EFFECT OF SMART CITY APPLICATIONS ON SUSTAINABLE MANAGEMENT IN CITIES

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Abstract

As an essential part of our high-tech societies, smart city systems (SCS) have been playing a crucial role in shaping our technological, social, and economic lives. It also revolutionizes the decision-making process with the integration of the newest technological developments into managerial systems. This increasing trend also helps organizations to make bridges between SCS and sustainability issues. Integrating the SCS with United Nations (UN) Sustainable Development Goals (SDGs) is an increasingly interesting topic in the literature. Although there are many efforts, in systematic reviews, it is stated that there is a need for a depth understanding of how SCS in practice is applied by managers. In this respect, we aim to analyze the smart city applications in Konya Municipality and assess their SCS integration regarding 2030 Sustainable Development Goal 11 (Make cities and human settlements inclusive, safe, resilient and sustainable). This effort is important to understand how SCS can contribute to the global sustainability vision regarding city strategies.

Keywords
Smart city systems, sustainability, sustainable development goals, smart city applications

Introduction

To reach an ideal 21st century city form, smart city systems are presented as an important instrument in all over the world. With the tremendous development in the technological advancements, it is reasonable to rely upon new technologies for overcoming city management problems regarding economy, society and environment. Giffinger et al. (2007) defines Smart City as "a city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of activities of self-decisive, independent and aware citizens". This wide definition raises the expectancies from technology in an upper-level and sustainability issues becomes an important matter as well as other economic contributions of smart city systems. Considering the inter-disciplinary perspective of recent business context, it is important to handle economic, social and environmental sustainability issues together.

Regarding these concerns, United Nations (UN) 17 Sustainable Development Goals (SDGs) set standards for a decent living for all people on a healthy planet by 2030 (UN Statistics Division, 2022). One important aspect of this vision is its emphasis on the population growth in urban areas and need for better city management strategies regarding sustainability. The use and rise of smart city (SC) systems in urban places in which community, technology, and policymakers collaborate to provide productivity, innovation, livability, wellness, sustainability, accessibility, good governance, and outstanding planning has increased demand for technology-based solutions (Yigitcanlar and et al., 2018). SC systems are also seen as an important element of a bigger "smart planet" approach, which suggests a global technology-based sustainable city vision (Su and Fu, 2011). Despite this emphasis on global level smart policies, very few studies focus on the SC systems' relation to SDGs. UN's 2030 vision has a specific SDG (11 - Sustainable Cities and Communities) for cities and it is important to present the role of SC systems in reaching this vision. In this regard, in the Turkish City of Konya context, this study outlines the current and future role of smart city applications (SCA) to the construction of sustainable cities and advise researchers further relevant topics.

SC systems use information and communication technologies in an efficient way that provides intelligent responses to different kind of city needs, including not only daily livelihood, public safety, business activities but also the environmental protection (Qin and Zhao, 2010). There is a need for assessing cities smart city developments and their impact on environmental and societal sustainability. While cities are progressing through SC Systems, it is important

to respect social cohesion and environmental sustainability issues (Aletà et al., 2017). It is also underlined that existing research in smart systems and their impact on environment are studied mostly at organizational-level, and in city contexts are underexplored in the literature (Brauer et al., 2015). Therefore, this chapter aims to fill this gap by discussing an important city, Konya which has been implementing many smart city applications successfully.

Methodology

Methodology of this chapter is twofold. First, a comparative analysis of six smart city components of Giffinger et al., (2007) with SCAs applied in Konya city context is made. Here it is aimed to provide a summary list of SCAs in Konya and give a general idea of Konya smart city system. Then, 11th SDG of "Sustainable Cities and Communities" is handled, and contributions of selected SCAs for the sub-targets and indicators are presented.

