Chapter 5
Green Building Industry Essence for Environmental Sustainability

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Abstract
From site selection through design, construction, maintenance, operation, restoration, and demolition, green buildings, sometimes referred to as sustainable buildings or green construction, use little resources and respect the environment. Today's environmental issues and sustainability difficulties include promoting more efficient and effective use of the resources already in use, such as power, water, and building materials, preventing waste, using environmentally friendly and responsive building design techniques, and being environmentally viable inside the construction industry. According to figures provided by the National Building Code, the energy consumption of buildings accounts for forty percent of the world's total energy consumption as well as eighteen percent of worldwide emissions, which equals nine billion tonnes of CO_2 emissions annually (NBC). This highlights the critical necessity of incorporating sustainability into all new development, which contributes to the construction of a sustainable environment as well as a healthy ecosystem. This chapter aims to familiarise readers with the significance of the green construction business by providing a comprehensive overview of the sector’s environmental sustainability in terms of ecological characteristics, human health and productivity, and environmental profits. Aspects of modifying existing buildings to make them more sustainable, as well as the actions implemented in India’s burgeoning Smart Cities, are also highlighted.

Keywords: Green Building Industry, Sustainability, Energy Efficiency, Waste Management, Smart Cities

1. Introduction

As a result of the exponential increase in the manufacturing sector and the improvements in the technological use of energy, which have increased all over

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the planet, irreparable damage has been done to the global climate. This would have a negative impact on the quality of life of both current and upcoming generations. As a result of the proliferation of new infrastructure projects in emerging nations such as transitional economies as well as the widespread inadequacy and inappropriateness of the utilisation of existing structures, Chadderton (2012) asserts that the construction industry is obligated to adopt environmentally friendly building practises and technologies. Additionally, he warned that emissions of greenhouse gases from buildings will more than quadruple in the following two decades if the necessary steps are not done right away (Chadderton, 2012). As a result, the ecological design industry, which refers to the process of designing or altering buildings throughout their life cycle to become concerned about the environment, sustainable, and resource-efficient, is a key phrase in 21st-century architecture.

2. Environmental Impact of Conventional Building Sector

There is an essential global dialogue about conventional building materials, and most construction materials are focused on instant building solutions to accomplish multiple goals. It is estimated that the construction industry absorbs up to forty percent of all energy and contributes up to thirty percent of the world's yearly greenhouse gas emissions (UNEP, 2023). As per the Green Building Council (IGBC) Indian report, conventional buildings currently account for up to one-third of the world's total energy needs. In addition, carbon dioxide emissions account for up to 47% of all global emissions worldwide, with India ranking 144th nearly 1.4 metric ton in carbon emission rating (Dixon, 2010). With an increase in the traditional building materials, this effect is extreme, undesirably impacting the troposphere day by day. This can be arranged as follows:

- Extreme Greenhouse Gas Emission
- Excess Energy Used and Consumed by Conventional Plant
- Excess Water Usage
- Extreme Buildings Demolition and Construction Effects
- CO_2 Emissions of Construction Materials (*Mined Industrial Process*)

Thus, there is a resilient need for green buildings industry across the globe covering all economies. The majority of the nations, including India, are in the underlined position of population blast and rapid urbanization and industrialization, leading to further pressure on all natural resources.

3. Short review on Environmental sustainability of green building Industry

When it comes to environmental resilience, the green building sector uses sustainable land use to increase urban biodiversity and safeguard the ecosystem (Henry and Frascaria-Lacoste, 2012). Figure 1 shows a list of the foundational components and elements of the green building sector. Reducing waste from construction and destruction is essential to ecological building design (Akadiri and Olomolaiye, 2012, Yeheyis et al., 2013). The recovering rate needs to be over 90%, which necessitates the utilisation of recycled and repurposed materials in new building, in order to mitigate the obvious negative impacts that trash from construction and demolition have on the surrounding environment (Coelho and De Brito, 2012). Conventional buildings often perform worse than green buildings when it comes to water efficiency, power efficiency, and the reduction of carbon emissions. Green buildings, on the other hand, typically perform better. According to Turner et al. (2008) findings, a building that has been awarded the LEED certification can save more than 28 % energy than the amount that is considered to be the national average. Construction that is green or sustainable utilises less water, makes the best use of energy, protects natural resources, generates less waste, and gives occupants a healthier environment. It is also emphasised to use renewable energy. The National Building Code of India gives recommendations for energy use in green buildings (NBC).

Figure 1. Pillars of Sustainable Green Building Industry

4. Ecological Characteristics of Green Buildings Industry

The following are important Ecological aspects of green building industry:

4.1. Ecological Sustainable Location

It alludes to a location where there would be the least ecological risk while building is underway.

Additionally, it has access to necessities like sand and water, decreasing pollution brought on by transit. A location that is ecologically sustainable should have facilities for ground water recharge and maximise the usage of location storm water management. At these areas, effective measures can be taken to protect top soil so that it absorbs less water (LaGro, 2013).

4.2. Ecologically viable construction material selection

An environmentally friendly industry makes the most of reusable, renewable, sustainably managed, and bio-based components (Mokal et al., 2015). It is possible to use a wide variety of materials that have a high percentage of recycled content. Some examples of these materials include structural steel, carpets, carpet padding, ceiling and floor tiles, and mixed concrete made with recycled concrete aggregate, fly ash, slag, among other ad mixtures. The production of bio-based materials and finishes involves the utilisation of agrarian waste and by-products including straw, wheat, barley, peanut shells, soy, and sunflower amongst other things like these. This element also includes the reuse of domestic waste as biogas. Figure 1 depicts the three stages of the building material life cycle that Umar (2012) discussed, with the emphasis on recycling at each stage that is pre-building, building, and post-building.

4.3. Water Efficacy

The major objective here is to maximise the building's efficient use of water, which will lower the amount of water required for particular operations. Effective landscaping techniques and the application of cutting-edge wastewater management technologies are some strategies that can be used. In these environmentally friendly buildings, water-saving technologies including waterless urinals, wastewater treatment facilities, and rainwater harvesting are installed (Grace, 2009).

