

## Circular Economy Inspires the Design of Smart Cities Towards Contributing to SDG-11 Sustainable Cities & Communities

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### Abstract:

This paper focuses on the issue of the circular economy in the context of SDG-11 Sustainable Cities & Communities as one of the main goals of today's society. Introducing smart cities, considering the sustainability challenges that cities will face shortly and the recent technological developments that will enable them to become "smart". Under the general context of sustainable development, the circular economy is becoming an important part of providing resources to future generations, based on intra-generational and inter-generational solidarity. A smart city can be understood as a sustainable city, a city that performs well economically, administratively, environmentally, and housing-wise. This paper aims to identify some important measures that are recommended to advance this vision. It also aims to highlight the potential social and economic benefits and challenges of urban circular development; it also supplies initial evidence of the synergistic benefits created through combining the design and economic development and linking the two approaches together rather than applying them separately.

### Keywords:

Circular Economy, Smart Cities, SDG-11 Sustainable Cities & Communities

### الملخص:

تركز هذه الورقة البحثية على موضوع الاقتصاد الدائري في سياق أهداف التنمية المستدامة-١١ المدن والمجتمعات المستدامة كأحد الأهداف الرئيسية لمجتمع اليوم. التعريف بالمدن الذكية، مع مراعاة تحديات الاستدامة التي ستواجهها المدن قريباً والتطورات التكنولوجية الحديثة التي ستمكنها من أن تصبح "ذكية". في ظل السياق العام للتنمية المستدامة، أصبح الاقتصاد الدائري جزءاً مهماً من توفير الموارد للأجيال القادمة، على أساس التضامن بين الأجيال وبين الأجيال. يمكن فهم المدينة الذكية على أنها مدينة مستدامة، مدينة تؤدي أداءً جيداً اقتصادياً، وإدارياً، وبيئياً، وسكنياً. تهدف هذه الورقة إلى تحديد بعض الإجراءات المهمة التي يوصى بها لتعزيز هذه الرؤية. كما يهدف إلى تسليط الضوء على الفوائد الاجتماعية والاقتصادية المحتملة وتحديات التنمية الدائرية الحضرية؛ كما أنه توفر دليلاً أولياً على الفوائد المتأخرة التي تم إنشاؤها من خلال الجمع بين التصميم والتنمية الاقتصادية وربط النهجين معاً بدلاً من تطبيقهما بشكل منفصل.

تقلل المدن الذكية من التكاليف عن طريق تقليل استهلاك الموارد والطاقة اللذين لهما أهمية لتلبية احتياجات تقديم الخدمات الحضرية. يمكن أن يؤدي نهج الاقتصاد الدائري إلى زيادة كبيرة في عدد المدن والمستوطنات البشرية التي سيتم تبنيها وتنفيذها وتطويرها وتطبيق استراتيجيات وخطط متكاملة للإدماج، وكفاءة الموارد، وتخفيف آثار تغير المناخ والتكيف، والقدرة على

الصمود. من الدراسات الواضحة، يمكن للمرء أن يدرك أن المدن الذكية تقلل الانبعاثات وتوفير الطاقة، من خلال الأتمتة وإدارة النفايات والأنظمة التي تعمل على تحسين الصحة العامة والبيئة. باختصار، يغطي موضوع البحث هذا منظور متنوع للهدف - الذي يهدف إلى جعل المدن والمستوطنات البشرية شاملة، آمنة ومرنة ومستدامة، حيث يتميز نموذج الاقتصاد الدائري بميزتين رئيسيتين تؤكد الأولى على أهمية وجود دورة حياة المواد والثانية أن نماذج أعمال الاقتصاد الدائري تغلق الحلقات وهذا يشمل تلبية الاحتياجات دون امتلاك منتج، وتوسيع قيمة المنتج، والتصميم منتجات طويلة العمر على مستوى المستخدم النهائي حيث يساعد ذلك في توسيع قيمة المورد والكفاءة الصناعية.

