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Resilience to Disasters with Cities that Are Smart Sustainable Cities

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Abstract

Limited-density urban sprawl, brittle infrastructure, limited resilience, and people's inadequate ability to deal with calamities are characteristics shared by the majority of today's cities. The unplanned, rapid urbanisation that is occurring is also leading to an increase in the frequency and severity of disasters as well as their effects. These are mostly caused by poorly planned and managed urban development, degraded ecosystems, and poverty. Nearly 890 million people (or 60% of the world's population) reside in cities that are vulnerable to at least one major natural disaster, such as an earthquake, cyclone, flood, or drought. This information comes from a research conducted by the United Nations. Years of progress are inevitably destroyed by disasters, which also result in loss of life, damage to property, and deterioration of urban and environmental systems. Stimulating these intricate urban systems—which include housing, transportation, water supply, sanitation, and other infrastructure and services—will boost urban areas' resilience and aid in crisis management. This is because cities are complex systems integrated together. However, smart cities make use of information and communications technology (ICT) to increase public participation, strengthen urban processes, and improve city services all of which contribute to increased resilience to disasters. Effective urban planning can have a significant impact on communities' preparedness and recovery capacities, helping cities become catastrophe resilient from the very beginning. Communities can recover from a disaster, rebuild in accordance with a shared community vision, and become better prepared for a disaster with the aid of smart growth tactics include establishing flexible land-use policies, focusing public investment, and involving the entire community in decision-making. This study attempts to investigate, using a variety of examples, those features of smart cities that contribute to and strengthen cities' resilience to disasters. According to the study, there is a strong correlation between disaster resilience and smart development. Smart growth, smart urbanisation (smart grids, eco-cities, compact development), and low-carbon footprint strategies are some of the most important things to take into account when addressing the current level of urban disasters.

Keywords: Urbanisation; Disasters; Resilience; Smart growth; Carbon footprint of smart cities

Introduction

Most of today's cities have poor resilience, brittle infrastructure, limited density urban sprawl, and people who are not equipped to handle disasters.

In addition, the rate of unplanned urbanisation is increasing along with the frequency, volume, and impact of disasters. These increase losses and have a major detrimental impact on the economy. Nearly 890 million people, or 60% of the world's population, live in cities that are susceptible to at least one major natural disaster, such as an earthquake, cyclone, flood, or drought, according to study conducted by the United Nations. Consequently, catastrophes are increasing the vulnerability of people and development, which may eventually reverse years of progress and lead to deaths, injuries, monetary losses. In addition to the estimated 100,000 deaths annually attributed to natural hazards, it is predicted that by 2050, the annual global cost of natural disasters will surpass $300 billion [1]. Given that a city is an amalgam of complex urban systems, such as those related to housing, transportation, water supply, sanitation, and other urban infrastructure and services, should be strengthened in order to improve urban resilience and aid in disaster management.

"The 21st century is the century of the cities and of urbanisation," as it has been accurately said [2]. Since urbanisation is an inevitable and irreversible process, we must take advantage of it and adapt to ensure the sustainable growth of cities. According to data from the State of World Population 2001, 280,000 more people are added to the population every day [3]. Approximately 75% of them will live in underdeveloped nations [4]. The world faces significant ecological, economic, and social challenges as a result of the fast urbanisation and expansion of megacities, which can result in catastrophic events including natural catastrophes, climate change, and environmental degradation. Emerging cities offer benefits even in the face of urbanisation. Cities are hubs for cutting-edge technology and economic expansion. Therefore, well-thought-out urbanisation plans can lower energy consumption, improve infrastructure, slow down or stop urban sprawl, and lessen the effects of climate change, disasters, and unfavourable environmental effects.