Smart City Applications for Sustainability in the Case of Konya Municipality

Located in the center Anatolia, Konya is the largest province in Turkey in terms of land area with a population more than 2 million in 2022. Konya Metropolitan, which is one of the first cities to start smart city investments and applications throughout Turkey, has come to a position where it can compete with other smart cities in the world. Konya is the first municipality to use smart card application (elkart) with Intelligent Public Transportation Systems (ATUS) in 2000s. It is also the first city in the world to use bank cards in all vehicles of public transportation in 2013. (Karayilmaz and Özker, 2020). Konya has more than one hundred different smart city applications in different field such as; Konya City Information System, Konya wastewater treatment plant, Aslım electricity production plant and Intelligent Transportation System (Mangır, 2016). Konya smart city applications are put into action and adopted by different sub municipality units, so the city seems to be an integrated smart city in the near future (Bilici and Babahanoğlu, 2018).

Smart City Main Components and Konya's Strategy and Roadmap

Within the scope of the "Konya Smart City Strategy and Roadmap" studies prepared by Konya Metropolitan Municipality, it is aimed to carry out the smart city activities of all institutions providing services in the city within the framework of a certain planning and in cooperation (Nalcakar, 2019). In this context, studies will also be carried out for the emergence of a Local Smart City Strategy and Road Map, which can be shown as an example for Turkey in the perspective of 2030. In the literature six main components are mentioned to become a smart city or community (Giffinger et al., 2007), which are:

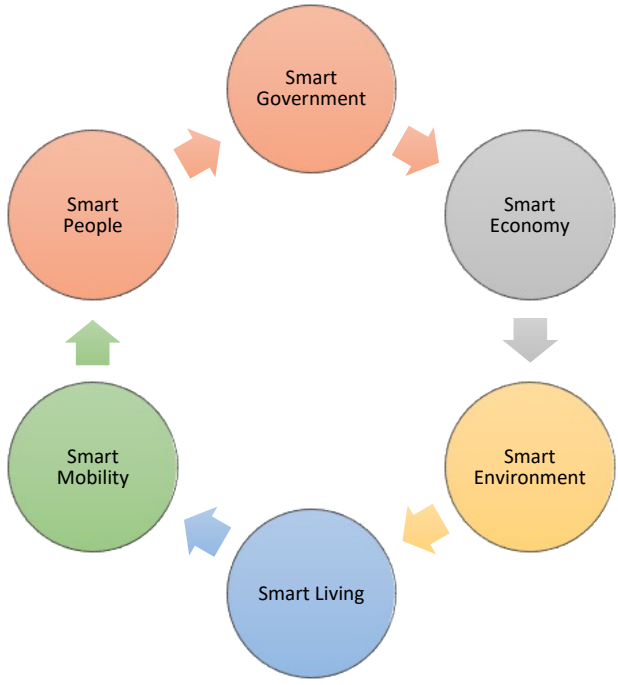

Figure 1. Six main component of smart city
Source: *(Giffinger et al., 2007)*

These components are representing the smartness level of a city, each of them presenting an important smartness dimension. However, it is also claimed that specific aspects of each dimension are linked to each other and there could be some overlaps (Dameri and Rosenthal-Sabroux, 2014). It can be hard to distinguish for placing a specific smart city application under only one of these components. For instance, a public transport application could be both related to smart mobility, smart environment, and even smart living. Considering there are approximately 58 smart city applications (SCA) in Konya, it would be misguiding to limit them under one of these categories. Therefore, after shortly introducing the smart city components and give a few examples SCAs from Konya, we provide a summary of SCAs in Konya and their relationship with components (Table 1).

Smart Government

Smart Government is about enhancing the links and interactions between the government and all stakeholders within a municipality, including citizens, businesses, and other civil society organizations (Pereira and et al, 2018). A municipal government that implements a smart city plan is ideally

positioned to reevaluate the quality, scale, and scope of services it provides to inhabitants and businesses. Some of the applications presented under the title of smart governance in the example of Central Traffic Management System, Maintenance and Repair System, Open Data Portal. Akıllı Üst Geçit Sistemleri is a system that where density analyzes and security monitoring are made by using the overpasses with the city card. Alttan Isıtmalı Kavşak Sistemi is anti-icing road heating system especially for winter conditions. The system where icing is monitored when city roads drop below 4 degrees. Elektronik Denetleme Sistemi where traffic vehicles are tracked electronically via cameras. Moreover, there are warning system that monitors the height of traffic vehicles.