### الكلمات الدالة:

الاقتصاد الدائري، تصميم المدن الذكية، أهداف التنمية المستدامة- ١١، المدن والمجتمعات المستدامة

## Introduction

For too long, humanity has taken a linear approach towards resource consumption, a major challenge for sustainability, where demand for products and services is increasing all over the time because of the increase in population, and the increase in the manufacturing process, which is causing many problems to the planet, and exhausting its resources and this include, air pollution, increasing levels of carbon dioxide (CO<sub>2</sub>) in the atmosphere, depletion of soil fertility and deforestation.1

A circular economy has to be implemented in cities, for some reasons, the main one is that industrialization and urbanization are deteriorating our planet and the environment, so we need to find a solution for that. Moreover, there are poor regulations and gaps already taking place due to the increased demand for energy, and the usage of resources, where governments of countries need to put some restrictions and limitations on that too.2

Changes in production methods and some aspects like education, regulations, and technology could be achieved if CE was seen as an overall development plan for the targeted cities. Adding to this, the application of CE will help in saving resources and will help in generating alternative energy sources. The circular economy can be applied to all sectors of the economy, where it is very successful in different countries and sectors, such as food industry, textile industry, chemical industry, and wastewater management.3

Working toward CE provides practical action and tools that aid the transition to the doughnut's macroeconomic vision. Most people think that a circular economy is mainly about recycling, but this is not true, recycling rates differ widely from developing to developed countries.4 But recycling has been the main solution proposed so far to close the loops in the current linear system of consumption.

But recycling only is not enough, because of two basic reasons, the first one is that household wastes are a very small part of all the waste generated from the process of consumption, whether it is generated from energy, chemicals, or transportation. The second reason is that wastes were not designed to be recycled from the beginning, where some of their components are toxic or cannot be separated easily.5

In this regard, the big picture of economics has to be changed from the self-contained market to the embedded economy. Human nature should be changing from the rational economic man to the socially adaptable human, that knows how to adapt to the givens of the world around him.

Knowing about systems from mechanical equilibrium, which focuses on the demand-supply equilibrium, to dynamic complexity, which considers the systems and feedback loops. Design to distribute, as in traditional economic models, there was a strong emphasis on growth, which would bring everything back to distributive by design, such as Kuznets curves. The new approach of creating to regenerate, from growth will clean it up again to regenerative by design. From growth addicted to growth agnostic, which means designing an economy that encourages human prosperity regardless of whether GDP is increasing, decreasing, or remaining constant.<sup>6</sup> To help in shifting cities to be more sustainable regarding production and the consumption patterns, a concept called Urban Metabolism (UM) was raised which offers a technique to identify and measure the flows of the city, which provides city planners as well as citizens, with information to make decisions that allow cities to be more livable. These flows include Flows in and Flow Out.

Flows include resources, such as metals, plastics, fuels, food, and water. While flows out, include manufactured products, it may include wastes in the solid, liquid, and gas forms. As resources flow through a city, they are processed, so that inhabitants can survive through the providence of clean water, food, heat, and power. One useful tool for measuring CE is the material metabolism of the cities and its per capita distribution across its resident population is the Input/output (I/O) accounting.<sup>7</sup>

The circular city results in an urban system that is regenerative, accessible, and plentiful by design. These cities aspire to eliminate waste, retain assets at their best worth at all times, and use digital technology to achieve these goals. Circular City must have a built environment, that reflects a modular and adaptable constructed environment that uses healthy materials to increase the occupants' quality of life while reducing the usage of virgin materials. Also, it must include an urban mobility system, that is mainly multimodal, electric-powered mainly dependent on renewable energy. An urban bioeconomy is another important factor that has to be found in the sustainable cities, that includes nutrients that are captured in organic fractions and are appropriately restored to the land while both creating value and reducing food waste, it may also generate organic fertilizers that can be used in urban and rural agricultural processes.