The majority of cities' low-density urban sprawl is mostly to blame for their heightened vulnerability to natural disasters. Thus, smart growth principles combined with high-density compact development will benefit catastrophe management in two ways. It will lower exposure in the first place, and smart growth will also improve resilience in terms of readiness and recuperation. These days, smart growth, smart development, and smart cities are novel ideas. These arose from the necessity of sustainable development in view of the drawbacks of fast urbanisation, an increase in natural disasters, and climate change. Consequently, the way that disaster management is handled in cities may be dynamically altered by fusing methods to disaster preparedness and recovery with eight fundamental ideas of smart growth. The eight essential components of a smart city are as follows: smart buildings,

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smart energy, smart mobility, smart information communication and technology, smart planning, smart citizens, and smart governance. These characteristics are highlighted in the literature.

In particular, these will serve as an effective tool for disaster management in three ways: first, by reducing sprawl and, consequently, exposure to disasters; second, by strengthening infrastructure and enhancing adaptation and resilience during the disaster; and third, by enhancing communication efficiency and, consequently, enhancing post-disaster management and enabling emergency management and mitigation with immediate effect. This research has identified a few of these smart growth strategies that can be used as disaster management tools.

Methodology

Using smart development to create disaster preparedness

A resilient city is less vulnerable to both man-made and natural calamities. By strengthening its ability to respond to problems posed by climate change, disasters, and economic shocks, it lessens its vulnerability. Smart urbanisation and smart growth are more effective ways to create resilient cities to disasters. In light of eight essential components of smart growth, this part aims to explore urban resilience to disasters and pinpoint the core ideas of smart growth that will strengthen resilience.

These can be divided into four groups to discuss. (1) Smart planning tools for the pre-disaster stage (such as compact development, smart infrastructure, and transportation); (2) Smart planning tools for the emergency disaster response stage (such as smart communication, emergency response services based on smart technology); (3) Post-disaster stage smart approach (this stage provides an opportunity to rebuild smartly and fill the gap of lack of urban resiliency needed for disaster management; thus development of smart cities, use of renewable (4) Smart approaches to disaster resilience at the policy level.

Smart planning tools for the pre-disaster stage

High-density compact development, which is derived from smart planning, can boost resilience. Urban areas present opportunities for sustainable development, as stated by UNDESA. With the rapid urbanisation occurring, there is potential to reduce greenhouse gas emissions, upgrade and retrofit existing urban centres' facilities and networks, and provide high-quality energy services, energy-efficient transportation, and improved electricity transmission [5]. Urban areas present opportunities for sustainable development, as stated by UNDESA (2013). With the rapid urbanisation occurring, there is potential to reduce greenhouse gas emissions, upgrade and retrofit existing urban centres' facilities and networks, and provide high-quality energy services, energy-efficient transportation, and improved electricity transmission [6]. According to the analysis, there is a roughly one-third reduction in capital and operational expenses associated with more compact land use for roads, transit, water and wastewater, emergency response, recreation, and schools. This not only shows the financial savings but also the land usage savings that would be realised [7]. By focusing development away from identified flood-risk locations, earthquake zones, landslip areas, etc., compact development lowers urban sprawl [8], which lessens the population's exposure and vulnerability to natural disasters [9]. By cutting down on travel times, this raises the reservation's standard of living overall and facilitates easier access to facilities, services, and resources. International organisations have embraced a number of these efforts. The most well-known and recent are the joint projects of the Federal Emergency Management Agency (FEMA) and the Environmental Protection Agency . Among them are the following: assisting Spirit Lake Nation with land use planning; assisting the state of Vermont with flood recovery and resilience; assisting the coastal North Carolina projects of Wilmington and New Bern City in getting ready for sea level rise; and developing safe growth strategies for the San Francisco Bay Area. The literature contains detailed references to these.

Development of intelligent infrastructure

Urban resilience can be attained by carefully planning where to build new infrastructure, choosing adaptable technologies that don't break down in times of emergency and building infrastructure that is sturdy enough to withstand collapse during or after disasters. The "Smart Seoul 2015" project expands the use of mobile-web applications and smart technologies to deliver infrastructure and services that are focused on the needs of citizens.

These can adapt to the effects of climate change and calamities more quickly, more quickly, and more resiliently. According to the report, a smart city is any enhancement made to a modern city's infrastructure and functions by utilising information and communications technology (ICT). ICT transmits data via sensors and serves as a communication link between physical infrastructures. As a result, it creates a convergence of processes that allow a smart city to operate as a massive, autonomous intelligence unit that is highly knowledgeable and capable of responding to unforeseen circumstances [9].