Smart Economy

Smart Economy refers to all measures that attempt to improve and strengthen a city's economy that are sustainable, and ICT based (Bifulco and et al, 2016). The most essential goals are to improve the general business climate, a city's attractiveness for start-ups, investors, firms, and new (highly qualified) personnel, and to build the economy in an innovative and sustainable way to raise competitiveness (Dagilienė and et al, 2020). Each city is claimed to have different challenges to develop smart economies (Kumar and Dahiya, 2017) and requires context specific research. Smart economy understanding is very central to smart city strategies such as planned and sustainable economic development, improving city's competitiveness and attractiveness for investments.

"Akıllı Aydınlatma Sistemi" is automatic lighting system according to the weather conditions. Another smart economic application is e-belediye, all municipal transactions and documentation can be done through online systems. And also, online payments are available for municipal services over the online portal. About the agriculture, "e-Desen Kırsal Alan Bilgi Sistemi" indicating the soil type of rural areas depending of their value.

Smart Environment

The term Smart environment refers to how a municipal government manages the built and natural environments in order to increase livability for people and visitors (Aletà and et al, 2017). Using new technologies and innovative methodologies aids in the implementation of regulatory and cultural changes that promote long-term norms and practices (Liu and Zhang, 2021). Some significant goals of "smart environment" efforts include waste reduction, pollution monitoring and management, emission reduction, water management, energy efficiency, and expediting the local energy transition (Binz and et al, 2012). With assistance of SCAs, cities are both expected to monitor environmental impacts of city activities (Ullo and Sinha, 2020) and develop more environmental friendly strategies. In this regard, there are many innovative SCAs applied in Konya.

Konya municipality focus on the green transportation with Akıllı Bisiklet Sistemi which is 4th generation smart shared bike system. There are more than a thousand shared bicycles at 100 different point in city center. Moreover, city has also air and noise monitoring system which is controlling the air quality and loud warning in city center. Konya has well management, bus stops and meteorology management system which are use renewable energy infrastructure.

Smart Living

Smart Living component aims to improve the quality of life for residents and visitors by using an inclusive strategic approach (Rodríguez Bolívar, 2021). Smart Living focuses on an intelligent lifestyle facilitated by smart technologies (Han and Kim, 2021) which offers better opportunity in convenience, comfort and security for people (Yan and Shi, 2013). For municipal governments two areas are addressed to optimize the advantages: facilitating livability and maximizing living environment (Mirzahossein and Mohghaddam, 2021).

Regarding these, following SCAs are considered important for Konya: Akıllı Aydınlatma Sistemi is very common in city center which is automatic lighting system according to the external conditions. About the transportation, Akıllı Kavşak Sistemleri is intelligent intersection system working according to the number of vehicles. Furthermore, thank to Akıllı Otopark Sistemi, drivers can easily find available free parking over the Intelligent parking system applications. Thus, cars spend less time in traffic and reduce their carbon footprint. Last but not the least, Merzarlık Bilgi Sistemi is one of the most widespread application that, showing and describing grave address being in city cemeteries.

Smart Mobility

Smart Mobility focuses on improving urban transportation efficiency and service quality in order to encourage the use and adoption of new mobility solutions, as well as to improve people mobility through effective mobility management and targeted infrastructure expenditures (Porru and et al., 2020). For cities and communities, it is a significant issue to achieve cheaper, faster, and more environmentally friendly mobility, as well as integrated multi-modal transportation (Agarwal and et al, 2015; Verma and et al., 2020). Mobility could be a critical functioning issue for many metropolitan areas and Smart Mobility applications are generally used to support the traffic flux optimization and also gather citizens' opinions about livability or local public transport services' quality (Benevolo, 2016). Konya municipality has a variety of SCAs under this component.

