dimensions

The dimensions of the smart city are linked to economic development, the provision of natural resources and the quality of life within the city.

There are a number of dimensions that characterize the smart city, represented by;

a) The smart economy: which is linked to factors such as international relations and marketing, in addition to activating the role of scientific research and technologies in raising the economic level.

b) Smart life: activities and events include contributing to the provision of a good life, including the health and educational system, in addition to providing high-quality buildings.

c) Smart environment: Providing a smart environment is achieved through a combination of factors such as managing natural resources, protecting the environment and reducing the level of pollution

d) Intelligent people: to create a smart city, a sufficient level of culture must be provided by individuals and work to increase their creative level

e) Intelligent Transportation: To achieve intelligent transportation, which is achieved through the use of technologies in the transportation system to provide a safe and sustainable transportation environment.

f) Smart government: It is the development of the government work system through technologies and the provision of government services through an electronic channel.[38]

2.8 Internet of Things and the Smart City

The Internet of Things (IoT) is the backbone and mainstay of the smart city. (IOT) enables devices and other things to connect to the World Wide Web, as well as communicate with each other through network and cloud services.

In other words, all the devices that connect to the World Wide Web and collect data and share it over the network, and because some things are not classified as devices, some people tend to use the word (things) instead of the word devices in this term, and the term (IOT) is used For anything connected to the Internet, these things are intelligently prepared to be integrated across embedded systems throughout. It is a network of devices that communicate with humans as well as with other devices.[39]

The term (IoT) first appeared when using ATMs in 1974, and it is one of the forms of the Internet of things, and despite this long period now, some studies indicated that 87% of users until 2015 did not know the meaning of the truth of this term and this is a strange paradox. According to Cisco, in 2008, there were more devices connected to the Internet than humans, and this number reached 5 billion devices in 2015.

Smart cities need three main components: hardware, connectivity, and intelligence, and these elements can be provided through IoT technology.

The use of (IoT) makes smart cities feasible, because the creation of smart cities is based on the use of all electronic devices and linking them to each other through a unified network, and this is the basis of this technology.[40]

2.9 Smart City Challenges

Establishment the smart city faces complex and diverse challenges that may include security, safety, continuity of communication, efficiency and the high cost of its establishment, as the cost includes the cost of construction and the cost of continuity in managing the city's operations.

Natural factors are also among the challenges facing the smart city, the natural factors are the city's ability to transform into a smart city, as well as its ability to face natural disasters.

Government policy and the nature of societies are also challenges to establishing any smart city, as well as the increasing population growth and the continuous acceleration in information technology. The smart city must keep pace with the development and new innovations in applications and the requirements of daily life.[41]

3. REQUIRMENTS OF SMART CITY

3.1 Requirements For The Establishment Of Smart Cities

Communication and information technologies are the infrastructure and the basis for development in smart cities, as it consists of a group of elements connected to each other through networks.

Networks comprise a set of communicative links; Satellites, radio beams, and optical fibers. These networks deal with sensors and monitoring software distributed in various geographical areas through which data is collected and processed by software.[42]

These components offer many advantages and opportunities including; providing effective communications within the city, providing services and developing new ways to provide them, facilitating dealing with the government, and creating new opportunities for education and self-development. [43]

3.1.1 Data Collection Techniques

a) Sensors: The sensors collect a set of data related to; Weather, traffic conditions, location, health status, radioactivity, weather conditions, and other information.[44]

b) Surveillance cameras: Surveillance cameras are one of the techniques for collecting information, as they photograph and transfer events to special storage warehouses.

c) (RFID) technology: (RFID) technology stores information through smart chips, where it is read by a hand-held reader. It is possible to encrypt the stored information and authorize certain people to read it to prevent cases of fraud and alteration of information.[45]

These devices consist of the following elements;

a) An electronic device for storing and transmitting data

b) A device for reading and writing data

c) Antenna for connecting the reader to other devices

It has applications in several fields;

i) The fields of internal and external transport

ii) Fields of medicine and health care

iii) The field of media and advertising

iv) Commercial and market transactions

v) Cultural fields.[46]

The most important types of RFID devices;

a) Inert cards: they are not equipped with a battery and depend on the reader's energy and provide short distances (4-5 m), reflecting radio signals

b) Active cards: transmit radio signals, are equipped with a battery, and provide long distances of up to 100 m.[47]

3.1.2 Wide Area Networks

Networks are used to transfer data and information from sensors and other data-collecting devices to control and decision-making centers.

Networks within the city provide a mechanism for exchanging information and data between institutions and groups of individuals.[48]

Wide area networks are;

a) Wide area wired networks which include

i) Optical fiber networks: which is a network of optical fibers, which is characterized by high speed and a huge capacity in data transmission, but it is expensive when installing and requires highly trained cadres. [49]

These networks are used to transfer data in computer networks and the Internet.

ii) DSL networks: It is the delivery of digital service over wired telephone network lines. One of the disadvantages of these networks is the length of the line connecting the subscriber and the telephone station, which is considered a factor affecting the transmitted data rates.[50]

b) Wide area wireless networks which include

i) Satellite Internet:

Satellites are considered the right solution for providing services and covering communications, especially in areas where there is no communications infrastructure, because they have the ability to cover large areas of the earth and the geographical terrain does not affect them.

This technology is summarized by the spread of a group of satellites in a low orbit, each of which covers a certain area of the globe, and communication is made between satellites and ground stations, as well as communication between the satellites themselves to transfer communications to other geographical areas.[51]

ii) UMTS:

Global System of Mobile Communications: Mobile networks of different generations are considered one of the technologies used in large-scale wireless networks, as their basic principle is dividing service areas into several areas called cells, and a tower is used to cover each cell. This technology provides many services; Voice and image transmission, Internet services, coverage of large geographical areas, and high data transfer speed.[52]

iii) (Wi-Fi):

Wi-Fi networks use radio waves to exchange information rather than cables and wires. It is characterized by its ability to penetrate walls and barriers, and high capacity in data transmission.

Wireless Internet service is provided in public places through points called (Access Point) and any area covered by the Wi-Fi network, and the Wi-Fi network is available for use in it is called (Hot spot), the area of Wi-Fi coverage ranges between 45-90 m inside the buildings and reaches several kilometers abroad.

Features of Wi-Fi networks

a) The process of setting up the network is easy and fast, as it does not need to extend wires

b) The connection speed is up to 54 mb.

c) Wi-Fi networks are cheaper than wired networks.

d) Devices can be moved in all directions.