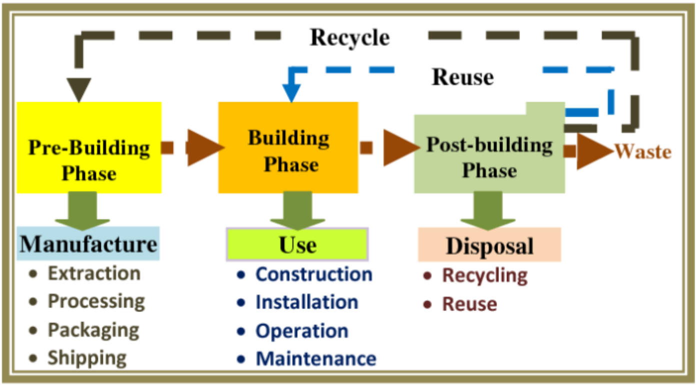

Figure 2. Three stages of the building material life cycle (Umar, 2012)

4.4. Energy Efficacy

It entails the deployment of various on-site renewable energy generation techniques in order to lower the building's overall energy consumption (solar, wind etc.). Building orientation, form, design, interior colours, and finishes are all optimised to make the most of natural day lighting (Cook, 1998). This lessens the reliance on energy for artificial lights. The design of window frames, sashes, and curtain wall systems optimises energy performance. It is recommended to use electrical equipment that has been rated by the Bureau of Energy Efficiency (BEE). There are CFC-free refrigerators and air conditioners installed.

4.5. Enhanced indoor air quality

Construction of buildings should use low-emission materials to improve the health of the residents. All inhabitants of the building will utilise natural light to the fullest extent possible. Cleaning products that are environmentally friendly and biodegradable and don't emit toxic agents or leave behind residue are used (Fisk, 2000). Cross ventilation/ improved ventilation system should be included, improving interior air quality.

4.6. Waste Management

Buildings contribute to noise, water, and air pollution, and today's ecological issues are especially critical due to global warming. Fabrication firms are starting to adopt green supply chain management to make their operations ecological, and green materials are preferred in building design to reduce the production of waste. Some of the sustainability considerations that producers use include green buildings, ecological design and development, and waste management for constructions (Yuan, 2012). According to Begum et al. (2006), disposal is the best way of minimizing the production of building waste. In addition, to get rid of recycling restrictions, material types must be chosen very carefully, which means recyclable materials should be preferred, as shown in Figure 2 in third phase that is post disposal phase the most important pillars are recycling and reuse (Umar, 2012).

5. Human Health and Productivity in Green Building industry

According to some studies, there may be additional benefits to green building that are not directly related to price. These academics concentrated on the advantages and assistances of green buildings for people. This is because people spend a lot of their time indoors living in structures. These have been proven in terms of productivity, indoor climatic efficacy, and thermal comfort.

5.1. Thermal comfort: Complicated dynamics of temperature and humidity is intimately related to client satisfaction in the construction industry (Mekhilef et al., 2012). Researchers have paid a lot of attention to modelling and quantifying the degree to which thermal comfort in green construction in contrast to typical buildings. Thus, it was feasible to advise the required range of room temperature (Sicurella et al., 2012). Adaptive thermal comfort is not the only consideration; psychological, physiological, cultural, and behavioural factors can also be important (Deuble and de Dear, 2012).

5.2. Effectiveness of Indoor Climate: One of the most significant aspects of the advantages of green design for people is effectiveness of indoor climate. Indoor climate quality, which includes volatile organic compounds productions and other pollutants, is a serious issue in buildings (Yu and Kim, 2010). Therefore, indoor climate efficiency is crucial in all top green building rating systems (Yu and Kim, 2011). Abundant studies have confirmed that green buildings can reach higher interior temperature efficiency levels than conventional structures, which benefits resident health and productivity. The result is an improvement in user satisfaction with construction. In fact, the research by Leaman and Bordass (2007) discovered that people who use green buildings seem to be more understanding of interior environmental quality than people who utilise typical construction methods (Leaman and Bordass, 2007).

5.3. Productivity and the health of humans: When people move into green buildings, their healthcare and their levels of productivity both improve, according to a number of studies that have been done on the subject (Gou et al., 2012). For example, Ries et al. (2006) indicated that the socioeconomic advantages of environmentally friendly building should not be ignored; specifically, in terms of effectiveness and absenteeism, green building has been shown to be beneficial. Their research demonstrated a 25% increase in efficiency, and when tenants move from conventional buildings to environmentally friendly buildings, absenteeism drops by a significant amount. In point of fact, there is a difficult challenge involved in preserving a delicate equilibrium between the effectiveness and resources of the indoor environment, as well as the cost-effective functioning of heating, exposure to air, and air conditioning plants (Omer, 2008).

6. Environmental profits of sustainable building industry

The green building industry minimizes harmful impacts by more effective preparation, design, construction and activity focused on Green Standards. Energy cost savings and decreased maintenance costs make green building especially appealing for owners who cater to owners (Kotkar and Salunkhe, 2017). Thus, in terms of environmental, social, and economic aspects, the green building industry is advantageous. Summing up these environmental benefits is as follows (Tathagat and Dod, 2015, Kotkar and Salunkhe, 2017):

- Conservation of scarce natural resources.
- Optimize life-cycle economic performance.
- Reduction in natural areas, habitats, biodiversity etc.
- Decrease in energy consumption without giving up the comfort levels
- Reduction in water consumption.
- Improving and shielding the health and well-being of the occupants.
- Limited waste generation due to recycling and reuse.
- Increase in user productivity.
- Reduction in air and water pollution (with direct health benefits).

- Heighten aesthetic qualities.
- Enhanced image and marketability.

In the residential sector, the concepts and techniques of the sustainable building industry can be of assistance in dealing with nationalised issues such as the management of end user waste, water efficiency, the elimination of fossil fuel in nature by improving energy efficiency the conservation of natural resources, and other such issues.

7. Retrofitting of existing buildings

Transforming an existing building into a green one is not impossible, although it can be difficult to some degree. There are several basic things that can be retrofitted at relatively low cost into an existing building and sometimes pay for the retrofit in time. In order to replace anything that already exists and is in working order, existing buildings need substantial investment. Not all of the required adjustments, however, need to be done at the same time.

We can start with small installations, such as leaking pipes that need to be patched or restored. If the building is being refurbished, we can go for the sustainability philosophy in mind and use environmentally friendly recycled materials and paints. If the building is old or modern, one of the best ways to save money and save water is to add low-flow fixtures.

Methods for reducing power use and water use are some of the simplest green upgrades to an existing building. For instance, when a light bulb burns out, replace it with an ultra-low-energy bulb like an LED bulb. Moreover, native plants and garden designs, which need less (or no) irrigation, can be utilized while landscaping the existing buildings.

8. Suggestions for transition

We can facilitate the transition towards a sustainable energy future by pushing for renewable sources of energy, or using them in our home and buildings. Renewable energy systems are a very good choice for recycling the atmosphere and producing lower emissions than traditional sources of energy. Green construction helps to keep the atmosphere safe and clean. We are taking more steps to save the future of our planet by using smart devices, eco-friendly materials and sustainable design techniques.

Consumer environmental attitudes have a significant influence on how the building industry adapts to go green. Consumers are also oriented toward this sustainable shift while keeping in mind the innovations. Growing consumer knowledge of the advantages of utilising eco-friendly products in recent years has sparked a positive and proactive response from manufacturers and developers worldwide. However, some consumer groups still need to be educated of this phenomenon's permeability.