## SDG- 11

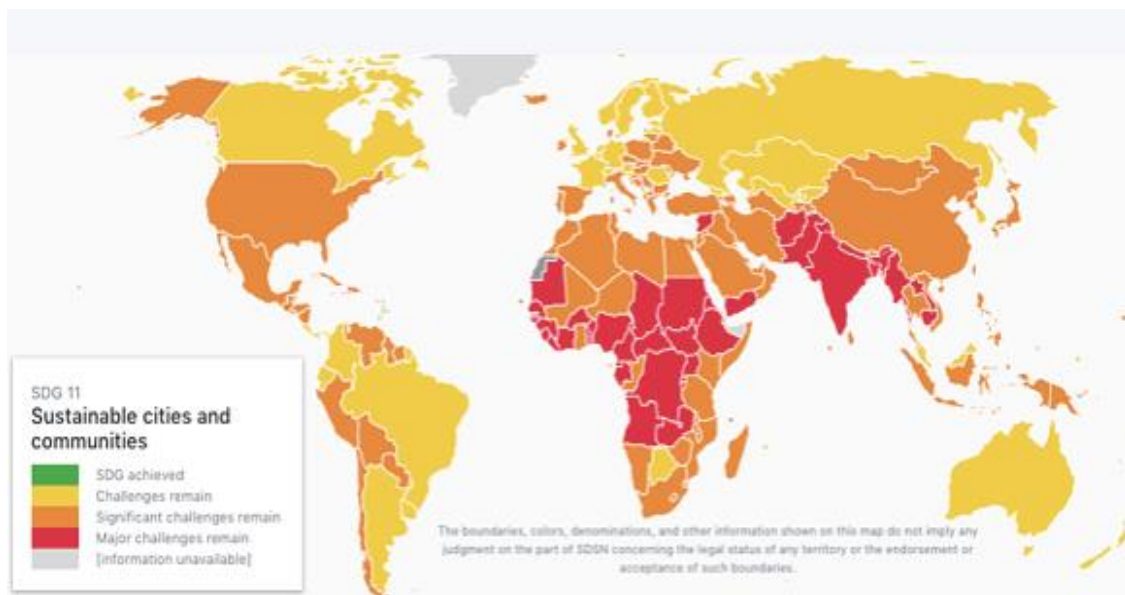
According to the UN, SDG 11 “aims to renew and plan cities and other human settlements in a way that offers opportunities for all, with access to basic services, energy, housing, transportation, and green public spaces, while reducing resource use and environmental impact”.<sup>8</sup>

According to Eurostat, this indicator can be divided into sub-indicators reflecting the progress of SDG-11, which include quality of life in cities and communities, sustainable mobility, and environmental impacts.<sup>9</sup> “Proportion of urban population living in slums”, informal settlements is vital to identify the fraction of the population living in slums, as rapid urbanization leads to a rise in informal settlements and poverty, that’s why a prosperous and inclusive city or country strives to decrease spatial inequalities and provide comprehensive solutions to urban poverty concerns. Other indicators are used to monitor the progress of SDG-11, such as the “proportion of the population that has convenient access to public transport, by sex, age and persons with disabilities, where smart city technologies can speed up and reduce the stress of regular trips by

implementing smart mobile apps that may reduce commute times by 15–20% on average by 2025, which is equivalent to nearly 15 minutes per day in the cities. Following the smart cities routes, installing IoT sensors on physical infrastructure can help in addressing problems before taking place, this may also help in changing bus routes for more time saving, installing traffic lights, and helping mainly in allocating the infrastructure budget of the targeted cities.<sup>10</sup>

The ratio of land consumption rate to population growth rate, the number of deaths, missing persons, and directly affected persons attributed to disaster per 100,000 population, the direct economic loss in relation loss to global GDP, damage to critical infrastructure, and the number of disruptions to basic services, attributed to disasters, the proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities, and the average share of the built-up area of cities that is an open space for public use for all, by sex, age and persons with disabilities”.<sup>11</sup>

According to SDG Index and Dashboard Report, the following chart shows that the majority of countries all over the world are still facing challenges regarding achieving goal 11, especially in Africa, while there is a noticeable progress that has been made in some regions such as North America and Europe. Although Africa is facing challenges regarding achieving SDG- 11, Egypt is showing a moderately improved score in the proportion of the urban population living in slums and the access to the improved piped water source, however, there is a deep need to improve the score that records the satisfaction with public transport.<sup>12</sup>



Source: SDG Index and Dashboard Report, (2022)<sup>1</sup>

## Economic Impact of Smart Cities

Smart cities have many economic advantages, including reduced expenses, increased livability, security and safety, resilience, and sustainability. As the majority of large cities have unsafe regions that are frequently left out of the advantages of economic progress driven by technology. The digital and economic inclusion of underrepresented minorities and communities, there are two top priorities that each country has to achieve, and this can be done

through projects like smart kiosks and public-private partnerships, which are disseminating the advantages of the sharing economy throughout the entire city.