Wi-Fi networks consume a lot of power and have a limited coverage area, as they can be used for connections in local wireless networks or for communication between computers located in the same place.[53]

iv) (Wi-Max):

They are communications networks that extend over long distances of up to 50 km and reach a speed of 40 mb, which are similar to (Wi-Fi) technology in their work, but they cover a wider area.

a) Allows high-quality video to be transferred to multiple sites

b) Coverage distances can reach 50 km.

c) It supports mobility technology, to connect vehicles to a center that monitors movement and responds to changes

d) High speed for audio and video transmission

e) Can be applied in areas with complex terrain

f) Great flexibility.[54]

The (Wi-MAX) network meets many of the requirements of smart cities by providing a wide range of services and applications;

a) E-learning, educational networks, sharing references, ease of communication, and easy access to the database.

b) Infrastructure of the water, gas and electricity network with electronic meters.

c) Provide broadband connectivity to mobile phone networks, video transmission capability, and provide location data.

d) Connecting the city's buildings together.

e) Intelligent transmission system, traffic light control and traffic control.

f) Achieving public security and safety through monitoring systems in streets, airports, harbors, sports stadiums, train stations, and public areas.

The (Wi-MAX)network provides an effective infrastructure in terms of efficiency, coverage, and performance. This infrastructure meets the requirements of the smart city and its various applications. This multifunctional network aims to reach a smart city management strategy.

By comparing wireless networks, we find that (WiMAX) technology has a fast data transfer rate, and the satellite network is characterized by a wide coverage area.

By comparing wireless networks and wired networks, we find that wired networks have limited capacity and do not meet the requirements of smart cities due to the difficulty of

connections in certain areas, and they cannot be used due to the large area, in addition to being unable to evaluate mobile services.

Wireless networks are characterized by;

a) Low operational cost

b) Low cost of application

c) Execution speed

d) Easy to implement in complex geographies

e) Easy to expand and add new stations or temporary terminals.

f) Flexibility in moving and moving components.

One of the main factors when choosing networks in the smart city; Scope of coverage, speed of data transmission, and costs. To choose the optimal networks, a distinction must be made between establishing a new smart city and transforming an established city into a smart city.

In the case of building a new smart city, wireless networks are chosen, as they provide optimal coverage and are characterized by their speed in transmitting data, and the use of wired networks in them is a waste of time and money.

In the case of a city, the use of available networks, which helps reduce costs.[55]

3.1.3 Software

It is a set of software, which are tools for simulation, manipulation, and presentation of results. Software is one of the basic tools that smart cities rely on in applications and all daily activities. The software adopted in smart cities can be divided into three groups;

a) GPS:

It is a global navigation system that uses distance and time to determine locations using satellites, and is characterized by high positioning accuracy.

It is used in smart city applications through the use of geographic information systems, especially in smart transportation applications, the production of maps, and hand-held information and data for the city with all its services and details.[56]

b) GIS:

A set of programs used to create a database to study phenomena, features, and spatial distribution.

Geographical information system is used to identify points, areas, lines, process the information associated with them and make data and information retrievable and perform analyzes on them.

The important features of this system is;

i) Connecting the data

ii) Representing positions

iii) Questions and inquiries about data and information.

A geographic information system has the ability to link information related to a place, store, and recall and analyze data.[57]

c) CAS:

They are all programs that are designed within the computer system and are used in the applications and operations of the smart city.[58]

3.2 Applications And Pillars Of Smart City

For the establishment of smart cities, a number of applications and pillars based on information and data foundations must be available, which provide the development and urban development of cities.[59]

3.2.1 Smart Government

The term smart government is the management of information and transactions between government institutions and citizens using electronic communication and information technology. In other words, it is the provision of services through multiple channels using technological means, which provides ease of performance, high efficiency, and a reduction in cost, effort, and time.

Smart government is an essential pillar for the development of smart cities, as it changes the administrative and organizational structure of the city, provides a smart environment for work, and defines the city's work mechanism through its applications and technologies.

The application of the smart government is through;

a) The ability to communicate and share information.

b) Availability of information through websites.

c) Performing services and transactions electronically, such as signing applications and official papers.[60]

The services provided by the smart government

i) Government to Government (G2G): the participation of different departments in the decision through the exchange of information between government departments and institutions at their various levels and types.

ii) Government to Employees (G2E): administrative transactions between employees in institutions and departments

iii) Government to Business (G2B): transactions between government institutions, companies and various components of the commercial market.

iv) Government to Citizen (G2C): are the services and transactions that the government provides to citizens electronically, and this is done anywhere and at any time through telecommunication networks.

When implementing smart government, data privacy should be taken care of and citizens should be identified electronically before using applications and communicating with service providers. It also provides easy access to information and data about services.

Of the requirements and challenges for the implementation of smart government;

a) Providing communication networks and tools to control communications through receivers and transmitters.

b) Increasing the skill of individuals in the use of technologies.

c) Administrative and legal challenges represented in information security and legal legislation.[61]

3.2.2 Smart Commerce

Smart Commerce or electronic commerce, its use of information technology and communication in the process of exchanging services and goods. These applications have

appeared in the recent period, which are known as electronic commerce or trade via the Internet, as these applications have enabled the completion of commercial transactions quickly without the need for the mutual parties to move or meet in a specific place.[62]

It does not differ much from traditional trade in terms of its nature, purpose, and content, but it has a peculiarity in the way it is implemented.

The difference in the implementation of electronic commerce is due to the fact that it embodies a type of economy that depends on advanced technology, and a large amount of knowledge and information.[62]

Smart commerce is divided into several sections depending on the identity and nature of the transacting parties;

a) Business to Business (B2B): buying and selling transactions and exchanging information between commercial companies take place

b) Business to Consumer interactions (B2C): Consumers deal with commercial companies

c) Business to Government (B2G): are the transactions between commercial companies and government institutions, such as licenses, taxes, disposal of goods, or what the government makes of purchases from companies

d) Consumer to Consumer (C2C): These are the buying and selling operations that take place between consumer citizens.

One of the requirements of smart commerce is to provide clear, flexible and transparent regulatory laws to achieve public interests, in addition to training and qualifying technical cadres through an educational policy that includes information on computers and electronic transactions.

Also, providing an electronic structure that helps to conduct business transactions via the Internet is important requirements for smart commerce.

Smart commerce faces many challenges, including;

Lack of individual information and weak electronic awareness

Weakness of the legal structure responsible for certifying electronic business operations

The possibility of hacking and electronic fraud.[62]

3.2.3 Smart Tourism

Achieving the application of smart tourism in archaeological and tourist areas through the use of technological techniques contributes to achieving competition between cities.