9. Summary of Findings of the Green building industry

In summary, the findings of the green building industry can be seen as:

- ❖ It establishes minimal urban sprawl and avoid excessive degradation of precious land, habitat and open space. It preserves important environmental assets by carefully inspecting each site.
- ❖ By using efficient engineering and construction techniques as well as recycling of construction waste, it reduces the usage of non-renewable building resources.
- ❖ It maximises the use of biomass materials that have been sustainably managed, newly developed energy-

efficient materials, and resource-efficient composite structural components.
- ❖ It preserves the current water cycle and constructs the site to closely resemble the local hydrological processes. It emphasises ground water recharge, on-site infiltration, and storm water retention.
- ❖ The building's location, design, and material selection are all optimal, and it makes aggressive use of energy-saving measures to further reduce any negative environmental effects. Additionally, it maximises the utilisation of clean, renewable, and other low-impact energy sources.
- ❖ It offers building occupants a secure, accommodating, and effective indoor environment. It makes use of the optimum circumstances for indoor air quality, thermal ease, access to natural aeration, and day illumination.

10. Green buildings and sustaibility in smart cities of India

The expansion of India's smart cities is primarily reliant on the creation of green buildings that are environmentally conscious, ecologically accountable, intelligently planned, constructed, and run with the least potential detrimental impact on the surrounding environment. A green building is one that, in contrast to a conventional structure, uses less water, protects natural resources, maximises energy efficiency, generates less waste, and provides healthier environments for the people who live or work there. Another name for this type of structure is a high-performance or sustainable building. A smart city aims to make its entire infrastructure, especially the residential infrastructure and the real estate constructions, liveable and sustainable by implementing the abovementioned structural and operational improvements. This is one of the goals of the smart city initiative.

The primary components of “green” buildings focus on energy efficiency, material efficiency through proper ventilation systems for boosting air movement, allowing daylight in, sheltering roofs with trees as an alternate to air conditioners, generating energy from waste materials, and integrating solar power panels as an alternative to high energy demand in smart cities. These components are designed to decrease the amount of energy needed to run the building. Integrating design efficiency helps smart cities go green by reducing operating costs and improving performance. This is accomplished by making structural alterations to the design of new structures and bringing about desired improvements in the design of older architecture.

The goal is to achieve water efficiency while simultaneously maximising the use of the rainwater that is collected and promoting the recycling and reuse of water. Other aspects of green efficiency, such as the reduction of toxic substances, the creation of environmentally friendly indoor environments, the lessening of waste production or pollution, the use of building materials with a low toxic load, and others, are gradually being incorporated into smart cities. Green buildings are a vital element in the development of smart and sustainable cities in India. The “Green Building Movement,” which was embraced by the Confederation of Indian Industry (CII) in 2001, had two primary goals: the first was to create a built environment that is sustainable for everyone; the second was to assist India in becoming one of the world powers in the sustainable construction sector by the year 2025. It is planning to put this innovative concept of green buildings into action, particularly in urban areas, with the goal of mitigating the negative effects of growing urbanisation. Both rapid urbanisation and extremely high rates of population increase have a detrimental influence on society as a result of the fact that they cause dangerously high levels of carbon dioxide emissions and astonishing ground water depletion as a result of excessive water use.

In order to create a better future for both people and the environment, “green buildings” (GB) are constructed with the goals of lowering water consumption and increasing water reuse, employing non-renewable energy sources such as solar or electric energy, and modifying building structures to allow for the greatest amount of natural light and ventilation possible. In addition to these goals, they intend to cut down on waste and put it to better use, offer people a living environment that is healthier and more environmentally friendly, and emphasise the importance of aesthetic aspects. For this reason, modernising older buildings is an extra option to generate places in smart cities that are suitable for human habitation. However, it is not necessary to construct new buildings in place of older ones; rather, older buildings can be rehabilitated by performing the necessary repairs, such as repairing leaky pipes and other fixtures, using eco friendly paints, reducing power usage by promoting the use of ultra-low-energy bulbs like LED lighting, rainwater collection, planned landscaping, waste water treatment facilities, and other measures.

The Indian Green Construction Council (IGBC), which was established in 2001, is collaborating with various agencies of the federal government and state governments across the country to advance the green building movement. The National Building Code (NBC) highlights the fact that, in comparison to traditional structures, green buildings are able to maximise energy costs without sacrificing the amenities associated with modern lifestyles. This work is particularly challenging in the context of India because of the large costs required; however, it is evident that the cost will be soon recovered due to the savings it will produce. The nation's attempts to save energy and its natural resources will be aided by strict adherence to the green building standards that have been established.

According to Pawar (2012), we need to contemplate the topics of energy conservation, efficiency, and smart growth in a way that is both brave and comprehensive. The goal of both a smart company and a smart city should not only be growth, but rather sustainable growth. Although it is patently evident that this is also true for environmental reasons, it is also true for causes connected to the cutthroat nature of the business world's competitive environment. In addition to the obvious advantages of preserving the environment and our health, India's economy would also profit from the construction of high-performance green buildings (Pawar, 2012).

Numerous companies, through the use of ratings, play a vital role in the process of turning the concept of green building into a reality in India. Green buildings are those that have a minimal or non-existent influence on the surrounding environment. GRIHA, a rating system established by TERI, was given official recognition as India's National Green Building Rating System by the Ministry of New and Renewable Energy of the Indian government. Through the use of rating criteria, buildings are being incentivized to adopt environmentally friendly practises and serve as a model for the rest of the country. In addition, the Confederation of Indian Industry (CII), which is an important pillar of the Indian Green Building Council (IGBC), is actively working to improve the environmental friendliness of buildings through the implementation of various proactive programmes.

The concept of LEED-India was adopted privately from the work of the United States Green Building Council, and participation in the ratings is entirely voluntary. They serve the purpose of certifying the successful design, construction, and operation of green buildings. According to the Green Building, Guidebook for Sustainable Architecture, there are a number of different ways that buildings can be designed to be environmentally friendly.

According to the sustainable sites, energy, water efficiency, atmosphere, material and resources, and innovation are the five unique environmental criteria that make up the ranking system for sustainable architecture. For the persistence of improving the overall energy efficiency of buildings, the Indian Bureau of Energy Efficiency (BEE) has developed the Energy Conservation Building Code, also known as the ECBC. The Reserve Bank of India (RBI) building in Delhi was given four stars by the ECBC, whereas the RBI building in Bhubaneshwar, Orissa, was given five stars. The establishment of minimum criteria for the design and construction of energy-efficient constructions is the primary objective of this initiative.