Strengthening the competition between communities to attract businesses, even when it is involving favorable tax incentives and fostering an environment that is beneficial for businesses generally, will positively impact the economy of the specific countries. Cities that are connected smartly through technology will have a positive impact not only on the microeconomic level but also on the macroeconomic level, the growth rates will proceed in increasing through the appearance of the sharing economy, and service economy concepts that advocate the efficiency of pooled assets instead of the ownership of assets, which eventually will be lowering the total costs, another value-added approach has appeared, which is a peer to peer and on-demand economy models that connects consumers directly together with no need for intermediaries and the decrease in the real-time delivery of purchases that increases efficiency.<sup>14</sup>

## Smart Cities

Smart cities are places where traditional networks and services become more efficient by deploying digital solutions for the benefit of residents and businesses. Smart cities are a promising concept for a better future of global urbanization and the combat of its downsides. Smart cities use data and digital technologies to make better decisions and enhance people's lives. More detailed, real-time data allows agencies to observe events unfold, analyze how demand patterns are changing, and respond with faster, lower-cost solutions. Smart cities are the optimal paradigm for urban development. A smart city is an integrated, forward-thinking concept that may be used to define a technique for city development via the lens of digital technology and knowledge ecosystems. Three layers collaborate to make a smart city tick; The first is the technological foundation, which consists of a critical mass of smartphones and sensors linked by high-speed communication networks. Specific applications comprise the second layer.<sup>15</sup>

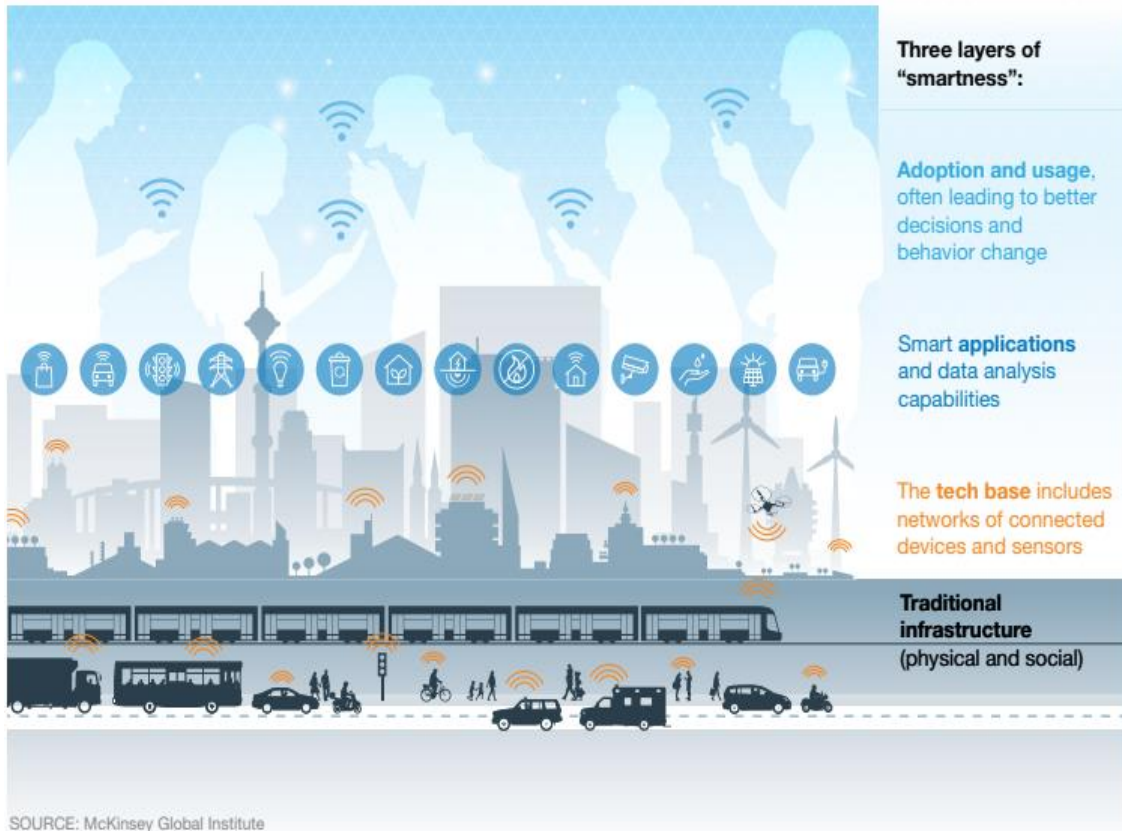
Furthermore, adopting this vision to a city's specific requirements, goals, and restrictions is critical. Yet currently, no city can claim to be entirely "smart." On the contrary, because cultures and technologies evolve so rapidly, the smart city must review itself and experiment with new ways of thinking about technology and its involvement in the common good. Transforming raw data into alerts, insights, and action requires the necessary tools, which are provided by technology providers and app developers. The third layer involves utilization by cities, businesses, and the general public. Many applications only succeed if they are broadly accepted and affect behavior.