Smart cities aim to develop tourism awareness and provide the needs of tourists by using digital tools to provide explanations, provide knowledge content for archaeological sites, and create a flexible database.

The requirements of smart tourism is the use of digital technology to develop information technologies that provide interactive tourism, where these technologies are usable on mobile devices such as; GPS, multimedia, and wireless networks (Wi-Fi and Wi-Fi Max).

Preparing media content and media for tourists requires effort in preparation and a scientific and historical reference. Technologies also require providing easy access to data and flexibility for development in terms of quantity and quality.

Smart tourism offers a range of services, including:

i) 3D virtual tours through the computer

ii) Define paths in real and virtual locations

iii) Providing tourists with internet connection

iv) Providing tourists with a digital tourist guide that provides information.[63]

3.2.4 Smart Health Care

The working principle of the smart healthcare application is to provide medical services by means of communication and information technologies, by integrating medical devices with the general infrastructure of the smart city.

These technologies can provide monitoring systems to enhance the health of individuals and create direct communication between hospitals and homes to ensure that health care is provided to individuals quickly, such as diagnosing symptoms and first aid.[64]

One of the technical requirements to achieve the smart healthcare application is to provide communication networks, which include sensors, local networks, mobile phones, satellites, interactive communication tools, and image and sound transmission technologies.

Smart healthcare systems face of challenges, which are; protecting the privacy of the geographical location, protecting the privacy of data, the quality and speed of communications, especially in critical cases, as there are cases that cannot bear the delay with the necessity of rapid treatment.[64]

3.2.5 Smart Education

Smart education is meant to transfer individuals from a real reality to a virtual reality that has the same characteristics and differs in spatial nature.

It is the possibility of receiving science and knowledge from distant sources at the same time and speed.

Electronic learning or smart education and the use of technological means are of great importance in qualifying human cadres and developing the economy and cities based on knowledge.[65]

Smart learning is divided into two parts

a) Asynchronous transfer: It is the provision of lectures by video recording, and they are used and referenced at any time

b) Synchronous transfer: It is to provide lectures in a direct view and to achieve interaction between the professor and the recipient of the lectures.

Interaction and the provision of communications are the essence of the smart learning process. The user interface represents the main gateway to the educational system. Smart learning also includes access to electronic libraries, resource sites and research.

The technical requirements for achieving smart learning are communication and information networks, (video conference) technology that allows the ability to transfer images and sound directly, which enables the transfer of seminars and conferences to several sites, and direct transmission means such as cameras and monitors.[65]

3.2.6 Smart Transportation

Using smart transportation applications and benefiting from communication and information technologies in transportation systems, which contributed to improving the lives of citizens, and providing many solutions to transportation problems in cities such as traffic delays, traffic

congestion, and energy consumption. Smart transportation systems add electronic and communication technologies to obtain information on transportation facilities, direct communication between vehicles, and information on road accidents.

Smart transportation applications combine control technologies with a huge amount of information in order to better manage transportation.[66]

These applications provide sustainable smart cities through more efficient transport networks, increase the number of passengers in public vehicles, and reduce the need for private transport. Smart transportation systems are represented by;

a) Managing car parks, and guiding drivers to the nearest empty car park. This information can be displayed through devices within the car.

b) Traffic management by tracking the movement of cars and sending data to control centers.

c) Reducing pollution by installing sensors that monitor air quality and reducing gaseous emissions.

d) Electronic collection of fees, which allows drivers to pay fees for transportation services using electronic cards.

e) The ability to access electronically the documents, including the validity of the driver's license

The technical requirements for smart transportation applications are the establishment of communication networks based on (Wi-Fi and WiMAX), networks of sensors, providing the streets with billboards, and communication equipment. Networks must be flexible, scalable, and deal with devices with diverse characteristics.

The challenges faced by the implementation of smart transportation systems include economic, technical, and social challenges.

On the economic level, the implementation of internet networks and sensors network constitutes an economic challenge for smart cities. On the technical level, the immediate exchange of data and the possibility of obtaining accurate information represents a technical challenge for smart cities. The social challenges of smart cities are represented in the inability

of individuals to deal with these technologies, so individuals must be trained to ensure their efficiency.[66]

3.2.7 Smart buildings

The term smart buildings was not clear at the beginning of its emergence in the eighties of the last century, as it was associated with the use of modern technologies to support the response to variables and automated behavior.

Smart buildings are buildings that depend on networks and information technology and are equipped with sensors and computers aimed at providing comfort and luxury to the residents.

Smart buildings use communications and technical information to manage operations within the building such as; Lighting, air conditioning, and other home appliances and operating them remotely at the time of need, which reduces the annual operating costs.

Smart buildings were defined at the Canadian American Conference as a combination of energy conservation, energy management, automation, communications and safe living technologies.

One of the advantages of smart buildings;

a) It can identify visitors and residents through a voice print or facial features so that information is sent to control centers to ensure that no assault occurs

b) Scanning devices on the codes placed on food packaging provide information on food stocks and thus knowledge of the existing food stocks.

c) The lighting and ventilation control units achieve the required balance between the external and internal environmental conditions.

d) Reporting of risks and malfunctions and sending them to the mobile phones of the population.

e) Resist the attack on the building through the automation of the gates control.

f) Early detection of fires when they occur, with the help of fire sensors distributed within the building.

The technical requirements for smart buildings can be determined through the techniques necessary to transform the existing building into a smart building.[67]

3.2.8 Smart security and safety system

It is intended to provide the material, moral and psychological needs of the city's residents and visitors. Which includes security against natural and unnatural disasters, and security against thefts, attacks and threats.

One of the challenges facing the applications of the smart security and safety system is the high cost of providing the technical requirements. These technical requirements include; Early warning units, fire detection units, elevators and air conditioners self-control units.[68]

3.2.9 Smart environmental monitoring

The important applications in smart cities is to establish a smart system to monitor the environment surrounding the city by reducing energy consumption, which in turn leads to a reduction in pollution in cities. The technical infrastructure and the use of communications and information technology and the tools provided for analysis, monitoring, simulation, and modeling are an important tool in the field of environmental conservation by controlling energy consumption and emissions.

Communication and information technology networks offer several applications in the field of environmental monitoring;

a) Providing information about the climate and its elements such as temperature, humidity, and wind speed.

b) Providing information on pollutants in the environment.

c) Providing automatic control over the water and electricity networks.

d) Providing information about network failures.[69]

3.2.10 Smart Zones

Smart areas or smart complexes are scientific gathering sites where services and infrastructure are available to form a scientific community that stimulates innovation, invention and creativity in various fields. It is a system managed by specialists with the aim of promoting a culture of innovation and competitiveness and increasing the society's knowledge wealth.