Green buildings in smart cities strive to achieve the 3 P’s, or people, planet, and profit, in the most literal sense possible. This means that in addition to being profitable for the industry and cost-effective for individuals, green buildings should also strive to make the planet a more hospitable place to live and provide comfortable housing for the local population. The “green construction” movement is here to stay and will continue to be beneficial to individuals, society, and the nation as a whole (Pawar, 2012). "Green building" is a response to the errors that humanity has made in the past, and it is becoming increasingly popular. Green buildings not only have numerous positive effects on the surrounding environment, but they also offer numerous financial benefits to both the people who construct them and the people who live in them. They are cost-effective in a variety of different contexts. According to an article published by Times of India, the improved performance of green buildings over the course of their lifetimes results in decreased costs associated with their life cycle, as well as those associated with their operation and maintenance. Even though sustainable building practises are quickly becoming more widespread in India's smart cities in direction to ensure the long-term viability of economic growth, a significant number of barriers still need to be eliminated before the concept can be put into practise in a manner that is more efficient.

Incentives for green buildings, the ease of multiple approvals, awareness of novel practises, adequate skill-based training for experts involved in the construction of green buildings, including engineers, contractors, architects, workers, and so on, introduction of energy-saving new technologies, and so on, should be the top priorities in order to make domiciliary, commercial, and public spaces more sustainable. Therefore, the construction of smart cities with environmentally friendly architecture employing sustainable technology would in some way strike a balance between growth and sustainability while preventing environmental harm. This would be accomplished by avoiding environmental damage. In point of fact, green buildings are an essential component of the environmentally friendly cities of the future, are included into the innovative planning of smart cities, and will stimulate economic growth.

11. Distingusishing characteristics of a smart city

A smart city will have certain characteristics, recurring motifs, and advanced infrastructure. In certain circles, the term “attributes of a smart city” is used interchangeably with “characteristics of a smart city.” As a result of the fact that the development of a smart city is dependent on themes, it is also common to refer to these concepts as the pillars of a smart city. In point of fact, infrastructure is a vital component of any smart city since it serves as the foundation for operational activities. This section provides more information on the elements that were described before in the context of a generic smart city implementation.

12. Indicators of a smart city

A smart city is built from the mixture of many different features. According to Mohanty et al. 2016., the vast majority of plans for smart cities include four primary characteristics: sustainability, urbanisation, quality of life, and elegance as shown in figure 3. Under each attribute, there are just a few subattributes that are concerned. The terms “infrastructure and governance,” “pollution and waste,” “energy and climate change,” “social concerns and economics,” and “health” all fall under the umbrella term “sustainability.” The term “sustainability” refers to a city’s ability to meet the requirements of its residents and continue running municipal operations while also preserving the environmental integrity in all of the factors listed above. The increase in quality of life is shown by the emotional and economical well-being of urban citizens. The transition from a rural to an urban setting is analysed via the lens of the urbanisation attribute, which focuses on the political, economic, technical, and institutional components of the urbanisation process. The goal to enhance environmental, social, and financial criteria of the city and the people who live there is what is meant by the term "smartness."

Since the 1980s, the concept of sustainable urban progress has been regarded to be the most prevalent paradigm. In point of fact, the widespread focus that is now being placed on sustainability was a significant factor in the growth of smart cities. The concept of the “triple bottom line” is applicable to supplementary aspects of sustainability (Wheeler and Beatley 2008). The concept of triple bottom line considers the interrelationships and interdependencies that exist among the sub attributes shown in Figure. 3.

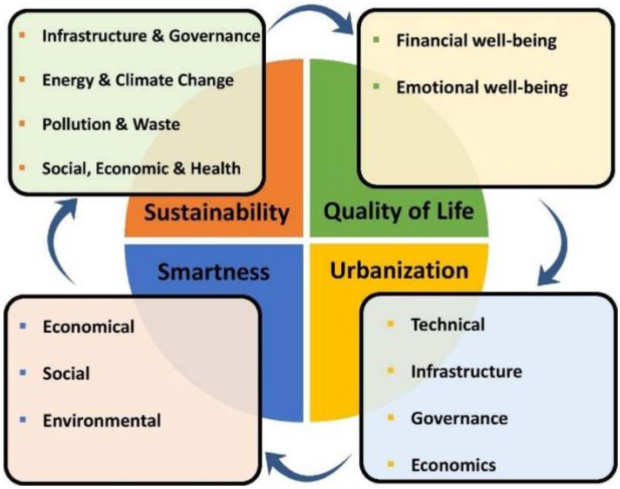

Figure 3. Indicators of a Smart City

The natural resources of the cities of the contemporary world are progressively being put to use in the development of these cities. As a result, it is very necessary to investigate the implications of their being a shortage of non-renewable energy sources. As a consequence of this, protecting natural heritages and energy sources has become an imperative need for ensuring the continued viability of smart cities (De Jong et al., 2015).

In the past, the ultimate objective of projected smart cities was to achieve an enhancement in quality of life. The implementation of new solutions, which result in fewer restrictions on social learning and obstacles to social involvement, leads to an enhancement in the quality of life enjoyed by residents. In addition, contemporary city governments implement clearly defined social programmes in order to acknowledge the accomplishments of their inhabitants and to provide employment opportunities. As a result, the quality of the city's supply of services is improved, and the quality of life and financial situation of competent personnel is also improved. At the end of the day, quality of life enforcement is satisfied by the financial and emotional well-being of both workers and residents. There have been efforts undertaken in a variety of cities to boost the quality of life. For instance, the city of Yokohama in Japan has established an artists' circle in an effort to enhance social values (Sasaki, 2010). The purpose of the circle is to bring together artists and conduct exhibits, seminars, and performances. Additionally, in Chicago, healthcare service campaigns have been developed in order to develop the services that are provided to inhabitants of the city who are underprivileged (Oakley and Tsao, 2007).

The contemporary world views cities that are on the cutting edge of technological development as the urban utopias of the future (Datta, 2015). According to some experts, the problems that arise as a direct result of fast urbanisation require the most comprehensive solution, which they believe to be the concept of the smart city. Some of the most major challenges produced by urbanisation include the crisis in waste management, the snarlup in traffic, the contamination of the air, the bad impacts on human health, the lack of resources, and the deterioration of infrastructure (Borja, 2007, Washburn et al., 2009, Toppeta, 2010). In order to provide effective management, urbanisation is split into two distinct groups, namely, urbanisation that was brought about by industrialization and urbanisation that was brought about by entrepreneurialism. The quickening of the pace of economic development and the link that exists between the formulation of policy and its implementation are the primary motivating factors behind the urbanisation of entrepreneurial activity. As a direct result of rapid improvements in technology, the conventional concept of urbanisation has been superseded with a more nuanced approach. Several pieces of study were conducted with the goal of gaining a deeper comprehension of the connection that exists between urbanisation and the growth of smart cities. The concepts of smart cities and urban development have been analysed in Yigitcanlar et al. (2008). These concepts include culture, science and technology, urban policy, social and economic development.