Smart cities are commonly regarded as catchphrases in many countries and indicate that technology is used as part of the governance process. They urge individuals to utilize public transportation during off-hours, switch routes, use less energy and water at different times of day and alleviate stresses on the healthcare system through preventative self-care.<sup>16</sup>

As mentioned earlier, several aspects need to be considered to achieve the "smart" results of a city. However, intelligent results require proper use of technology and governance processes and the participation of different sectors of society. However, using technology, integrated systems, and governance can lead to that. Both technical and non-technical risks. Such risks

may not be fully understood by planners and can be misleading about the use and benefits of smart cities. The ability to design a smart city ecosystem and integrate it into a better risk management process can support smart city goals.<sup>17</sup>

The smart city goes beyond the use of digital technology to achieve better resource use and lower emissions. This means smarter urban transportation networks, improved water and waste treatment systems, and more efficient ways of lighting and heating buildings. It also means meeting the needs of more interactive and responsive city governments, safer public spaces, and an aging population.



**Smart cities add digital intelligence to the urban world and use it to solve public problems and achieve a higher quality of life <sup>1</sup>**

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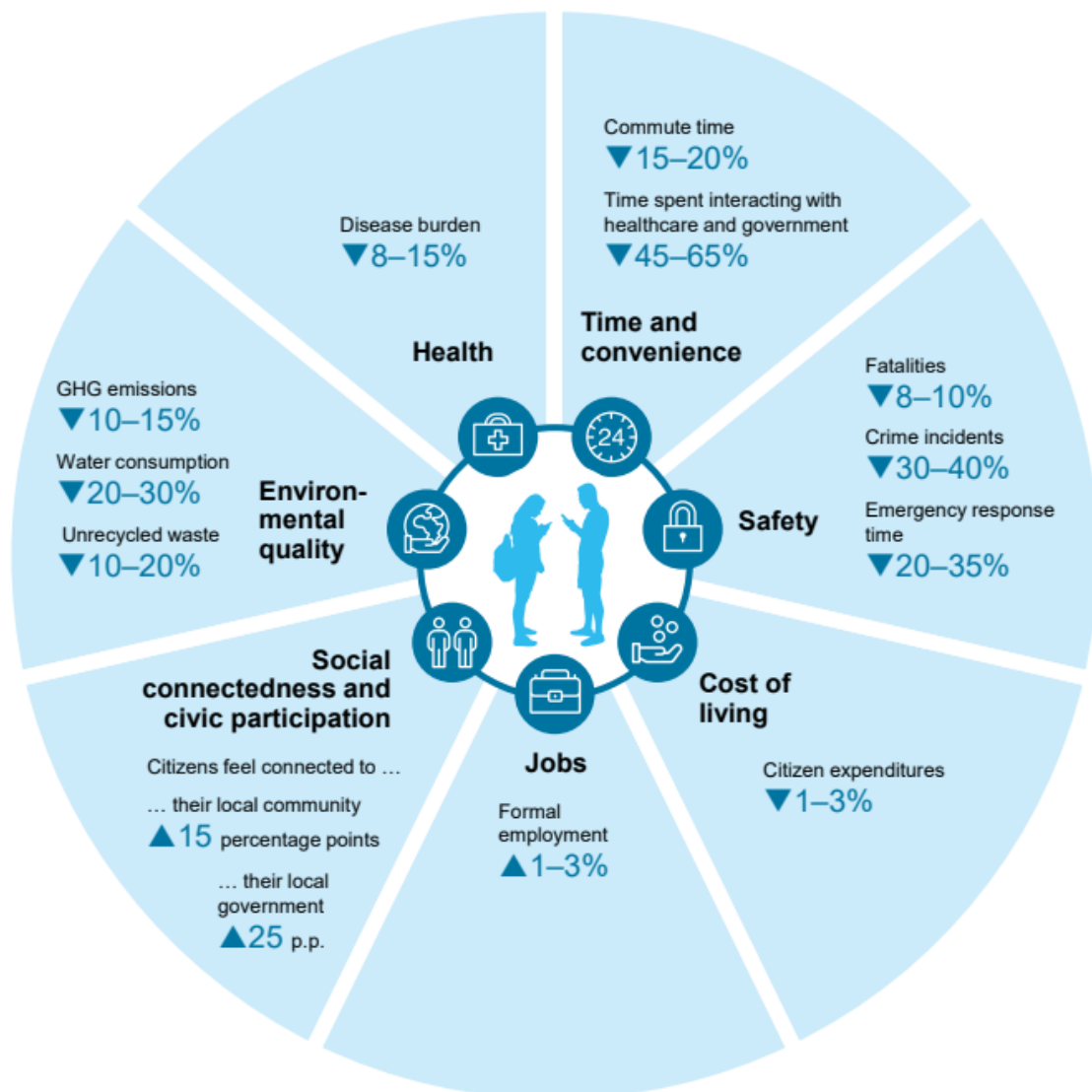
Environmental pressures increase as cities, industries, and consumerism expand. Building-automation systems, dynamic power pricing, and some mobility applications might all work together to reduce emissions by 10 to 15%. Water-consumption tracking, which combines improved metering with digital feedback messages, has the potential to drive individuals toward conservation and lower consumption by 15% in places with high residential water demand. Leakage from pipes is the leading cause of water waste in many underdeveloped countries. The use of sensors and analytics can reduce losses by up to 25%. Pay-as-you-throw digital tracking, for example, can cut the volume of solid trash per capita by 10 to 20%. Cities can save 25 to 80 liters of water per person per day and 30 to 130 kg of unrecycled solid waste per person per year.<sup>19</sup>