"ATUS Akıllı Toplu Ulaşım Sistemi" is intelligent transportation tracking and monitoring system focused on public transportation and monitoring

of municipal vehicles. They have the opportunity to monitor all public transportation vehicles in the city and even make announcements from the control center. KONASA is global satellite network monitoring system which supported digital radio communication system via wireless satellite.

Smart People

Last but not the least, Smart People component aspires to change the way citizens interact with the public and commercial sectors as individuals or businesses, through smart city applications (Attaran and et al, 2022). While general tendency in the literature is to give equal importance to six smart city components (e.g. Batty et al., 2012), some give prominence to the Smart People dimension (Kumar, 2015). It is because of the fact that without active participation of the people, smart city would not be functioning in the first place. As the fundamental block of Smart City system, a city with smart people attributes can attract high human capital, worker with higher qualifications and expertise (Kumar and Dahiya, 2017). Regarding this, Konya have following important SCAs that increase its Smart People capacity:

"Açık Veri Portalı" means municipality data is presented to citizens in a transparent way and serving in different languages. Besides, E-Hemşeri application allows the people of Konya to communicate with their fellow countrymen. On education side, "KOMEK Uzaktan Eğitim Sistemi" offer vocational education via e-learning platform.

Table 1. SCA's and their relationship with smart city components - Konya

Application Smart City Application	Smart governance	Smart people	Smart living	Smart environment	Smart mobility	Smart economy
Open Data Portal	X	X				
Intelligent Lighting System			X	X		X
Smart Building (Science Center)	X					
Smart Bicycle System				X	X	
Smart Station Systems			X		X	
Smart Human		X				
Smart Junction Systems			X		X	
Smart Parking System			X		X	
Smart Stadium	X					
Smart Overpass Systems	X					
Underground Heated Junction System	X					
Vehicle Tracking System	X				X	
ATUS Intelligent Public Transportation System		X	X		X	

AYKOME - Infrastructure coordination center	X				X	X
Municipality Business Tracking System	X					
Icing Tracking System	X		X			
Environmental Management Information System				X		
e-address system		X	X			
e-municipality						X
e-Desen Rural Area Information System			X			X
E-Countryman		X				
e-payment						X
e-Paw Application				X		
e-License	X					
Electronic Supervision System	X		X			
Electronic Clearance Monitoring	X					X
Electronic guidance system	X	X				
Young Card		X				
Noise Control System				X		
Excavation Vehicles Tracking				X		X
Line Management System					X	
Air Quality Monitoring System				X		
ILBIS-Districts Information System	X					
Solid Waste Conversion				X		
KBB TV		X				
KGYS - City Security Management System			X			
Komek Distance Education System		X				
KONASA - Fixed GNSS Network					X	X
Koski Tracking	X			X		
Central Traffic Management System	X					X

Cemetery Information System			X			
Mobile Masnavi		X				
Mobile Application		X				
Online Competition		X				
Digital Radio Communication			X		X	
SCADA Maintenance and Repair System	X					
Simulation System	X	X				
Social Card		X				
Irrigation Automations				X		
Server Systems	X		X			X
Agricultural Area Analysis		X		X		X
Contactless Debit Card Integration					X	X
public transport announcement system					X	
Free Wifi		X	X			X
Station management with Renewable Energy				X		
Well management with Renewable Energy				X		
Meteorology management with Renewable Energy				X		
Police Management System			X			

When we look at the classification in the Table 1, Konya smart city applications are in almost all different titles. However, it is possible to say that there are more studies in the field of smart management and smart people. In addition, it can be said that these applications are more human-oriented. On the other hand, although the city's public transportation and transportation infrastructures are enough strong but there are fewer applications in the field of smart mobility.