Alternatively, improving the current urban infrastructure will have two benefits: it will reduce energy consumption and infrastructure costs while also meeting the needs of new development [10]. Moreover, it will increase resilience. In order to provide the technical foundation for better standards, codes, and practices that will assist communities in enhancing the resilience of their buildings and infrastructure systems, the National Institute of Standards and Technology (NIST), for instance, conducts post-disaster studies. This is based on a number of initiatives, including Wind Engineering, Community Resilience, Fire Protection, the National Earthquake Hazard Reduction Programme (NEHRP), Progressive Collapse, and Disaster and Failure Studies.

Post-disaster stage smart approach

Cities' transport systems have played a major role in the formation of entire new economies, reducing distances between people, and raising living standards for millions of people. However, the bulk of greenhouse gas emissions, including CO_2, that arise from the burning of petroleum-based products, such as petrol, are attributable to the transportation industry. Approximately 25% of the world's CO_2 emissions are attributable to the transport industry. According to the IEA (2002), global transport emissions are increasing at a rate of about 2.1% annually and 3.5% annually in developing nations. According to Saxena and Bannister , they have an effect on climate change, which in turn influences the frequency, severity, and intensity of catastrophes, particularly hydro-meteorological disasters like flooding, extremely high temperatures, high and heavy rainfall, etc. In order to identify the more efficient development patterns, the Urban Land Institute and the EPA conducted a study titled "Growing Cooler" in 2008 that looked at data on compact development using two parameters: (i) vehicle miles travelled and (ii) carbon dioxide emissions. According to the study, in 2050, compact development might cut CO_2 emissions by 7% to 10%. Using wise methods and decisions is another facet of smart transportation. These include features like intelligent traffic lighting systems, enhanced safety control systems, battery technology, charging stations, advanced driver assistance systems, and vehicle tracking

systems, among others. The transition from private vehicles to more efficient and quicker public transport is another significant factor. This will lessen carbon emissions and traffic gridlock, which is the main issue during and after disasters.

According to a Smart Growth America project called "Transportation for America," the cost and lost time due to traffic congestion would increase 15% across the country if there were no public transportation options.

In a different instance, England takes a big stride to quantify its risk reduction by employing sustainable and intelligent transportation. A study titled "The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Research Report" was released by the Department for Transport of the English government in 2004. The study was based on a project called "Sustainable Travel Towns," which involved three towns: Darlington, Peterborough, and Worcester. In a different instance, England takes a big stride to quantify its risk reduction by employing sustainable and intelligent transportation. A study titled "The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Research Report" was released by the Department for Transport of the English government in 2004. The study was based on a project called "Sustainable Travel Towns," which involved three towns: Darlington, Peterborough, and Worcester.

The program's implementation, which was evaluated between 2004 and 2009, aimed to decrease the usage of cars. This involved the government spending £15 million to improve walking and cycling, public transport marketing, and travel awareness programmes. Some policy amendments were also implemented. Effects on social and environmental

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Economic and environmental goals revealed that residents' car usage decreased by roughly 5~7%, which improved travel reliability and helped ease traffic. This translated into a yearly per capita carbon savings of about 50 kg of carbon dioxide in 2008 compared to 2004. In a different instance, England takes a big stride to quantify its risk reduction by employing sustainable and intelligent transportation. A study titled "The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Research Report" was released by the Department for Transport of the English government in 2004. The study was based on a project called "Sustainable Travel Towns," which involved three towns: Darlington, Peterborough, and Worcester.

The implied risk reductions per kilometre were, for the most part, equal to or higher than the implied reductions per kilometre that occurred nationally. Thus, by offering a variety of routes and modes of transportation, smart growth transportation methods are more effective and lessen traffic. It can be quicker and simpler to choose from a variety of routes to go from point A to point B when streets are fully connected into a network. Vehicle dependency is decreased via more complete integrated development that applies the smart growth principle and provides mixed land uses.