Air-quality monitors do not automatically address the sources of pollution, but they can identify them and serve as a starting point for future action. Beijing cut harmful airborne pollutants by



nearly 20% in less than a year by regularly monitoring pollution sources and adjusting traffic and development appropriately. Individuals can take preventative precautions by sharing real-time air-quality information with the public via smartphone apps. Depending on current pollution levels, this can lessen harmful health consequences by 3 to 15%.

Smart-city technologies assist cities in getting more out of their assets, whether they have large legacy systems or are constructing from the ground up. The need to invest in physical assets and upkeep cannot be avoided, but smart technologies can provide new capabilities when fundamental components are upgraded. Cities were formerly trapped in capital-intensive, particularly long-term infrastructure plans. They may now adapt more flexibly to shifting demand by combining traditional buildings with smart solutions. If population development accelerates in a remote community, constructing a new subway or bus route and expanding the fleet may take years. A privately owned on-demand minibus service, on the other hand, might be up and running considerably faster.<sup>20</sup>



SOURCE: McKinsey Global Institute analysis

**Smart city applications can improve some key quality-of-life indicators by 10 to 30 percent<sup>2</sup>**

## Circular Economy in Smart Cities

A circular economy means more than recycling waste. The transition to a circular economy is very important and we must respond to the changes that are taking place at the international level. In cities that are projected to accept 66% of the world's population by 2050, decision-makers take action on sustainability, and the circular economy is one of the hottest models. In the circular economy, many different actors need to work together to function efficiently. So far, it's hard to understand when looking at the entire circular economy, and from that perspective, it's hard to imagine creating a circular economy.<sup>22</sup>