Smart zones provide management of the flow of technical knowledge between institutes, universities, markets and companies, facilitating the formation and growth of economic facilities, and providing high-quality equipment and spaces in addition to valuable services.

Smart regions are four types;

a) Business Incubators: These are places that provide facilities for companies in order to increase opportunities for growth and continuity, and to create local development and job opportunities.

b) Research Centers: They are located near universities or academic institutions and focus on research and innovations.

c) Innovation Centers: These are institutions that provide services to new companies working in the field of developing technical products.

d) Technical Centers: These are institutions that provide companies working in the field of technology with several activities such as research and other scientific matters.

One of the technical requirements for the establishment of smart areas is the provision of new infrastructure, advanced services, a wide range of research and development plans, as well as the preparation of special places with studying the components of these places and the available opportunities.[70]

4. EVALUATION CRITERIA FOR SMART CITY

4.1 Evaluation criteria for performance of smart cities

Performance evaluation is necessary to compare cities to choose the best among them, determine the negative and positive within the smart city, know the necessary procedure, determine the opportunities and benefits of development, evaluate the current situation of the city, raise awareness and draw attention from individuals to the important issues for developing the smart city, where individuals learn about the components of their city.

Performance appraisal is a tool for development in the future. Through this evaluation, we can identify strengths and weaknesses, and thus develop the necessary solutions and analyzes.[71]

Several important criteria and strategies for evaluating smart cities have been developed, and the research dealt with a detailed study of a set of these criteria, namely;

a) The criteria of the Intelligent Communities Forum.

b) The criteria of the Regional Science Center at the Vienna Technical University.

c) The criteria of the researcher "Nicos Kemninos".

Characterized by these criteria by their spatial scope, comprehensiveness, and detail, use standard values in order to avoid errors, and give workable results.

Many researchers have developed indicators and criteria for evaluating the smart city, which contributed to directing the choice of investors as well as increasing the competitiveness of smart cities. [72]

Three steps can be identified to evaluate cities, namely:

a) Methodology: It is the methods of collecting and analyzing data and determining the cities to be evaluated.

b) Objective: is to define the objective of the evaluation.

c) Presentation: It defines the way results are presented, analyzed and evaluated.

The assessment of cities includes; the database, where the history of the data and accessibility, and the criteria used, the overall calculation mechanism, and the methods of displaying the final results must be taken into account. [73]

4.2 Criteria "Nicos Kemninos"

The researcher developed forty indicators that were used for the purpose of evaluating the smart city, and these indicators were classified into four groups:[74]

The first group includes creativity and knowledge institutions

i) Students enrolled in universities

ii) Employs in universities

iii) Percentage of spending on research and innovations.

iv) Number of people spending on research and development

v) Percentage of government institutions spending on scientific research

vi) Percentage of institutions spending on licensing

vii) The number of institutions that support small projects

viii) The number of technical institutions

ix) Number of technology transfer centers

x) The percentage of investment financing out of total trade financing.[74]

The second group is the skills of individuals and the level of education

i) People with higher education degrees

ii) Contributors to long-term education

iii) Fresh graduates

iv) Industry researchers

v) Researchers in the public field

vi) Researchers in the private field

vii) The ratio of employment in higher education to total employment

viii) Employment rate in manufacturing industries

ix) Employment rate in high-tech services

x) Number of creators. [74]

The third group is creative performance

i) Number of patents

ii) Number of new brands

iii) Number of innovative manufacturing projects

iv) Number of innovative services projects
v) The number of institutions that organize a research and development department
vi) The ratio of selling new products to the trading value
vii) Sales of new products
viii) Creation of new companies
ix) Export of high-tech products
x) Export of high-tech services.[74]
The fourth group is digital components and technology services

i) The area of city covered by wired networks

ii) The area of city covered by Wi-Fi networks

iii) The area of city covered by the ADSL network

iv) The number of computers

v) Internet connections

vi) Extensive communication

vii) Users of government e-services

viii) Institutions that have websites on the Internet

ix) Institutions that provide B2B and B2C services

x) Digital service providers.[74]

Through these criteria, the smart city is based on assessment inputs (individual skills, knowledge institutions, digital technology) and also on outputs (creativity).[74]

4.3 Intelligent Community Forum (ICF)

Criteria for evaluating smart cities were developed through the Intelligent Communities Forum, through which it was found that smart cities are based on;

a) Owning wired or wireless telecommunications networks in residential areas, government events, and all business sectors, with incentives provided by the government to establish networks when necessary.

b) Development of individuals through effective education and training, which creates a force capable of performing knowledge work.

c) Expand citizen participation in decision-making through government programs.

d) Innovation in the public and private spheres, and the financing of new projects.

e) Attracting new business owners through effective marketing for development.

These criteria are based on knowledge, creativity, and communication technologies.[75]

The criteria presented through the forum seek to know the ability of individuals to work in areas of knowledge, the ability of society to create an environment suitable for innovation, the evaluation of government services, and the evaluation of digital communications.

Based on these criteria, forty different cities were evaluated; small cities such as "Pirai "in Brazil, large cities such as "Tinjin "in China, rural cities such as "Barrio "in Malaysia.

Two strategies can be inferred from this evaluation;

a) Integrating new economic structures for creativity and focusing on knowledge-based development.

b) Focus on information technologies such as; Communications, electronic services, and technology training.[75]

4.4 standards of the Regional Science Center of the Technical University of Vienna

A number of researchers at this university presented 31 influential factors for evaluating smart cities, where smart city applications include: smart government, smart people, smart economy, smart life, smart transportation, and smart environment.

The researchers also analyzed the performance of each factor, by selecting 1-4 indicators, where the number of indicators reached 73.

The criteria were chosen based on the basic concept of the smart city, which was used to express places that use communication and information technologies, or cities that have smart industries such as technology industries, in addition to cities that have smart people and seek to develop the education system.

