Smart Cities: Innovative Solution to Rapid Urbanization Challenges
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Currently, about 50% of the world's population live in urban areas and some experts predict that this will increase to 70% by 2050. Studies show that although cities occupy less than 2% of the landmass of the earth, urban residents consume over three quarters of the world's natural resources and are primarily responsible for green-house gas emission. Smart cities are becoming an innovative way of helping to address the challenges of population growth, such as traffic congestion, aging infrastructure, environmental pollution, etc.

In simple terms, a smart city is a city that leverages information and communication technologies (ICT) to improve its operations and quality of life for the benefit of its citizens by making its services more flexible, efficient, and sustainable, while remaining economically competitive. In general, a smart city is made possible by advances in technology that enable real time monitoring of desired metrics and data analytics for quick response and effective city management. These technological advances enable efficient operations of smart city components, such as smart infrastructure, smart building, smart transportation, smart energy, smart healthcare, smart technology, smart government, and smart citizen.

Technological Backbone of a Smart City
For a smart city to operate successfully, it needs smart infrastructural backbone, of which ICT infrastructure is paramount. ICT infrastructure includes communication infrastructure, such as fiber optics and Wi-Fi networks, as well as service-oriented information systems. These form the backend of a smart city and make other infrastructures, such as rapid transit systems, power supply systems, water supply systems, waste management systems, hospital systems, and buildings smart. The smart infrastructure may have physical infrastructure, sensors, firmware, software, and middleware as its overall components. The middleware is a type of software that plays a crucial role in automation and quick response of smart infrastructure by accumulating data and combining them into a common platform for analytics, reporting, efficient city

SMART CITY COMPONENTS

decision-making, and service delivery. The Internet of Things (IoT)—a network of interconnected physical objects (called "things"), including computers, smart phones, sensors, actuators, wearable devices, homes, building structures, vehicles, and energy systems—is a key technical backbone of smart cities because devices in the IoT objects transmit the data accumulated by the middleware for analytics to help realize the benefits of smart city operations.
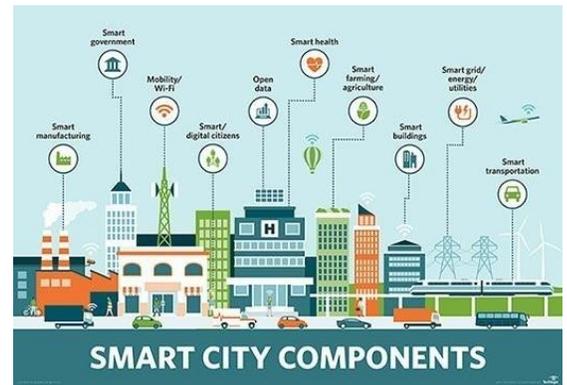
Selected Benefits of Being a Smart City
Being smart has several benefits for a city:

Economic Development: Deployment of smart technologies does not only improve effectiveness and efficiency of services, but it also brings new "eco-friendly" jobs. Investments in smart city technology in North America are expected to increase from $118.5 billion in 2016 to $244.5 billion in 2021, **according to BCC Research**. A recent **report by ABI Research** predicts the positive impacts of smart city technologies on economic development could see cities locking in incremental growth of over 5% and driving more than $20 trillion in additional economic benefits in the coming decades. According to the report, public investments in smart city technologies could have multiplier effects of up to 10 times, with a potential incremental GDP growth of $10 trillion. Additionally, smart city technologies will lead to Structural Smart Urban Economic growth, with an expected increase of 2.8% by 2026.

Evidenced Based Decision-Making: As stated above, the data analytics made possible by middleware enables city officials to gain access to useful information for real-time monitoring and effective decision-making to enhance the lives of city residents.

More Efficient Transportation Services: Smart transportation technologies can lead to road safety, traffic and parking management, traffic flow optimization, and offer riders the ability to track bus and train locations and schedules. Under a partnership between the US Department of Transportation and the Tampa Hillsborough County Expressway Authority, the City of Tampa has piloted a deployment of **Connected Vehicles** that allows vehicles, roadside infrastructure, and mobile devices to communicate with each other to provide improved safety and mobility solutions enabled by connectivity. The city of Chicago made the city's public transportation system easier for residents by launching a mobile application that enables citizens to track vehicles in real-time, view updated bus and train schedules. and make payments online.

Improved and Cost-Effective Public Utility Services: Smart sensor technologies are increasingly changing the way public utilities and infrastructure are managed to reduce costs and enhance safety. Data analytics and smart sensor technologies have enabled the conservation of valuable resources to help meet human demand by reducing inadvertent waste of water and electricity. For example, smart sensors allow city utility personnel to quickly identify leakages in pipes and address them to reduce waste. Smart electric grid allows for two-way communication between electricity providers and consumers about peak usage and outages to help consumers track their usage and make modifications to save costs. A pilot smart metering technology in the city of Cape Town, South Africa tracked customers' water usage, relayed that data to their accounts, and sent itemized daily bills to the customers. This resulted in about a 50% drop in residential homes water consumption and savings for customers.

Safer and Better Infrastructure: Smart technologies can help cities have huge savings by upgrading and maintaining aging infrastructure such as bridges, roads, and buildings through predictive analytics that identify areas that need attention and remediation to avoid infrastructure failure. This is made possible by smart sensors that transmit data on structural defects, such as cracks in bridges, to help notify appropriate city personnel to address the problem.

Selected Challenges of Developing Smart Cities
Despite the benefits, there are also challenges that affect smart city development and the evolution of the smart city market. Studies show that although some new government initiatives have resulted in increased smart city activity in recent years, the global smart city market is still at an early stage and most smart city projects are either trails or cover only parts of the city. A recent smart cities survey **report released by the US Conference of Mayors** suggests that although there is strong support from government leadership at the local, regional, and national levels, securing financial support for long-term projects remain a challenge. The report reveals that the two key challenges faced by cities are: ensuring the city will have the financial resources to sustain the smart city project over time, and securing sufficient funds to start the project. Other challenges identified include aligning multiple city departments and stakeholders, overcoming citizen and business concerns over privacy and data sharing, finding appropriate ICT solutions, and developing necessary relationships with appropriate private sector solution providers. Studies conducted in other parts of the world also identify poor public-private participation, high IT infrastructure and intelligence deficit, and lack of citizen involvement as some of the barriers to smart city development. Effective smart city development calls for measures to overcome these challenges.

Overcoming the Challenges to Smart City Development
To address the funding challenges, cities need to consider public-private partnerships and develop long-term funding opportunities for their smart city projects. Some of the existing business models that must be considered in this regard are the Build-Operate-Transfer (BOT), Build-Operate-Comply (BOC), and Municipal-Owned-Deployment (MOD). Under the BOT model, city authorities work with a private sector partner who funds and develop the services, deploys the smart city infrastructure, and operates it until it is transferred back to the municipality. Under the BOC model, the municipal authorities provide the initial source of funding as well as a platform for smart city development to enable the third party to develop the services and deploy the infrastructure, while complying with stipulated regulations. Under the MOD model, the municipality develops the services and deploys the smart city infrastructure to achieve the city's intended goals. Cities also need to implement project management methodologies that include appropriate communication and stakeholder consultation strategies to bring interested parties on board, and to deploy up-to-date privacy and cyber security solutions to address citizens and business concerns. Finally, in order to realize the potential of smart cities as innovative means of resolving urban challenges, cities need to engage experts to examine their unique circumstances, and their IT infrastructure needs to ensure appropriate investments are made to help form the backbone of the smart city development.