This is a complex type of organization with changes in both production and consumption. the circular economy is based on the unique characteristics and sectors of a city and not all of these parts can be created and implemented at the same time. For this reason, it is important to first understand how the circular economy works in the context of the city. Circular economy practices can be practiced at the micro, meso, and macro levels in any part of a functioning economy (for example, micro refers to factory processes, meso refers to an industrial estate or city levels, and macro refers to regional, national, or continental level). Reduce resource consumption and minimize waste. At the same time, the transition to a circular economy must correlate with the development of smart cities. Circular economy discussions and practices are essential to this transition, which is seen as just beginning in developing countries.<sup>23</sup>



**Who can enable the transition to a circular city?**  
**Source: Circular Economy Guidebook for Cities<sup>2</sup>**



## Smart Cities in the context of SDG 11

Smart cities represent basic urban development trends based on the use of technology to support the sustainable development of cities. Such urban development patterns encourage the achievement of sustainable development goals. In particular, promoting safe, resilient, inclusive, and sustainable cities (SDG 11).<sup>25</sup>

This means using technology for almost all urban functions. Specific goals clarify this general perspective and highlight issues such as living standards, transportation services, and adaptation to climate change. Each goal comes with an indicator that measures its performance. Over the last three decades, smart interventions are prioritized by city managers and combined in the practical realm of sustainable cities, which have become common and familiar in all disciplines. It is also seen as the process of identifying the scale of interdependence around us and how they are best connected in urban/urban space and is important for achieving urban sustainability.<sup>26</sup>

Economic growth, social cohesion, and environmental protection are directly linked to the "smart" aspects of the city. Therefore, it focuses on the role of smart technology in achieving SDG 11. This includes the prospect of achieving SDG 11's unique goals, consistent with state rules and process-related governance definitions. Consider the main rationale for smart cities. In the following, we will provide recommendations that support/enhance urban functions while considering contributions to the achievement of SDG 11. Against this background, a thorough discussion of economic planning is based on the achievement of the SDGs.

## Discussion

Although smart cities are complicated designs that can be easily challenged, the stubbornness of resistance to the inevitable change against the integration of using new digital technologies is a total loss. Yet, sketching the vision defines developing a new understanding of urban problems; effective and feasible ways to coordinate urban technologies; models and methods for using urban data across spatial and temporal scales; deploying new technologies for communication and dissemination; developing new forms of urban governance and organization; defining critical problems relating to cities, transport, and energy; and identifying risk, uncertainty, and hazards can only be achieved in a smart city.

The transition to the circular economy offers a chance for countries to modernize their economy, making their future greener, and competitive, it also offers a transformative agenda with significant new employment opportunities and growth potential as well as stimulating sustainable consumption and production patterns. CE also offers the potential for a sharing economy alongside sustainable production for more suitable production-consumption patterns. To this, circular economy relates the infrastructure of smart cities to their operational functioning and planning through management, control, and optimization; to explore the notion of the city as a laboratory for innovation; to provide portfolios of urban simulation which inform future designs; to develop technologies that ensure equity, fairness and realize a better quality of city life; to deploy inspiring technologies that ensure informed participation and create shared knowledge for democratic city governance, and to ensure greater and more effective mobility and access to opportunities for urban populations. Finally, this research predicts the concept changes that will occur in the coming decade as a result of the fusion of the circular economy approach within the future of design advancing smart city.

## Conclusions

Smart cities reduce costs by reducing the resource and energy consumption required to meet the needs of urban service delivery. A circular economy approach could significantly increase the number of cities and human settlements to adopt and implement, develop and implement integrated strategies and plans for inclusion, resource efficiency, climate change mitigation and adaptation, and disaster resilience. From the evident studies, one can perceive smart cities that reduce emissions and save energy, smart cities that lead to automation, and waste management systems that improve public health and the environment. In summary, this research topic covers a diverse perspective on Goal 11- which aims to make cities and human settlements inclusive, safe, resilient, and sustainable.

CE model has two major key advantages; The first one emphasizes the importance, and quality of the material life cycle and the second is showing that CE business models are closing the loops and this includes satisfying needs without owning a product, extending product value, designing long-life products at the end-user level where this help in extending resource value and the industrial efficiency.

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