According to these criteria, European smart cities were evaluated, and the objective of the evaluation presented was: to clarify the advantages and characteristics of each city, the specific evaluation of a selected group of cities, the possibility of comparing cities, and to identify strengths and weaknesses.[76]

Smart government:

a) Contribute to decision making (3 indicators: city representatives in relation to the population, political activities in relation to individuals, and the importance of politics in relation to individuals).

b) Social and public services (3 indicators: municipal spending, children's participation in care centers, and citizens' satisfaction with the level of schools.

c) Government integrity (2 Indicator: Satisfaction with transparency and agreement on fighting corruption). [76]

Smart transportation:

a) Local transport (3 indicators: public transport, citizens' satisfaction with the means of transport used, and citizens' satisfaction with the quality of transport).

b) Global transport (1 indicator: Ease of universal access).

c) Availability of technical infrastructure (2 Indicator: Availability of computers in homes and availability of broadband Internet in homes).

d) Safe and sustainable transportation systems (3 indicators: traffic safety, sharing of means of transportation, number of economical cars).[76]

Smart environment:

a) Availability of natural ingredients (2 index: sunrise hours and availability of green areas).

b) Pollution (3 indicators: summer smog, certain environmental problems, and chronic respiratory diseases).

c) Environment protection (2 indicators: individual efforts to protect the environment and opinions on the issue of environmental protection).

d) Natural resource management (2 indicators: effective consumption of water and effective consumption of electricity).[76]

Smart life:

a) Cultural events (3 indicators: the rate of cinema visits per person, the rate of museum visits per person, and the rate of theater visits per person).

b) Health conditions (4 indicators: average age, number of hospital beds, number of doctors, and quality of the health system).

c) Personal security (3 indicators: number of crimes, number of crime deaths, acceptance or satisfaction with personal security).

d) Housing (3 indicators: provision of minimum laws, housing size, and people's satisfaction with housing).

e) Educational activities (3 indicators: number of students, ease of access to educational institutions, and quality of education).

f) Tourism and attractions (2 indicators: the importance of the city as a tourist site and the number of tourists staying annually.

g) Social unity (2 indicators: awareness of the dangers of poverty and the poverty rate).[76]

Smart people:

a) Competency level of people (3 indicators: availability of research centers, number of individuals enrolled in higher education, and language skills).

b) Contribute to long-term education (3 indicators: availability of books, percentage of contribution to long-term education, and participation in language courses).

c) Ethnic and social pluralism (2 indicators: the participation of foreigners and the participation of citizens residing abroad).

d) Flexibility (1 indicator: Getting a new job).

e) Creativity (1 Indicator: The participation of individuals working in the creative industries).

f) Openness (3 indicators: turnout for elections, attitude towards immigration, and availability of information about the city).

g) Contribution to public life (2 indicators: turnout for local elections and participation in cooperative work).[76]

Smart economy:

a) Innovative spirit (3 indicators: total research expenditures, number of workers in knowledge sectors, and number of patents for individuals).

b) Contracting (2 indicators: the rate of self-employment and the number of new companies).

c) Economic image and branding (1 indicator: decision-making centers).

d) Productivity (1 indicator: the rate of output per capita).

e) Labor market flexibility (2) Indicators: unemployment rate and employment rate).

f) International Relations (3 indicators: the headquarters of international companies, air transport, and the transport of goods). [76]

4.5 Smart Cities Evaluation Criteria Comparison

By comparing the previous standards, we find that the standards of the Regional Science Center at the University of Vienna are more detailed and comprehensive, distinguished from the rest of the standards by their spatial scope, and their reliance on standard values to avoid errors resulting from the lack of some data, containing detailed criteria for selecting the cities to be studied, and using recent data.[76]

As for the criteria of the Intelligent Communities Forum and the criteria of “Nicos Kemninos” it does not include a method of calculating or announcing the sampling methodology, as well as the lack of detailed results.

The criteria of "Nicos Kemninos" include forty indicators, while the criteria of the Intelligent Communities Forum include five factors through which the evaluation is carried out without the need for indicators.[74]

The objective of the criteria "Nicos Kemninos" is a scientific objective, while the objective of the criteria of the Intelligent Communities Forum is to direct investments and the economy.[74]

Through a comparison between the evaluation indicators of the Regional Science Center in the University of Vienna and the evaluation indicators of "Nicos Kemninos", we find that the indicators in evaluation of the regional science center were comprehensive and dealt with the various dimensions of the city, while the "Nicos Komninos" criteria focused on four axes; Creativity, digital infrastructure, education, and knowledge.[76]

Have neglected the environmental factor in the assessment.

Thus, we can say that the evaluation criteria for the regional science center at the Technical University of Vienna is more objective, more comprehensive and can be adopted to transform any city into a smart city.

5. MODELS OF SMART CITIES

5.1 Arab and international examples of smart cities

The countries of the world differ in the field of adding technologies and their interest in information technology. Some countries have started in the early stages of moving towards smart cities, which is preparing the infrastructure necessary to establish a smart city. Others have taken advanced steps towards relying on technologies and have started to establish complete smart cities.[77]

Most of the world's countries have begun to develop integrated policies to support the establishment of smart cities and adopt their applications at the national level, as the countries of the world have become aware of the importance of adopting technology and its impact on social and economic development.

The countries of the world began to build new smart cities and transform existing cities into smart cities that depend on information technology in the conduct of daily activities. The number of smart cities created globally has exceeded 2,000, and 1,500 were established before 2010. This number is increasing at a rate of 20% annually.[15]

5.2 Converting existing cities into smart cities

5.2.1 Groningen City

Groningen city in Netherlands, and is considered the economic center of Northern Holland. It has a population of 190,000 people and is characterized by the number of students in it, which amounts to 50,000 students, as this number of students is one of the catalysts for transforming it into a smart city in addition to the initiatives of the local government. The factors for the success of the experience in this city are the cooperation between institutions, developed of new services, and the participation of communication and information technology, e-government, and political support.[78]

Smart applications in Groningen:

a) Medical services: The medical services provided in this city are represented in providing medical centers with the latest information via television and video recorder with the

availability of wireless networks, which achieves continuous monitoring by health care centers.

b) Education: There was cooperation between the University of Groningen, which focuses on theoretical aspects, and Hanze University, which focuses on the practical aspect. The goal was to provide students with access to the wireless network and to develop communication technologies for education. The network also provides lessons via the Internet.

c) Tourism: to meet the requirements of tourism using information technologies, from which services are provided to tourists; Internet service, GPS, and provision of hotel reservations through the Internet.

d) Security: checking car licenses and identifying violations through wireless networks.

e) Transportation: Enhancing the ability of vehicles to receive and send data, thus providing drivers with data. [79]

5.2.2 Mecca city

The Kingdom of Saudi Arabia has sought to benefit from the developmental energy provided by technological development. It has adopted initiatives based on information technologies and communication. One of these initiatives was the establishment of smart cities in which communication services are available to all individuals in various places, in addition to providing government services easily via wireless networks.

