IJEPEM

International Journal of Environmental Pollution and Environmental Modelling,
Vol. 4(2): 64-75 (2021)
(Research Article)

Smart Environment Applications and General Status In Turkey

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Received 02.08.2021; Accepted 11.10.2021

Abstract: Currently cities are faced with many environmental problems in parallel with increased population, like environmental pollution (water, soil, noise and air pollution, etc.), drinking water problems, water scarcity/use, resource scarcity, traffic, large natural disasters, lack of green space, insufficient infrastructure, migration and unplanned urbanization, public health problems, carbon emissions, rapidly increasing population, radiation and energy crises. Cities with rapidly increasing populations using communication technologies and technological infrastructure to resolve all these problems are called smart cities and it is unavoidable that future cities will be designed with the understanding of a new generation. One of the subareas of smart cities for solutions to environmental problems included among these many problems is the use of smart environment applications.
With the aid of smart environment applications using smart technologies, many types of pollutants including noise, different types of waste, carbon emissions (carbon footprint), radiation and light, in addition to the classic air-water-soil pollutants, can be monitored and managed. Smart environment applications can produce important solutions to solve chronic problems like water scarcity/use, energy, global warming and climate change, which directly affect these basic environmental problems.
This article investigates sample applications in cities taking important steps to become smart cities in Turkey and how smart environment applications are used to solve these problems in cities with large populations faced with rapidly increasing environmental problems. Sample applications will be presented by examining studies, reports and references related to organizations and institutions especially. As in the rest of the world, smart environment applications are rapidly being implemented in the design of example smart towns in our country. Through contributions of the Ministry of Environment and Urbanization and the Ministry of Industry and Technology, local administrations and other organizations on a city basis have taken important steps to becoming smart cities by using smart environment applications.
Keywords: Smart Cities, Smart Environment, Smart Technologies

INTRODUCTION

As emphasized in the abstract, for solutions to environmental problems occurring with the increase in population, one of the smart city subareas of smart environment applications using communication technologies and technological infrastructure have come to the agenda.

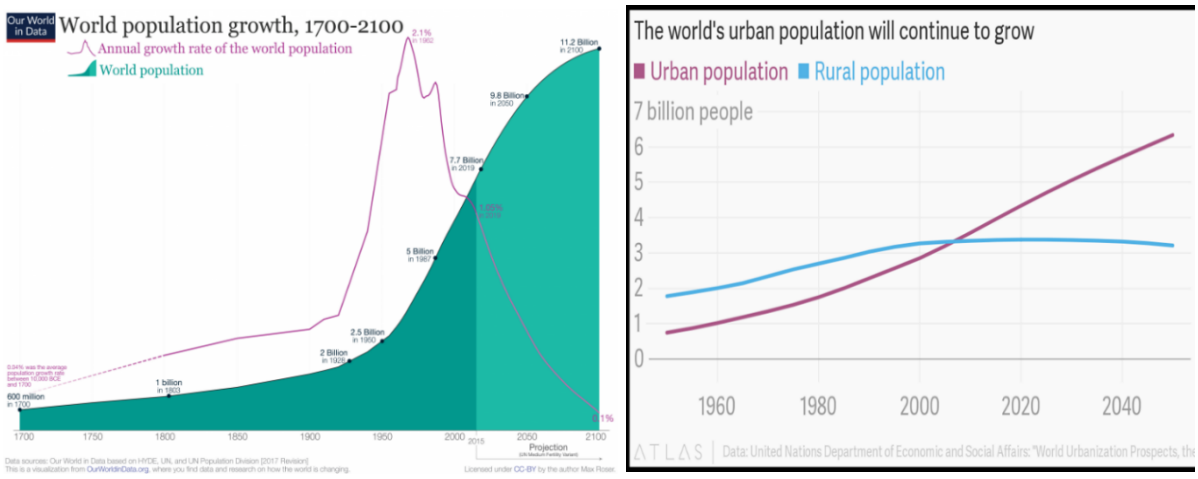

Figure 1. Increase in Global Population and Global Urbanization Rate[1-2]