Using smart planning tools for emergency disaster response

The main way that smart cities can enhance emergency response times is by becoming more advanced and able to react more quickly. This will reduce all possible and expected losses in the event of a tragedy. Because fire departments, emergency responders, and police stations are located closer to the areas they serve and have more route options, easy accessibility, and an immediate ability to respond to emergency calls, the compact planning and mixed land-use principle of smart cities optimises and reduces the response times of emergency services. The transportation management (access to transportation routes and reach abilities) during emergencies is cited as the second-most important factor in numerous studies and by numerous research organisations. Real-time communication and resource coordination are made possible by intelligent transportation system (ITS) technology for public safety and transportation service providers. Emergency Transportation Operations (ETO), which has been implemented in the United States since 2004, is an example of a successful application. Other examples include the use of ICT in Indonesia for mobility, cloud, and big data solutions, Disaster Management 2015, and ICDMS, an intelligent cloud-based disaster management system for vehicular networks (Figure 1).

Intelligent post-disaster phase method

Smart city models are strategies and frameworks for smart development. Cities' smart growth models provide an understanding of one or more smart growth applications that can be effectively applied to pre-disaster mitigation plans. Chinese smart city model: according to a Lux Research analysis, up to 18 Chinese cities have stated aspirations to become smart cities. These comprise a variety of small to medium-sized cities, including Ningbo, Wuxi, Chengdu, Wuhan, Kunming, Foshan, Shenzhen, and Guangzhou, as well as some of the largest cities, such Beijing and Shanghai. With a population of 7.6 million, Ningbo is a seaport city in the Zhejiang province. Since 2008, a 33-kilometer cross-sea bridge has been constructed, making it possible to travel from Ningbo to Shanghai in less than two hours. Ningbo unveiled its 2011–2015 action plan to become a smart city, and the "China Smart City Technology & Applications Expo" is scheduled to take place there shortly. The smart city plan states that projects will

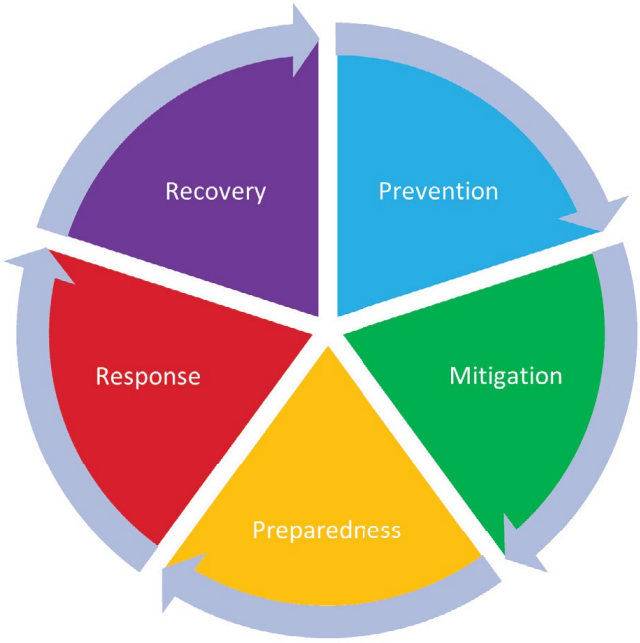

Figure 1: Disaster management cycle.

get RMB 40.7 billion in funding over the course of the next five years (12th Five-Year Plan period). The strategy focuses on five "speedups": constructing an international strong port more quickly, creating a contemporary metropolis, reorganising the industrial sector, creating a smart city, constructing an ecological civilization, and raising living standards. Logistics, manufacturing, public services, energy, social administration, traffic, healthcare, residential site management, and entertainment services are all covered by the 87 distinct initiatives. BT Cloud Computing Centre, Shuguang Cloud Computing, IBM Smart Logistics Centre, and Ningbo Branch Corporation of Tata of India are a few examples. Ningbo unveiled its 2011-2015 action plan to become a smart city, and the "China Smart City Technology & Applications Expo" is scheduled to take place there shortly. The smart city plan states that projects will get RMB 40.7 billion in funding over the course of the next five years (12th Five-Year Plan period). The strategy focuses on five "speedups": constructing an international strong port more quickly, creating a contemporary metropolis, reorganising the industrial sector, creating a smart city, constructing an ecological civilization, and raising living standards. Logistics, manufacturing, public services, energy, social administration, traffic, healthcare, residential site management, and entertainment services are all covered by the 87 distinct initiatives. BT Cloud Computing Centre, Shuguang Cloud Computing, IBM Smart Logistics Centre, and Ningbo Branch Corporation of Tata of India are a few examples.