The Kingdom of Saudi Arabia has followed a strategy for the establishment of smart cities that consists of two parts;

The first - the establishment of new smart cities (“King Abdullah Economic City”, “Jazan City”, and “Knowledge Economic City”).

The second - converting the current cities into a smart city (the city of Mecca).

The project of transforming the city of Makkah into a smart city is the second part of the strategy, by taking advantage of communication and information technologies and transforming them into a knowledge society, which helps in economic, cultural, and commercial development. [80]

Smart applications in the city of Mecca:

a) Monitoring systems: The city has been provided with monitoring systems for pilgrims to provide the necessary protection, record incidents, and transfer events to the control room. Monitoring systems include control points linked together with advanced communication systems.

b) Intelligent Transportation System: Intelligent transportation systems are used on public roads, which adopt electronic routing, speed restrictions, traffic signs and traffic light management systems.

c) Smart buildings: Smart buildings comprise a variety of modern technologies represented by automatic computer networks, a multifunctional telephone system, audio-visual means, surveillance cameras and control devices.

d) Providing information: Citizens and visitors to the city of Mecca are provided with information-supply devices, some of which are placed in public places, and they are display screens that provide information about the city and the weather, and some of them are in the form of a mobile phone with limited functions that enable users to access this information.[81]

e) Hajj activities: When transforming the city of Makkah into a smart city, consideration must be given to meeting the needs of pilgrims and umrah pilgrims and providing the necessary services using the latest technologies such as;

i) Entry visas and passports

ii) Distribution of flights and coordination with airline networks

iii) Providing electronic information to pilgrims through a special website that provides various information such as service delivery centers, getting to know public places, information about the rituals of Hajj.[82]

5.2.3 Dubai city

One of the strategies adopted by the United Arab Emirates is to transform Dubai into a smart city, so as not to rely only on oil in the economy, but rather to support commercial and economic centers. Dubai is considered the most developed city and the most economically active.

Work began to find an appropriate environment and infrastructure capable of accommodating the requirements of this transformation. There were two main factors that helped achieve this transformation:

a) Strong political will

b) Availability of the resources needed for this process.

the objectives of transforming Dubai into a smart city; Taking advantage of communication and information technologies , creating an environment that attracts international companies and enhances the local economy, and Attracting smart talent.[83]

Smart applications in the city of Dubai:

a) Smart Government: Government departments in Dubai have been transformed into departments capable of providing the best public services using the Internet and electronic solutions such as; Issuance of commercial licenses and work permits, payment of various fees, driving permits and entry visas. [84]

b) Smart commerce: smart commerce helps in globalizing economic activities and increasing the demand for labor, as well as changing the nature of the market and opening new channels for developing knowledge, in addition to activating new trends in economic sectors.

The city of Dubai has established an electronic commercial marketplace (Tijari.com) to be a portal for companies and a provider of commercial goods.[85]

c) Smart Learning: smart learning aims to spread electronic culture and introduce computer-related materials in schools with the aim of preparing generations capable of using technology and increasing their knowledge growth.

d) Smart Transport: The city of Dubai set up a comprehensive automated system for controlling traffic in 1995, establishing a traffic control center, and installing surveillance cameras to manage emergency traffic events.

e) Dubai Technology, Media and Electronic Commerce Free Zone: It is a commercial zone with financial and administrative independence located in the free zone located in (Jebel Ali). The businesses and activities that are practiced in the free zone include providing Internet services, media services, and electronic business.

f) Dubai Oasis for Projects: It is an area that provides services and keeps pace with the latest technologies, where it achieves the highest levels of luxury, and it is a model for applying the latest technologies. It consists of a group of large projects of towers and smart homes.[86]

g) Smart banks: Banks use the Internet to provide their banking services, as the emergence of electronic commerce was the cause of the emergence of electronic banks that provide their services through the Internet. In Dubai, Dubai Bank launched an electronic service to enable individuals to access and follow up on their accounts by visiting the bank's website through the Internet.

h) Dubai Internet City: Dubai Internet City was established to be an important technological base that works to provide facilities that attract international companies as well as attract new ideas. The city is a center for information technology-based activities and is the first e-commerce area that was opened in 2000 and is planned to be a regional and international center for the software industry.

i) Knowledge Village: a project that aims to establish a knowledge society, refine creative energies, and increase the number of specialists in the field of knowledge work. The project began in 2002 with an area of one million square feet within the scope of the Dubai Technology and Media Free Zone. The project includes; invention center, electronical learning center, media academy, multimedia libraries, and research centers. [87]

5.3 Creating new smart cities

5.3.1 Cyberjaya City

Cyberjaya is located in Malaysia. It was opened in 1999 and is considered the first smart city in Malaysia. The aim of its establishment was to attract global technology industries and information companies to Malaysia to carry out research and development work, as well as giving the opportunity for local industries to use the infrastructure provided by the project, where investors are encouraged to Incorporation of companies.

The development of this city was part of a project aimed at linking a group of smart cities, thus forming an information and communication hub known as (MSC). The project includes the establishment of two smart cities: (Putrajaya), which constitutes a center for government

services, and (Cyberjaya), which constitutes a center for technology companies, in addition to the presence of a university, research centers and smart schools.

The city of Cyberjaya offers many incentives for companies, including;

Equipping a wide network with the latest technologies and international specifications

Exempting companies from taxes for 10 years and allowing them to own and export capital.

Protecting intellectual rights and offering competitive prices.[88]

City Components:

a) The Multimedia Development Corporation (MDC) which located in the city center and is the main engine for the development of the MSC project.

b) The Multimedia University which established in 1997 and is equipped with the latest technologies and is considered a major center for education and research related to multimedia.

c) Research and development centers to support the information and communications sector

d) Many multimedia companies in addition to housing units. [88]

Smart applications in the city:

i) Smart Government: The concept of e-government is applied in administrative departments by using communications and information to create communication between government departments, citizens and companies.

The multi-function card: Using a smart card (MyKad) with multiple functions, as it is used as an identity card, a credit card, a teller card, a driver's license, and a health card.

ii) Smart Schools: Providing schools with communication and internet technologies, which help students participate in virtual lessons and gain information.

iii) Research centers: through which scientific institutes and institutions are encouraged to conduct research related to communication and information technologies.

iv) Smart healthcare: the formation of a regional center for the correct remote care by using technological technologies.

v) Smart Business: Work is being done to attract local and international companies to work in the field of multimedia and the Internet. [88]

5.3.2 Songdo City

The city of Songdo is located in southern South Korea and is considered the waterfront of the (Incheon) region. It was developed after the economic crisis in 2007 as South Korea searched for a new engine for economic growth, and developed a strategy to establish a major hub for global business and focus on knowledge-based technology industries.