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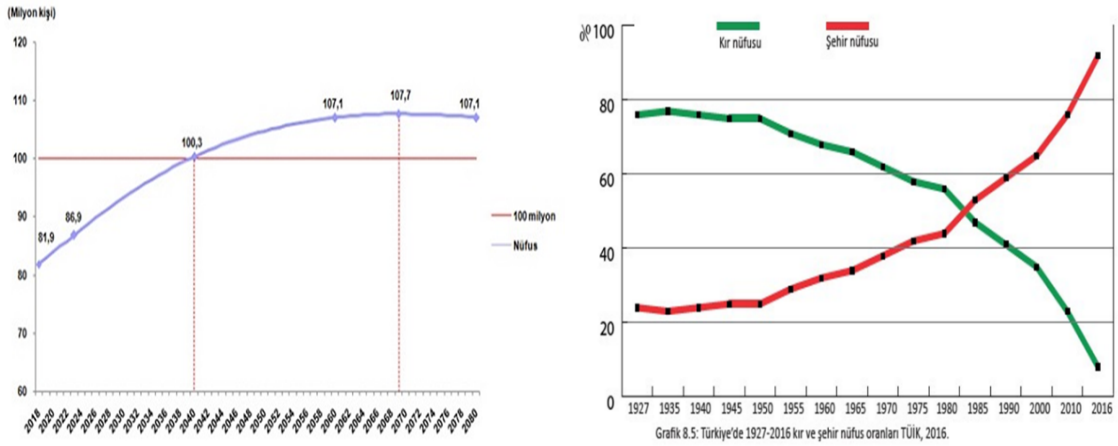

Figure 2. Population Increase and Urbanization Rate in Turkey[3]

As seen in Figure 1, the population increase in the world in general continues rapidly. The urbanization rate shows a parallel increase. In Turkey, the population of the country rapidly increased especially since the first years of the Republic, and in parallel the urbanization rate has an increasing trend. According to Turkish Statistical Institute (TÜİK) data, the total population of Turkey reached 83,154,000 people in 2020[3] (Figure 2). With the effect of changes in the local government law, the urbanization rate in our cities rose to above 90%. Many settlement areas previously located in rural regions have gained the status of being city neighbourhoods[3].

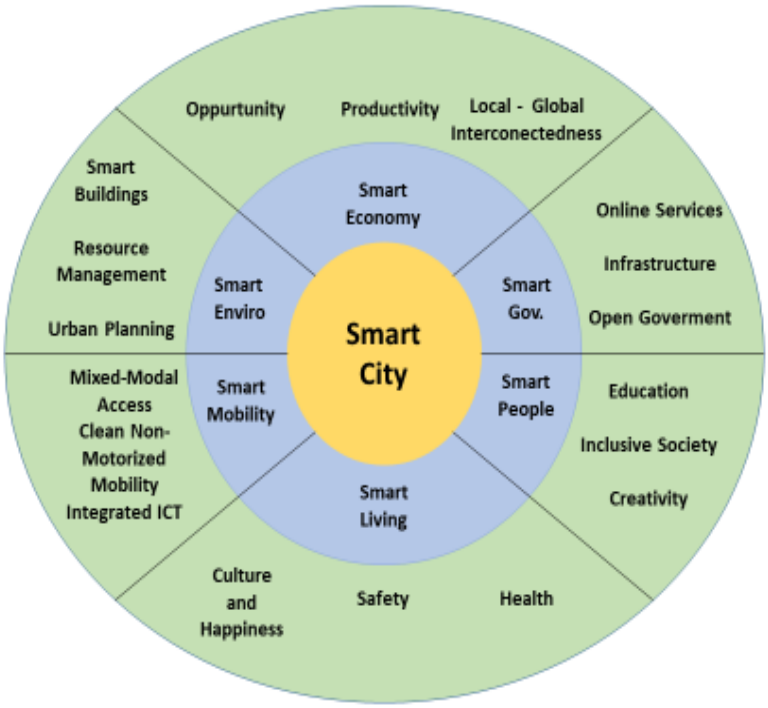

Figure 3. Cohen's Smart City Circle and Smart Town Subareas[4]