Novel approaches to urban development in particular domains. The smart city model is now available in its third release . Based on the "smart" combination of resources and actions of self-aware, self-determining, and self-aware individuals, the model defines a smart city as one that satisfies six criteria.8. Fig. 8.1 displays the smart city network model of European cities (Figure 2).

Using energy from renewable sources to boost resilience and effectively mitigate disasters The majority of natural catastrophes, including floods, earthquakes, and hurricanes, frequently result in power system outages. Renewable energy backup systems can act as a safety net against electrical system failure. One way to keep the electrical system from collapsing during calamities is to use portable systems to support victims and response teams after a disaster, or to supplement utility networks with renewable power sources. For these kinds of applications, photovoltaics, or solar electricity, are most common. The US Department of Energy project Operation Fresh Start, which has been successfully implemented in the cities of New Patterson, Missouri; Rhineland, Missouri; Soldiers Grove, Wisconsin; Valmeyer, Illinois; and Kinston-Lenoir County, North Carolina, provides an example of both features. The literature also emphasises the need of community resilience to disasters. The "resilience refers to the ability of a community – its systems, institutions, and residents – to adapt to changing conditions or to recover from an emergency event or disaster." At the local government level, there are many tactics that improve community resilience and work in tandem with solar growth, or vice versa. Examples of this are "Solar Outreach Partnership" projects in the United States.

The strategic use of renewable resources is another factor. Electric systems can produce dependable "base-load" power thanks to technological advancements. This can be done by the use of grid-scale battery storage to support renewable energy expansion, by the development of enhanced geothermal power potential, and by the acceleration of the development of advanced nuclear power technologies. For example, according to New York Times 2011, the Federal Department of Energy financed a solar map of the city, an innovative approach which identified that two-thirds of New York City's rooftops are suitable for solar panels and that together they could generate 5847 megawatts, enough energy to meet half the demand for electricity during peak periods and 14% of the city's annual electricity use.

Intelligent transportation networking: used for post-disaster evacuation routes, emergency management, and early warning systems. Transportation networking can play a critical role in guiding evacuation routes during catastrophes. Long-term advantages of smart transport networking include a decrease in carbon emissions. With the current state of greenhouse gas emissions, this is more important. According to the OECD-ITF Joint Transport Research Committee's Working Group (2010), Bongardt, Breithaupt, and Creutzig (2010), and UNDP (2011),