The strategy pursued by South Korea includes the establishment of three poles of growth, represented by three cities (Songdo, Cheongra, and Yeongjong) that form three free economic zones.

This city is called by several names, including the smart city, the international city, and the gateway to Northeast Asia. [89]

Smart applications in Songdo City:

a) The smart environment: The city has committed itself to the green building system, and has followed strategies, including reducing carbon dioxide emissions, using environmentally friendly transportation systems, and providing green spaces.

b) Songdo Tech Zone: Established in 1998, it has five main departments: Main Administration Center, Technical Trade Research and Development Center, Korea Industrial Technology Institute, Incheon University Research Center, and 35 private enterprise development research centers.

This zone aims to provide a suitable and encouraging environment for companies to benefit from in developing the local economy.

c) Providing services via the Internet: The city contains a computer environment that enables citizens to access various services at any place and time.

d) Systems to manage natural and industrial disasters.

e) Safety and security system, Smart education, Smart healthcare, and Smart traffic control.[89]

6. CONCLUSIONS

6.1 Conclusions

It is clear from the previous chapters of this research that providing welfare for citizens and visitors by transforming the city into a smart and sustainable city or establishing a new smart city is done through the basic pillars of this transformation and these pillars are linked with the factors that help to establish smart cities, which in turn depend on indicators to evaluate performance in a hierarchical relationship (figure 3) As the achievement of indicators provides us with the factors and by providing the factors that complement our basic pillars, which in turn achieve the desired goal, which is to achieve an ideal smart city that combines technology and social in all aspects of daily life.

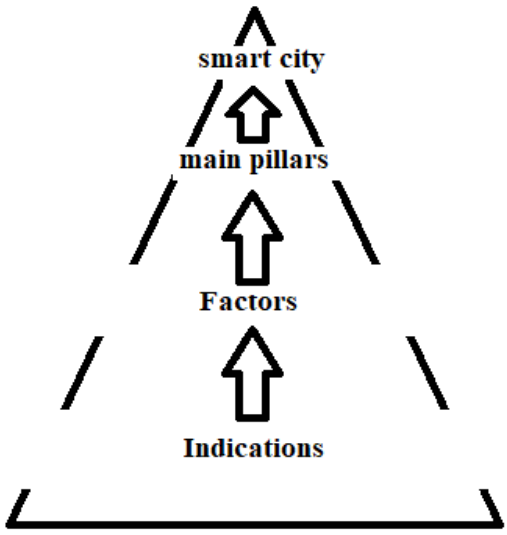

Figure 6.1 : The Hierarchical Structure of Smart Cities [76]

Through the criteria presented by the Intelligent Communities Forum (ICF) and the criteria of the researcher "Nicos Kemninos", we find that establishing a new smart city is based on four pillars, and each of these pillars is determined by a set of factors and their indicators. As for the standards of the Regional Science Center at the Vienna Technical University, the

establishment of smart cities depends on six pillars, adding to the factors and indicators of these pillars.

6.1.1 Smart cities in (ICF criteria)

The Intelligent Communities Forum (ICF) presented a set of pillars on which the establishment of smart cities depends, and each of these pillars has factors that must be achieved to reach ideal smart cities, as these pillars included (Technique pillars, social pillars, Creativity and knowledge pillars, and economical pillars) as shown in Table 6.1:

Table 6.1 Main Pillars and Its Factors in (ICF)

Technique	social	Creativity and knowledge	economical
wired or wireless telecommunications networks	Government roles in all areas of business	Universities and schools	good economy
Data and Analytics Centers	Expand the participation of citizens in making decision	Innovation in the private and public sectors	technology companies
Computers and technical equipment	Promoting digital democracy	research centers	Attracting new business owners
Applications and service programs	Incentives offered by the government to establish networks when necessary	People development through education and training	Effective Marketing for Development

6.1.2 Smart cities in ("Nicos Kemninos ”criteria):

According to the criteria "Nicos Kemninos", the establishment of smart cities or its transformation depends on four main pillars which include;

(Creativity and knowledge institutions, Skills of individuals and the level of education, creative performance, and digital components and technology services).

Each of these pillars depends on ten factors that are clarified in Table 6.2:

Table 6.2 Main Pillars and Its Factors in ("Nicos Kemninos" criteria)

creativity and knowledge institutions	**Skills of individuals and the level of education**	**creative performance**	**digital components and technology services**
The number of technical institutions	People with higher education degrees	Number of patents	The area covered by wired networks in the city
Number of technology transfer centers	Contributors to long-term education	Number of new brands	The area covered by Wi-Fi networks in the city
The percentage of investment financing out of total trade financing.	Fresh graduates	Number of new manufacturing projects	The area covered by the ADSL network of the city
The number of university students	Industry researchers	Number of new service projects	The number of computers
The number of university employees	Researchers in the public sector	The number of institutions that organize a research and development department	Internet connections
The percentage of spending on research and development	Researchers in the private sector	The ratio of selling new products to the trading value	Extensive communication
Percentage of people spending on research and development	The ratio of employment in higher education to total employment	Sales of new products	Users of government e-services
Percentage of institutions spending on research and development	Employment rate in manufacturing industries	Creation of new companies	Institutions that have websites on the Internet
Percentage of institutions spending on licensing	Employment rate in high-tech services	Export of high-tech products	Institutions that provide B2B and B2C services
The number of institutions that support small projects	Number of creators	Export of high-tech services	Digital service providers

6.1.3 Smart cities in (Regional Science Center of the Technical University of Vienna criteria):

The Regional Science Center of the Technical University of Vienna has identified six basic pillars for the establishment of smart cities, and each of these pillars is determined by a set of factors, as shown in Table 6.3:

Table 6.3 Main Pillars and Its Factors in (Science Center of Vienna University)

Smart government	Smart transportation	Smart environment	Smart life	Smart people	Smart economy
Contribute to decision making	Local transportation	Availability of natural ingredients	Cultural events	Competency level of people	Innovative spirit
Social and public services	Global transportation	No Pollution	Health conditions	Contribute to long-term education	Contracting
Government transparency	Availability of technical infrastructure	Environment protection	Personal security	Ethnic and social pluralism	Economic image and branding
	Safe and sustainable transportation systems	Natural resource management	Quality of housing	Flexibility and Getting a new job	Productivity
			Educational activities	Creativity	Labor market flexibility
			Tourism and attractions	Openness	International Relations
			Social unity	Contribution to public life	