The expansion of the city of Melbourne, which is found in Australia, was the primary focus of their efforts. In the same spirit, the authors of Caragliu et al. (2011) explored the relationship between urbanisation and smart cities by focusing on research carried out in Europe's smart cities. In their investigation, they found that urbanisation had a positive effect on smart city development. The authors found that there are a number of factors that have a positive impact on urban wealth. These factors include a focus on the urban environment, a high level of education, easy access to information and communication technology (ICT), and the use in public administration. The concept of a smart city, which revolves on the positive attributes stated earlier, is claimed by specialists to require urbanisation as one of its primary components in order to be successful.

The term “smart city” refers to a set of actions that are carried out with the goal of improving the economic, social, and environmental well-being of urban populations. Caragliu et al. (2011) looked at the degree to which factors such as human capital, the length of public transport networks, e-government, per capita gross domestic product, and employment in the entertainment industry were partially correlated with one another. This was done so that they could determine the level of intelligence of smart cities in Europe (Caragliu et al., 2011). Over the course of the past twenty years, academics have been undertaking studies to examine the link between advanced technological infrastructure and increased economic growth (Roller and Waverman, 2001). These experiments were carried out without making any reference to the preconceived concepts of intelligence that had been formed. In order to gain knowledge of the grade to which a city is smart in relation to the smart city initiatives framework, Alawadhi et al. (2012) conducted a case study that included four cities in North America. This study was carried out so that the researchers could gather data.

13. The priciples of a smart city

The four pillars or themes that make up a smart city are known as the institutional infrastructure, physical infrastructure, social infrastructure, and economic infrastructure (Mohanty et al., 2016). The European Union (EU) decided to go with a tried-and-true method that consists of six pillars, which is quite similar to the four pillars that were discussed before (Giffinger and Gudrun, 2010). The four pillars that make up the basis of a smart city are shown in Figure 4.

In the background of smart cities, governance falls within the purview of the institutional infrastructure. It is connected to taking part in the making of decisions, providing public and social services, promoting transparent government, and developing political tactics and viewpoints (The Government Summit, 2015). The administration of a city was made a great deal less difficult by giving political viewpoints the careful and attentive treatment they deserved. The growth of a smart city relies on making the most of its human resources in order to accomplish the best possible results. The involvement of citizens and the collaborative effort with them have a significant beneficial influence on the use of human capital.

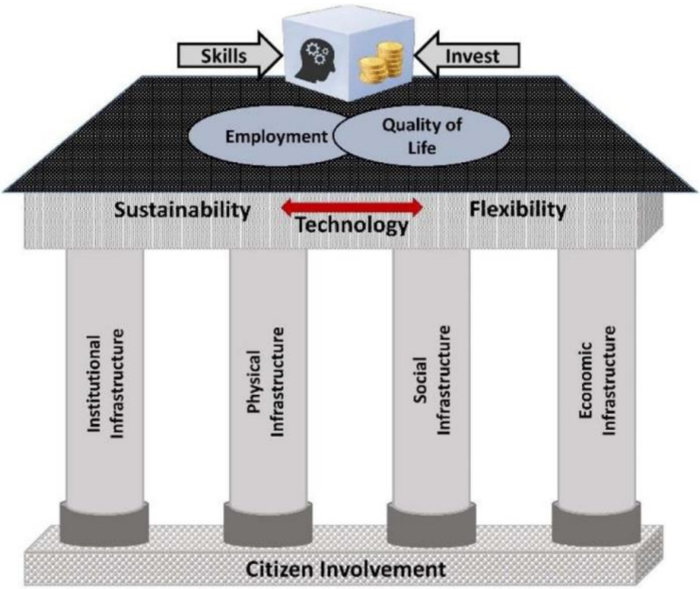

Figure 4. Principles of smart city

The function of the government in coordinating between its constituents and administrative entities is one that deserves special recognition. To ensure that the benefits of living in a smart city are fully realised, the institutional infrastructure communicates with both local and central administrations. When it is essential, a smart city's institutional architecture connects public, commercial, civic, and national institutions to ensure interoperability across services. In point of fact, the consolidation of various administrative organisations results in improved dependability, efficiency, and effectiveness in service to the populace. Another essential component of institutional infrastructure is the technocratic governance, which operates on the assumption that all aspects and services of the city may be improved via the use of technological solutions (Kitchin, 2014). Therefore, using the computational capabilities of the smart city, which conforms to instrumental rationality and solutionism, complicated social problems may be optimised (Mattern, 2013*,* Morozov, 2013).

The physical infrastructure is comprised, in its whole, not just of naturally occurring resources but also of those that were artificially produced. The city's ability to continue operations in the present and the future with resources that are sustainable is supported by the infrastructure pillar that focuses on the city's physical layout (Mohanty et al., 2016). The eminence of a city's technology for information and communication infrastructure has a direct bearing on how well it can perform the functions associated with being a smart urban ecosystem (The Government Summit, 2015). The relevance of the quality and accessibility of modern computer networks is comparable to that of the information and communications technology (ICT) infrastructure when it comes to the creation of smart cities.

In addition to this, the physical infrastructure is being expanded to incorporate environmentally friendly urban design, smart energy, the repair of existing structures and services, and sustainable infrastructure (The Government Summit, 2015). Many individuals consider that smart cities are the result to the problem of a shortage of natural resources. This belief is based on the numerous benefits that smart cities offer. As a direct concern of this, the majority of smart city advantages centre on the preservation of the natural resources of the city, such as its waterways, parks, and sewage systems (Vasseur and Dunkels, 2010). A smart city is one that takes use of skill to better administration, thereby enhancing the sustainability of natural resources at the same time.

The social infrastructure of a smart city is comprised of three distinct aspects: anthropological capital, intellectual capital, and quality of life. The degree of expertise, accountability, and commitment possessed by city citizens is an essential component in determining whether or not the thought of a smart city will be realised. As a result of this, social infrastructure has evolved into a component that is absolutely important for the growth and maintenance of a smart city. Even if smart cities are extraordinarily well organised, make use of cutting-edge technology, and are provided with cutting-edge equipment, the long-term success of smart cities cannot be guaranteed until societal awareness is first established. We are in a position to argue that social infrastructure has a substantial influence on the quality of life of urban residents since the use of information and communications technology (ICT) to improve the living standards of citizens falls under the purview of the social infrastructure pillar. Due to the fact that the social infrastructure pillar concentrates on people and the connections that they have with one another, it has come to be seen as an essential component for any and all smart cities (Nam and Pardo, 2011).