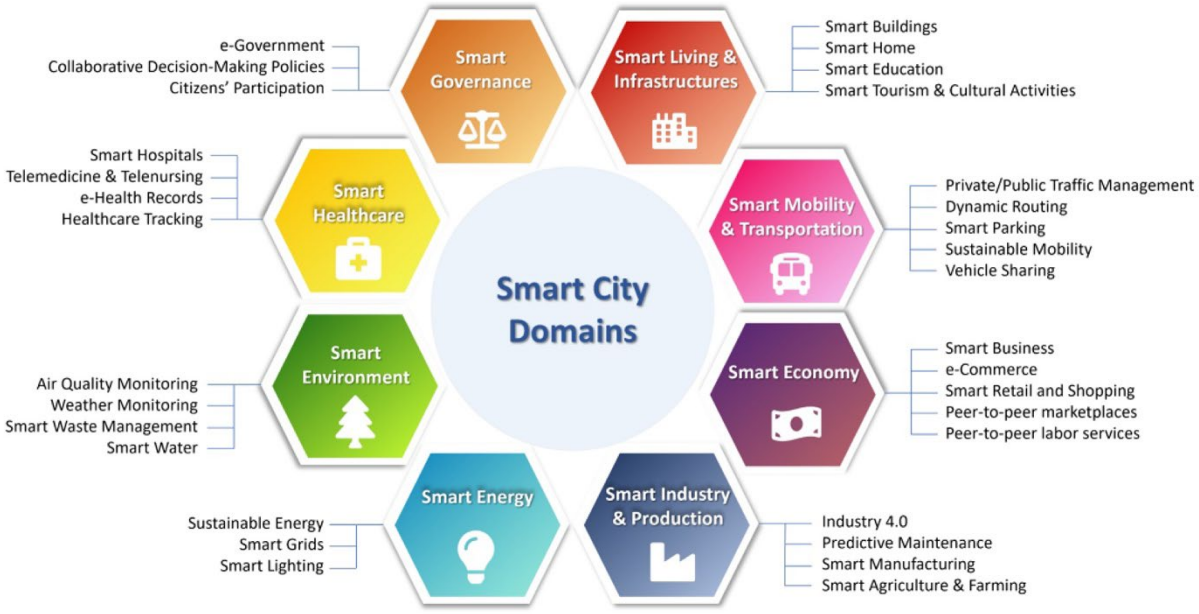

Figure 2: The network of smart cities.

the transport sector accounts for 23% of global CO_2 emissions and 30% of emissions in OECD member countries. Transportation evacuation solutions based on VANET Disaster Management System have been identified by numerous academics who have examined the application of intelligent transportation networking. The basic concept of ITS is the inter-connectivity of different transportation systems using cloud computing systems.

The intelligent transportation systems (ITS)11 is the application of information technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation taken up under the ITS Strategic Research Plan, 2010–2014. The intelligent transport systems (ITS) are visually depicted.

During disasters, smart networks that optimise energy use can also minimise accidents and infrastructure failures in urban areas. The smart grid is a relatively new concept. The literature says, "A smart grid is a digitally enabled electrical grid that gathers, distributes, and acts on information about the behavior of all participants (suppliers and consumers) in order to improve the efficiency, importance, reliability, economics, and sustainability of electricity services." Smart grid policy is organized in Europe as Smart Grid European Technology Platform. The energy systems of the twenty-first century are likely to be characterized by cheap and abundant use of information and communications technology (ICT), enabling more efficient energy use and integration of renewable energy through an integrated energy network. A smart grid is a modernized electric system that uses sensors, monitoring, communications, distribution system automation, advanced data analytics, and algorithm for anomaly detection to improve the flexibility, security, reliability, efficiency, and safety of the electricity system.

As an illustration, the Ministry of Interior oversees the Provincial Electricity Authority (PEA), a government enterprise. The PEA Smart Grid is utility information and communications technology to manage, monitor, and control the generation, trans- mission, and distribution of electrical energy. The PEA Smart Grid enables distrib- uted generation from alternative clean energy sources and maximizes profit from asset utilization with a new management system. The PEA Smart Grid also enables the use of electric vehicles and provides connection services to the electrical net- work through smart metering. Finally, the PEA Smart Grid will provide efficiency, security, safety, reliability, and international standards of power quality to meet cus- tomer needs in the twenty-first century.

Astute communication for readiness and early warning. Challenged by a natural disaster, smart cities can use faster and more sophisti- cated ICT infrastructure and analytical capabilities that enhance and synchronize the information flow between multiple public sectors? Even with the simplest tech- nology of mobile networks, a city municipality can reach the majority of its citizens at short notice. Cities can enhance from the experience of Japan, where the federal government launched an emergency warning system in February 2007, providing its municipalities with a plan and a solution to respond to natural disasters.