SDG 11 and SCAs of Konya Metropolitan Municipality

In this section, SDG 11 "Make cities and human settlements inclusive, safe, resilient and sustainable" will be examined with regards to the SCAs of Konya. After summarizing the SCAs relation with six smart city components, in this part, sustainability issue will be assessed. SCAs have already been claimed positively contributing sustainable environment and societies (Ramesh et

al, 2020). Smart city systems are instrumental for ensuring both social and environmental sustainability issues. Regarding, social aspect, smart systems strengthenes the connection between political entities and citizens, with the emphasis of democratic representation (Androniceanu, 2019). SCAs are widely utilized green information systems, which in return decrease the negative environmental impacts like pollution (Brauer et al., 2015). Both issues are gaining more and more importance for cities day by day, since there are serious challenges such as increased population in urban areas, polarized economic growth, increased green-house emissions and decreased budgets because of economic crisis;

United Nations Sustainable Development Goals (SDG) are important here to guide cities to a sustainable future. 11th SDG of "Sustainable Cities and Communities" is the most related goal for municipal smart city strategies. In the following sections, it is presented that how SCAs used in Konya are contributing to the targets of SDG 11. By doing that, it is aimed to picture the current role of SCAs in meeting sustainability goals and how this could be more utilized by municipal management. It is important for decision makers to see the crucial role of smart city systems for an effective city management. In this respect, SCAs will be examined and presented comparatively under the SDG 11's following 9 sub-targets:

11.1 Safe and Affordable Housing
11.2 Affordable and Sustainable Transport Systems
11.3 Inclusive and Sustainable Urbanization
11.4 Protect the World's Cultural and Natural Heritage
11.5 Reduce the Adverse Effects of Natural Disasters
11.6 Reduce the Environmental Impact of Cities
11.7 Provide Access to Safe and Inclusive Green and Public Spaces
11.8 Strong National and Regional Development Planning
11.9 Implement Policies for Inclusion, Resource Efficiency and Disaster Risk Reduction

United Nations have set sub-targets and indicators for SDG 11, which is presented in Table X. Within the scope of SDG 11, Konya Metropolitan Municipality offers specific scope solutions with SCAs. In order to evaluate these contributions of SCAs to SDG 11 targets, we have made interviews with the relevant unit chiefs and managers of Konya Metropolitan Municipality.

Table 2. SDG 11, sub targets and inicators

SDG 11 Targets	SDG 11 Indicators	Konya Smart City Applications
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing	e-address system
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	engelsiz app
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate 11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically	e-Desen Rural Area Information System e-countrymen intelligent people e-Desen Rural Area Information System e-countrymen intelligent people
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	Çevre Yönetim Bilgi Sistemi
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population 11.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP) 11.5.3 (a) Damage to critical infrastructure and (b) number of disruptions to basic services, attributed to disasters	Hava Kalitesi İzleme Sistemi
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	Environmental Management Information System Noise Control System Excavation Vehicle Tracking Air Quality Monitoring System Solid Waste Recycling Environmental Management Information System Noise Control System Excavation Vehicle Tracking Air Quality Monitoring System Solid Waste Recycling

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities 11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months	Police Management System Smart People Police Management System Smart People
11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	11.a.1 Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space	Agricultural Field Analysis Contactless Debit Card Integration
11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	No suitable replacement indicator was proposed. The global statistical community is encouraged to work to develop an indicator that could be proposed for the 2025 comprehensive review. See E/CN.3/2020/2, paragraph 23.	

Source: from the 2030 Agenda for Sustainable Development

Contribution of SCAs to Specific SDG 11 Sub-targets

When the "Proportion of urban population living in slums, informal settlements or inadequate housing" indicator expressed in 11.1.1 is evaluated; there is almost no slums throughout the province of Konya. In addition, thanks to the "e-address system" where the active home addresses of the citizens are followed, the residence addresses of the residents of Konya are tracked online instantly. In addition, with the "Social Card" application, it is expected that the basic needs of the people in need will be met with the card that can be used at certain points for their basic needs.