A conservative/conventional city, on the other hand, is not designed to support humans in making the most of their potential so that they can live lives that are satisfying. This is what differentiates a smart city from a conventional city. As a consequence of this, residents who are well-informed and have achieved a higher degree of education have a propensity to cluster in and around smart cities, which, on the other hand, encourage the growth of the city (Glaeser and Berry, 2006). For this reason, knowledge-based urban development is seen as a crucial component of the modern smart cities (Yigitcanlar et al., 2008). The authorities in the commercial world and the academic world have come to the conclusion that social infrastructure is an essential component of any smart city.

This is because of the incalculable relevance of social infrastructure.

The amount of research that is currently available provides a variety of distinct definitions for the economic infrastructure of smart cities. According to Kondepudi et al. (2014) and Mohanty et al. (2016), the definition of a smart economy is continuous and consistent economic development, as well as employment growth, which thrives in a smart city. Smart cities are cities that have a high concentration of technologically advanced businesses and residents. According to what was discussed at The Government Summit, the Smart Economy is an idea that extends beyond the parameters of the micro economy as well as the macro economy (Ferrara, 2015).

The term "smart economy" relates to the application of the most productive methods and applications of e-commerce and e- business in order to enhance the level of total output within a city. This can be accomplished by increasing the number of people working in the city. In addition, a smart economy is comprised of recent breakthroughs in information and communications technology, the manufacturing of goods and the supply of services that are related to ICT, and the incorporation of new technologies that boost the reliability and performance of economic management.

Lombardi and his colleagues conducted an analysis of the economic infrastructure of a smart city using an improved version of the triple helix model in addition to other performance measurements (Lombardi et al., 2012). Some of the important indicators that are used to measure the economic infrastructure of a smart city include the level of employment in a variety of businesses, the public research and development expenditures, the gross domestic product per head of city population, the gross inland energy consumption index, and the percentage of projects sponsored by civil society. The gross inland energy consumption index is yet another significant indication.

14. The elements of a smart city Y

A smart city is made up of a variety of different parts, some of which are illustrated in Figure 5. Some of these essential components include a “smart neighbourhood,” “smart energy,” “smart transportation,” and “smart healthcare.”

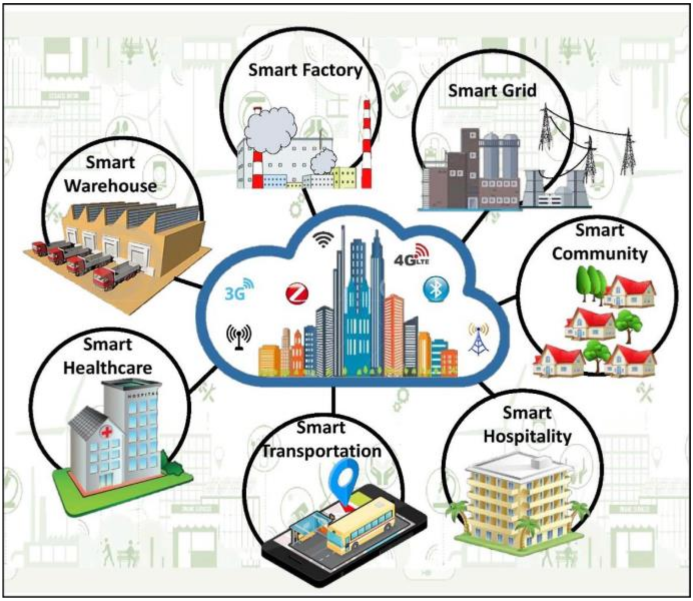

Figure 5. The basic constituents that make up the architecture of a smart city

Nonetheless, the make-up of a smart city differs from another with respect to the fields of study that are prioritised. One smart city, for instance, would think about integrating a disaster response system into the constructed environment, while another smart city might intend to incorporate a trash management system. In the next sub sections, we will talk about a few aspects that are present in the large majority of smart buildings.

14.1. Smart community

The goal of a smart community is to recover the health and happiness of urban residents, as well as the satisfaction of the residents. In this sense, the term “smart community” refers to the convergence of a significant number of water management systems, green buildings, and waste management systems. The term "smart buildings" may refer to both residential properties and various types of commercial infrastructure, such as offices, schools, data centres, factories, warehouses, and so on. According to what is said in Section 3, isolated components are unable to do very much in terms of performance. As a result, different additional components of smart city are linked with smart communities in order to optimise the benefits of smart city.

The term “generic smart building” refers to any structure that is equipped with smart appliances, sensors, as well as specialised software and hardware. In terms of the managing of energy, smart buildings and environmentally friendly buildings have a same goal. In point of fact, green buildings are centred on minimising their impact on the environment by cutting down on their overall energy use (Eichholtz et al., 2010). In spite of this, the energy management of smart buildings follows a unique method to improve energy efficiency. This strategy involves linking smart buildings to smart grids and natural energy plants via an already existing network. The capacity of smart buildings to make decisions based on data helps to enhance energy efficiency and decrease operating costs. This is perhaps the most essential benefit of smart buildings. Nevertheless, there is more to intelligent buildings than just improved energy efficiency. A further connection is made with other components of the smart building in order to handle security, observation, lighting control, automated processes, and so on.

In addition to this, the exploitation of the information gained through the use of the existing networks enables the smart buildings to improve the quality of the services that are provided to the habitat. Because of these advantages, the incorporation of smart buildings into a smart community has a noteworthy impact on the operations of a smart city. Smart homes, smart offices, smart warehouses, and other types of smart buildings all carry out their duties in an effective and precise way in order to provide inhabitants with high-quality services. One example of how a smart house might improve inhabitants' quality of life is by allowing them more control over their lights, home appliances, and other aspects such as security and energy usage (Khan et al., 2016, 2017a,b).

The productivity of supply chain management is increased by intelligent warehouses, which is to the benefit of the many stakeholders in the community. In addition, the contemporary world considers environmentally responsible waste management to be an essential component of any smart community. Because of the prompt pace of urbanisation and industrialization, the amount of waste that is produced is rising at an exponential rate. Waste created by individuals, public municipal services, and private offices may be managed more efficiently thanks to intelligent waste management (Neirotti et al., 2014). The process of managing trash is broken down into four main stages: collecting garbage, disposing of it, recycling it, and recovering it. The proper management of trash disposal is essential to the long-term viability of smart cities since improper garbage disposal creates a challenge for both human health and the surroundings (Rathi, 2006, Sharholy et al., 2008).

14.2 Smart transportation

Since the birth of civilization, humans have had an inherent need for a means of transportation. This requirement now applies to all modes of transportation, including road, river, rail, and air transportation, as a result of advances in technology. The many conventional modes of transportation across the globe were not linked to one another or to any others. On the other hand, the idea of linking commonplace things has transformed traditional transportation networks into networked contemporary transportation networks. This has caused a revolution in the field of transportation.