Clever Policy-Level Approaches to Disaster Resilience. Future iterations of our living systems must embrace all current activities and initiatives, even those in the incubation stages. At every stage of development, this calls for the careful preparation and execution of clever tactics that involve every player and stakeholder in the undertaking. As a result, certain policy-level initiatives have been identified. A national set of guidelines for neighbourhood location and design has been developed by the US Green Building Council (USGBC), the Congress for the New Urbanism (CNU), and the Natural Resources Defence Council (NRDC). These guidelines are based on the combined ideas of smart growth, new urbanism, and green building. Development projects that score highly in the Leadership in Energy and Environmental Design (LEED) grading system are certified in 2009. Projects may constitute whole neigh-borhoods, fractions of neighborhoods, or multiple neighborhoods. The goal of this partnership is to establish these standards for within the rating framework of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System (Figure 3).

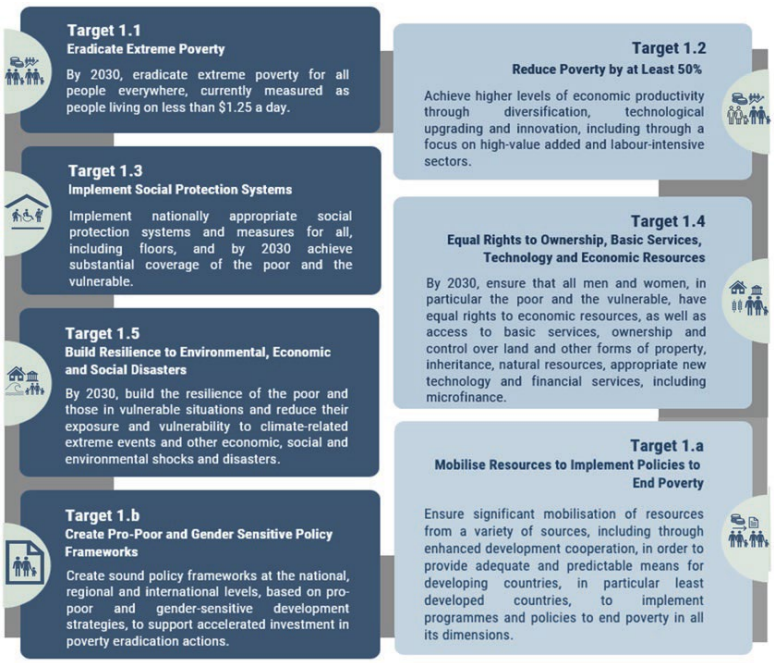

Figure 3: Targets of SDG-1.

Conclusion

As our present cities are generally characterized by high urbanization rates, and the world is undergoing changes due to globalization, urbanization, and technological advancements, it forces us to think and change our ways of living, especially in the cities of developing countries which are just not able to cope urbanization pressure. This challenge has been addressed many times by the economists and researchers by the development of "smart" technologies, which target the potential transformation of our cities into more responsive and self-sufficient smart cities. Smart cities use information and communication technology (ICT) to involve people, improve city services, and enhance urban systems that result in an improved integrated urban system which altogether improves disaster management intelligently. To make cities disaster resilient right at the inception stage, the efficiency in urban planning impacts communities' preparedness and capacities to recover from natural disasters. Other aspects of smart growth that focus on more efficient land-use patterns that reduce the spatial extent of the city though high-density compact development are needed. The smart growth strategies like creating flexible land-use policies, targeting public investment to catalyze private investment and engaging the entire com- munity in making decisions about the future can help communities recover from a disaster, rebuild according to a shared community vision, and be better prepared for the next natural disaster. Smart expansion can save public infrastructure and service expenditures, including those related to roads, water, sewage, garbage collection, utilities, school transportation, delivery services, and parking facilities, according to a number of studies. This contributes to the growth of a robust economy as well. These issues that have been highlighted here are merely the fundamentals that require further investigation to address disasters more intelligently. The idea has two main obstacles: first, no rules exist to enable this kind of planning; and second, additional research is required to fully comprehend the concept's range of benefits and drawbacks. Third, these technologies will only be successful with public involvement and a "inclusive approach," which is now a very difficult task. To engage in finding answers, the people must take ownership of the issues. The lesson here is that, even though a lot of technologies are being developed, it is crucial to choose the right technology for a given city based on its resources and population's degree of adaptability in order to create a smart, sustainable built environment that effectively resists disasters.

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