6.1.4 Main pillars of smart city

Through ("Nicos Kemninos" criteria, Smart Community Forum (ICF) criteria, and Vienna Technical University Regional Science Center criteria), performance assessment indicators for smart cities and the pillars presented through previous studies, We can identify the main pillars on which the ideal smart city depends, and these pillars can be identified;

i) Technical pillar

ii) Social pillar

iii) Economical pillar

iv) Environmental pillar

v) Scientific pillar

vi) Health pillar

As well as determining the factors of these pillars, as shown in Table 6.4:

Table 6.4 Main Pillars and Its Factors of Smart City

Technical pillar	social pillar	economical pillar	Environmental pillar	Scientific pillar	health pillar
wired or wireless telecommunications networks	The government provides support and supplies	good economy	Availability and management of natural ingredients	Universities and schools	Hospitals and health centers
Data and Analytics Centers	Collaborative citizens keen on development	technology companies	Protecting the environment	Innovation in the private and public sectors	The use of devices and technologies in the health fields
Computers and technical equipment	Promoting digital democracy	Attracting new business owners	Roads and the transport network	research centers	Average age of citizens
Applications and service programs	Security and privacy for citizens and data	Effective Marketing for Development	Tourist places and attractions	People development through education and training	health system quality

6.1.5 Simulation main pillars with logic gates

From the rules of mathematics: Anything that cannot be measured, cannot be improved.

The previous table shows us the main pillars on which smart cities depend, and each of these pillars depends on four factors. We can make a low-cost circuit, easy to program and apply, and available to everyone, through which we can know the extent to which all the basic pillars and factors for creating smart cities have been achieved. This circuit consists of logical gates, and in particular we can use the AND gate (AND gate gives a high output (Logic 1) if all the inputs are (1), when we have the output of the circuit (1), this means that all the pillars and their factors are available, and the smart city became ideal.

Giving values to the pillars as main variables, as well as giving values to the factors of these pillars as sub-variables, we will have four variables and each variable has four sub-variables as shows below;

Technical pillar = A = A_0. A_1. A_2. A_3

Social pillar = B = B_0 .B_1 .B_2 .B_3

Economical pillar = C = C_0 .C_1 .C_2 .C_3

Environmental pillar = D = D_0 .D_1 .D_2 .D_3

Scientific pillar = E = E_0.E_1.E_2.E_3

Health pillar = F = F_0.F_1.F_2.F_3

Ideal smart city = S =A .B .C .D .E .F

Now when you applay this variables in circute show in figure(4) we will get 2^4 =16 probability as show in truth table show in table 6.4:

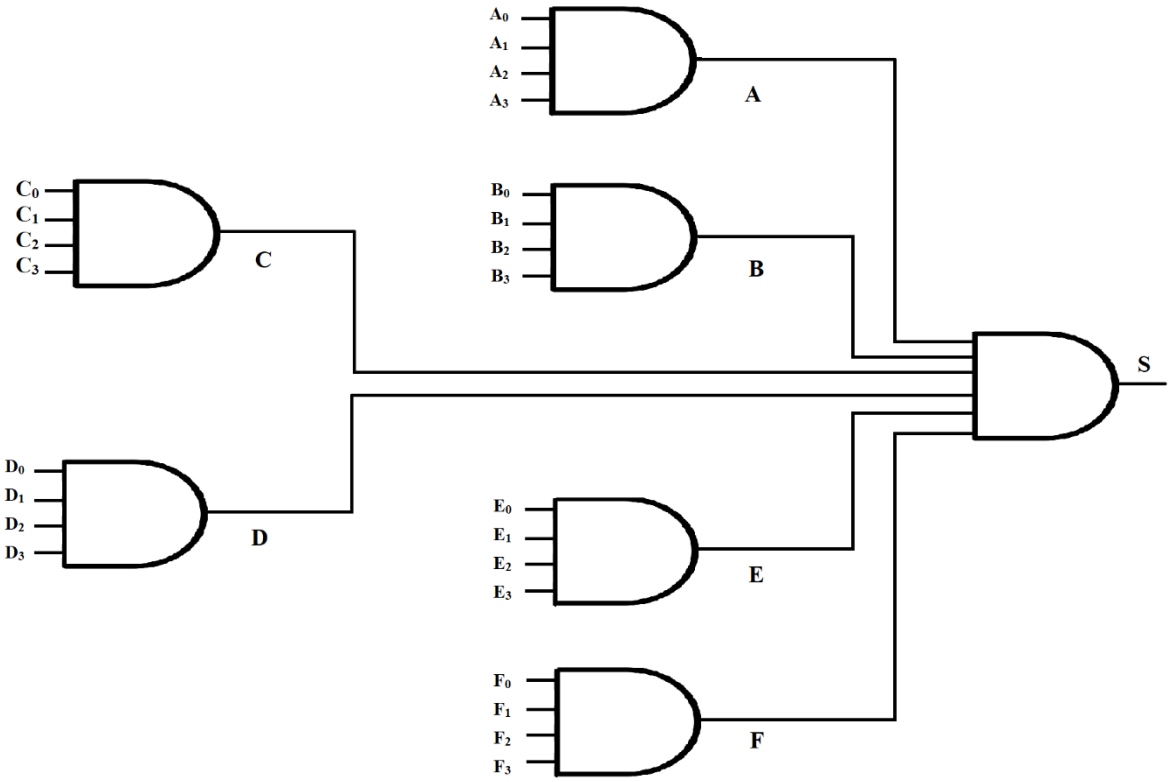

Figure 6.2 : Logic Circute

Table 6.5 Truth Table of Logic Circuit

F_3	F_2	F_1	F_0	F	E_3	E_2	E_1	E_0	E	D_3	D_2	D_1	D_0	D	C_3	C_2	C_1	C_0	C	B_3	B_2	B_1	B_0	B	A_3	A_2	A_1	A_0	A	S
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0
0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0
0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0
0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0
1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	0
1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0
1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	0
1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0
1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	0	1	0	0
1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Through the logical circuit shown in Figure 6.2 And the possibilities presented for the circuit's inputs, we find that the value of the variable (S) is achieved in the case of achieving all the main variables with their sub-variables, by obtaining an output result (1) for variable (S), we find that the factors as well as the basic pillars have been fulfilled

6.2 Future works

Smart cities offer a vision for the future, strategies and attractive prospects.

The main issue of this presentation is to understand the way to link the institutional, physical and digital aspects within the smart city where innovations and knowledge are energized and released and innovations increase.

Smart cities must keep pace with rapid technological development and continuous updating in applications and programs, as well as actually dealing with and introducing new pillars in order to continue their success.

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