As a direct consequence of this development, contemporary modes of transportation are outfitted with a wide variety of communication systems and navigation systems. As a result, every particle of a given transport type is associated with and linked to its neighbours. Extending the networks within the same medium, various transport media are interconnected with one other to provide a worldwide transportation system. The idea of intelligent transportation systems brought a great deal of attention to the field of vehicular ad hoc networks (VANET) (Naumov et al., 2006). In recent years, VANETs have become more popular as a tool for the management of traffic congestion in city suburbs via the use of vehicle-to-vehicle communication. Capacity of vehicle-to-vehicle communication as well as vehicle-to-infrastructure communication, because of advancements in communication in real time, modern transportation systems are now able to react effectively in response to real-time information. In addition, passengers are provided with information on the amount of congestion on the streets, alternate routes, alternative transit mediums, and so on by the intelligent transportation systems. In addition, smart transportation systems include safety and security measures for both travellers and pedestrians, which simultaneously improves the systems' overall performance. According to what has been discussed, current systems consist of global airline hubs, sophisticated road networks, interstate rail networks, subway as well as metro train connections, safety integrated public transportation, protected cycle paths, and guarded pedestrians pathways (Mohanty et al., 2016). In a nutshell, the incorporation of intelligent transportation systems into smart cities leads to an increase in the operational efficacy of the cities, as well as an optimization of the amount of time, money, dependability, and safety associated with urban transportation.

Hwang and Seah (2008) put forth the idea of an encounter detection algorithm for the next generation of air transportation, which would allow for the prediction and prevention of air traffic accidents through the sharing of data between aircraft. In addition to enhancing timeliness and reducing fuel consumption, the rail traffic management system that Mazzarello along with Ottaviani have devised also helps to avoid collisions by providing real-time instructions on acceptable speeds (Mazzarello and Ottaviani, 2007). In addition, innovative uses for transportation include the collecting of tolls using RFID technology, the administration of parking lots, and the inspection of passengers' passports at airports, and the hiring of taxis and monitoring of those taxis using mobile apps. The integration of these new dimensions into transportation networks not only improves the quality of life of city residents but also helps to ensure the city's continued viability.

14.3 Smart healthcare

14.3.1 Intelligent medical treatment

The exponential growth rate of the world's population presents a great deal of difficulty for current healthcare systems. Because of this, traditional medical procedures are unable to come across the needs of the world’s population in terms of medical treatment, and as a consequence, they have become outmoded and invalid. The situation continues to deteriorate as the

It is not the case that the number of medical specialists in the healthcare sector cultivates in direct proportion to the total population. As a result, there is a greater possibility that the incorrect prescription will be prescribed, that the patient will get an inaccurate diagnosis, and that there will be a misunderstanding of contagious and epidemic illnesses. The disparity between the ideal and the actual state of healthcare is made worse by the scarcity of resources and the excessive demand for the service. In order to close the gap that exists among the demand for healthcare and the provision of it, intelligent healthcare systems were developed as a solution. These systems preserve efficiency, accuracy, and sustainability.

The term “smart healthcare” refers to the confluence of traditional medical practises with more sophisticated medical intervention procedures, such as the use of medical equipment, sensors, wearable devices, alternative services, and information and communication technology. Modern intelligent healthcare services make use of sensor networks, information and communication technologies, cloud figuring, fog figuring, smart phone applications, and highly effective data processing mechanisms in order to meet the needs of patients and improve the overall quality of care (Roy et al., 2007, Demirkan, 2013, Catarinucci et al., 2015, Stantchev et al., 2015). Sensitive patient data is made available by smart healthcare services to authorised users, such as physicians, nurses, and laboratory specialists, across a protected hospital system network in order to allow better patient care. The use of controlled electronic health records (EHR) enables decisions to be made in real time based on the most recent information.

Catarinucci et al. (2015) came up with the idea for a healthcare system that is aware of the Internet of Things and can automatically monitor and track patients, medical practitioners, and biomedical gadgets. The suggested intelligent hospital environment makes use of RFID, and smart mobile skills, all of which are linked to one another by means of CoAP. Demirkan (2013) presented an additional smart healthcare framework, which conceptualised a data-driven mobile system and cloud-supported smart healthcare systems. This smart healthcare system was offered by Demirkan (2013). Roy et al. (2007) suggested a context-aware data fusion smart healthcare system in order to address ambiguity in a variety of settings and came up with the novel idea of context-aware mobile health. An increase in the quality of life of urban residents is likely associated with the improvement of healthcare services. As a result, the incorporation of intelligent healthcare systems into smart cities is anticipated to represent a significant step forward in the execution of the smart city idea on a worldwide scale.

14.3.2 Smart energy

Energy is a component that is required in order to carry out any kind of activity. Both renewable and non-renewable energy sources may be included in a highly diversified energy collection. Because of the nature of regeneration, renewable sources such as solar, wind, and geo-thermal energy do not decline with use. This is in contrast to non-renewable sources such as fossil fuels. For the better part of the last few decades, industry professionals have been advocating for the concepts of smart energy, green energy, and sustainable energy (Lund, 2014, Midilli et al., 2006, Chu and Majumdar, 2012) in an effort to raise awareness and publicise the most effective methods for energy consumption. Consuming green energy should have as little of an effect as possible on the natural environment. The preservation of non-renewable energy sources for use by both the present generation and future generations is the most important objective of sustainable energy practises. The notion of smart energy is more appealing than others since it advocates an all-encompassing strategy that integrates green energy, sustainable energy, and renewable energy. To sum up, the goal of smart energy is to meet energy needs by combining renewable energy sources in order to preserve the sustainability of non-renewable energy sources, while at the same time avoiding negative effects on the environment, such as lowering carbon footprints. As was said earlier, the fact that renewable energy sources can continuously produce fresh energy makes them ideal candidates for satisfying the requirements of the global energy market (Herzog et al., 2001). Over the last several years, in tandem with the growing need for energy, there has been a surge in interest in various forms of renewable energy.

As a direct consequence of this, a great number of research have been carried out to incorporate renewable energy sources into intelligent buildings. In certain instances, renewable energy plants are connected with smart grids, while in other instances, renewable energy sources are affixed to smart buildings. Han et al. (2014) suggested an energy management system for a microgrid that integrates improved photo voltaic (PV) generators and storage units. A design very much like this one, which makes use of solar energy and wind energy. In their paper, Boynuegri et al. (2013) suggested an algorithm for residential energy management that takes into account the degree of consumer satisfaction while simultaneously introducing renewable energy sources. In order to accomplish effective energy management in smart settings, a number of studies have been carried out in addition to the incorporation of alternative and renewable forms of energy. Home energy management systems that are based on power line communication (PLC) were suggested by Sharma and Saini (2017). In order to maximise efficiency in terms of power usage and to make intelligent appliance control more accessible Son et al., (2010) and Pipattanasomporn et al. (2012) suggested a demand-based response analysis along intellectual algorithm to control high-energy-demanding home appliances. This algorithm is based on the home energy management systems.