When the indicator is evaluated in the context of 11.2.1 "Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities"; Konya has many public transportation applications. Moreover; The "engelsiz app" mobile application has been developed and put into service to run smart city applications and services offered in the city for disabled and illiterate citizens in Konya from a single center. "Handicapped Konya Mobile Application" designed to meet the transportation priority needs of disabled citizens in daily life; It helps to solve problems such as getting on the wrong bus, getting off at the wrong stop, pavement height, incorrect

parking. With this application, Konya also won the good practice award given by the Ministry of Transport and Infrastructure at the International AUS Summit 2022.

Regarding the 11.3.1 and 11.3.2 indicators shown in Table 1, the above-mentioned “e-Desen Rural Area Information System”, “e-countrymen” and “intelligent people” applications have been implemented. In the context of the 11.4.1 indicator shown in Table 1, the “Çevre Yönetim Bilgi Sistemi” ve “Hava Kalitesi İzleme Sistemi” -detailed above- are actively used. 11.6.1 shown in Table 1. and 11.6.2. indicators, “Environmental Management Information System”, “Noise Control System”, “Excavation Vehicle Tracking”, “Air Quality Monitoring System” and “Solid Waste Recycling” applications are used in a coordinated manner in the city. Moreover, Presented in Table 1; 11.7.1. and 11.7.2. indicators, the “Police Management System” and “Smart People” applications detailed above are used in a coordinated way in the city. Presented in Table 1; 11.a.1. indicator, “Agricultural Field Analysis” and “Contactless Debit Card Integration” applications detailed above are just a few of the economic applications that support regional development in the city.

In addition, in the context of smart transportation and public transportation, “ATUS Intelligent Public Transportation System”, “Smart Stop Systems”, “Smart Junction Systems”, “Smart Bicycle System”, “Smart Parking System”, “Public Transportation Announcement System”, “Line Management System” and “Vehicle Tracking System” applications also make city life easier.

Conclusion

The United Nations General Assembly approved the 2030 Agenda for Sustainable in September 2015, the United Nations adopted 17 Sustainable Development Goals (SDGs). The new Agenda emphasizes a holistic approach to achieving sustainable development for all, guided by the principle of "leaving no one behind." The 17 Sustainable Development Goals (SDGs) that will change the world are as follows (Franco and Abe, 2020):

- No Poverty
- Zero Hunger
- Good Health and Well-being
- Quality Education
- Gender Equality
- Clean Water and Sanitation
- Affordable and Clean Energy
- Decent Work and Economic Growth
- Industry, Innovation and Infrastructure
- Reduced Inequality
- Sustainable Cities and Communities
- Responsible Consumption and Production

- Climate Action
- Life Below Water
- Life on Land
- Peace and Justice Strong Institutions
- Partnerships to achieve the Goal

On the other hand, when humans, machines, and ecosystems interact in novel ways, AI and increased automation offer both opportunities for sustainability and a plethora of unknown systemic risks. Some of these issues may be alleviated by using concepts that constitute "ethical AI," "responsible AI," or "AI for Good" that have emerged in recent years, notably those addressing justice, non-discrimination, accountability, transparency, privacy, and security. As a result, principles-based standards have emerged as the de facto norm for governing AI systems. AI advances can assist smart systems in optimizing management and effectively maintaining resilience and dependability. To accomplish important advancements in AI theories, technology, and applications, governments must support fundamental and applied research. Countries need competent AI people to perform AI research and development and to implement AI technologies in the business and public energy sectors. In the future decades, AI has the potential to alter numerous energy industries and boost growth. To stimulate private-sector firms, government investments in important industries and the establishment of AI clusters and ecosystems should be undertaken.

The capacity of AI to operate is effect on the study of sustainable management. As a result, governments are attempting to open their databases and create platforms that will allow for safe, private data sharing. A variety of ethical debates have centered on privacy, algorithmic bias, and security. Codes and ethical standards for deploying and developing AI to reduce damage are being developed by government-supported utilities. The goal of utilities and government AI policy is to maximize AI's wide range of benefits while dramatically limiting its drawbacks and hazards.

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