In point of fact, there are several suggestions for new energy management systems. For domestic settings, since it has a significant impact on the amount of power that is used overall. Domestic energy demand is expected to increase by up to 24 percent over the next few decades, according to forecasted energy reports (Erol-Kantarci and Mouftah, 2011). As a result, handling energy consumption at the base level appears to be capable in extending energy management at the city level with sustainability. Researchers have broadened their study to include the management of smart grids in order to increase energy use overall. A method to the scheduling of energy consumption that is based on game theory was proposed in Mohsenian-Rad et al. (2010). The entire energy demand, as well as the total cost of energy and the cost of daily power consumption per person, were all effectively decreased as a result of this technique. Erol-Kantarci and Mouftah (2011) looked at a situation quite similar to this one in order to achieve an efficient demand-supply balance, cut down on energy expenditures, and cut down on carbon emissions. Utilization of energy is increased to its maximum potential when HEM is combined with grid energy management.

14.3.3 Integration and inter-operation

The concept of a smart city can only be brought to life via the successful combination and coordination of the aforementioned elements. Improvements in performance, efficiency, quality of service, and intellectual decision-making may result from interactions between the system's many components. One scenario for a smart house that is included in a smart community, for instance, interacts with smart grid and renewable energy plants in order to maximise the use of energy by the smart home. In a similar vein, smart grids collaborate with smart buildings to handle demand response and real-time pricing. As a direct consequence of this, there is no wasteful use of energy in smart buildings located inside smart cities. After this tactic has been used in every intelligent structure, the phenomena of energy saving will have spread to the levels of the community, the city, the region, and finally the world.

Integration of several smart components, on the other hand, is not a simple operation; to put it another way, integration may be the most difficult effort involved in the deployment of a smart city in the actual world. Each component is made up of an uncountable number of different kinds of electronics and sensors. A significant amount of device heterogeneity leads to a significant amount of platform incompatibility, which impedes both integration and intercommunication within and among the many components of smart cities. Consequently, one of the primary concerns of integrating the components of a smart city is finding solutions to the problems that are caused by incompatibilities. A web of things based smart city design has been suggested by Khan et al. (2017b) in order to improve the integration of smart city components.

15. Challenges for smart cities

Challenges to the practicability of putting smart cities into action can be found at every level of the smart city development process, including planning, construction, and operation. The vast amount of data that needs to be collected and analysed, the variety of the devices, the cost of designing and operating them, the lack of information security, and the lack of sustainability are some of the most major issues. Figure 6 depicts a few of the primary considerations that should be addressed while designing a realistic smart city. One of the most significant problems for the practical placement of smart cities is the expenditure of design and maintenance. The cost may be broken down into the design cost and the operations cost. The cost of the design is the financial capital that is needed to implement the smart city. Therefore, a greater chance of execution in the actual world corresponds to a lower overall cost of the design. The day-to-day operations and upkeep of the city both result in expense to the city's operations. The requirement for low operating expenses is considerable in order to guarantee the long-term viability of service supply without placing an additional monetary strain on the local government. Nevertheless, optimising costs throughout the lifespan of a smart city is still a challenge that presents a significant amount of difficulty. Another important consideration for the architectures of smart cities is heterogeneity.

Smart cities consist of efficient sensors, appliances, gadgets, etc. The ability to combine all of these disparate components at the application level is essential to the effective implementation of the smart city concept. On the other hand, application layer integration and interoperability are made more difficult by the variety of platforms that exist. Although supporting universal access is a work that is time-consuming and challenging, smart cities are focused on building, identifying, and procuring hardware and software that permits the aggregation of these diverse subsystems. This is done in order to make universal access possible. This is because facilitating widespread access is one of the most chief goals of smart cities. Infrastructure security and information security are both heavily enforced in smart cities, despite the fact that high levels of security come with additional costs associated with design and maintenance. Changes of a revolutionary nature are brought about by advances in technology in major cities all over the world.

Figure 6. Common challenges for practical implementation of smart cities

The citizens, tourists, and companies of cities have all benefited from the adaptation of technology. Despite this, there has been a lot of debate over how to protect smart cities and their operations from any potential hazards that may arise as a result of the concurrent expansion of technology and hostile threats. An assault on a city management system (CMS) that is responsible for coordinating a vast number of tasks offers a broad variety of opportunities to result in negative impacts. For instance, a gas pipeline explosion took place in Johnson County, Texas, in June of 2010, as a result of confusions regarding the position of the pipeline and the construction progress statements made on the CMS. A similar assault on the control system of an Illinois water company in 2011 resulted in the destruction of a water pump and the cessation of water service to 2,200 homes. Because of this, the protection of information and the protection of infrastructure are of the utmost importance.

16. Conculsion

The Internet of Things gave rise to the idea of smart cities as a potential application area. In comparison to other concepts that make use of technology for information and communication in urban environments, such as “digital city,” “green city,” “sustainable city,” “intelligent city,” and so on, the word “smart city” stands out due to its holistic approach. Other concepts that fall into this category include “sustainable city,” “green city,” and “sustainable city.” To phrase it another way, “smart cities” might be conceived of as an amalgamation of several types of environment management systems in urban ecosystems.

In this study, the definitions, norms, and consequences of the principles related to constitution of a smart city are discussed. A straightforward explanation of the smart city perception is provided, after which the qualities and attributes of a smart city are outlined. After conducting an in-depth comparison of the many suggested designs for a smart city, we will now go on to discussing the more technical specifics of a smart city's generic architecture. A smart city is a system that improves the quality of life of urban residents by facilitating interoperability across a variety of different subsystems. Therefore, in order to recognise the significance of the composition, the primary components that go into the construction of a smart city are detailed in detail. According to the findings of the literature review, the development of a smart city is largely reliant on the rapid processing of data, the ubiquitous availability of information, and the interoperability of various devices regardless of platform. At the conclusion of the article, some of the most recent data are shown with some real-world examples of how smart cities have been implemented. Despite the fact that "smart cities" has developed a catchphrase in the contemporary domain, the concept still confronts a number of significant hurdles and problems. These problems are caused by the enormous amount of data processing that is required as well as the diversity of linked smart objects. We mentioned some difficulties that were found as well as some potential for making changes in order to broaden the scope of the existing body of knowledge and to provide direction for further investigation.

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