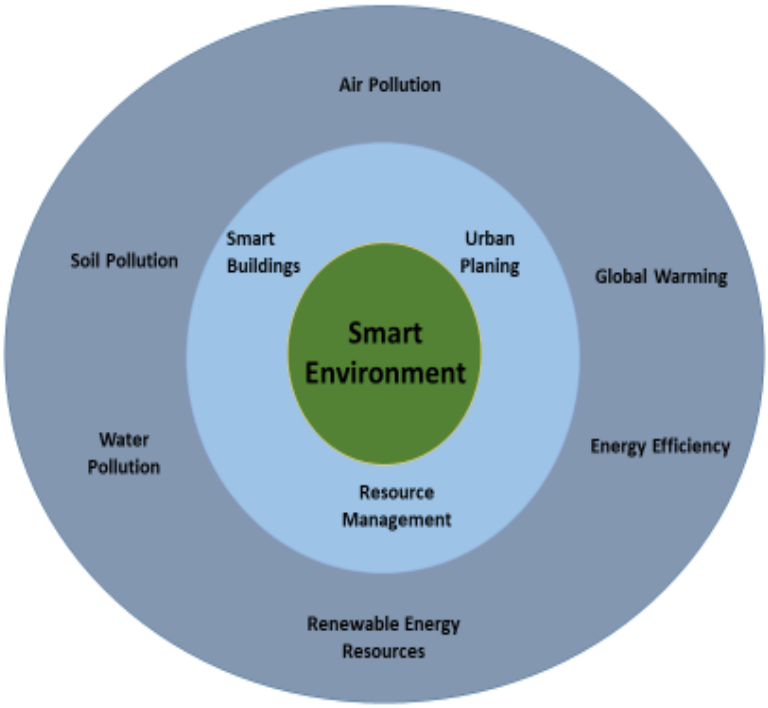

Figure 4. Diagram Showing Smart Environment Main Headings

As seen in Figure 3 and Figure 4; with the aid of smart environment applications, in addition to classic pollutants of air-water-soil, many other pollutants like noise, different types of waste, carbon release (carbon footprint), radiation, and light may be monitored and managed. Smart environment applications may produce significant solutions for chronic problems like water scarcity/use, energy, global warming and climate change, directly affected by these basic environmental problems[5].

MATERIALS AND METHODS

When 'smart town' and 'smart environment' applications in Turkey are examined, these applications occur in certain regions in cities and we see an integrated smart town vision has not yet been achieved in the fullest sense. However, the strategy plan called '2019-2022 National Smart City Strategy and Action Plan' prepared by the Ministry of Environment and Urban Planning has supported and implemented many applications related to the environment. After this strategy and action plan was prepared, attempts were made to popularize smart environment technologies and smart environment applications in many large cities like İstanbul, Ankara, Çanakkale, Konya, Antalya and Eskişehir [5-9].

RESULTS AND DISCUSSIONS

Included within the framework of 2019-2022 National Smart City Strategy and Action Plan, many smart environment applications were implemented in Turkey's largest metropolis of İstanbul, like an environmental control center, floating solar energy power plant, smart recycling containers, domestic waste incineration and energy production facility, and energy production from waste gas, as seen in Figure 5, 6 and 7 [10-13]. Related to air pollution, based on the vision statement 'to ensure İstanbul is a respected world city with high quality of life', the air quality surveillance center was founded and a variety of steps were taken to improve air quality and to create cleaner air for İstanbul. Air quality surveillance studies in İstanbul began with 2 mobile air quality measurement vehicles in 1995 and continue at present with nearly 40 air quality surveillance stations operated by İstanbul Metropolitan Municipality and the Ministry of the Environment and Urban Planning. To ensure İstanbul air quality data are shared with the public, and to create more efficient and quality air, air quality measurement values are published instantaneously every day on a website[14-15].

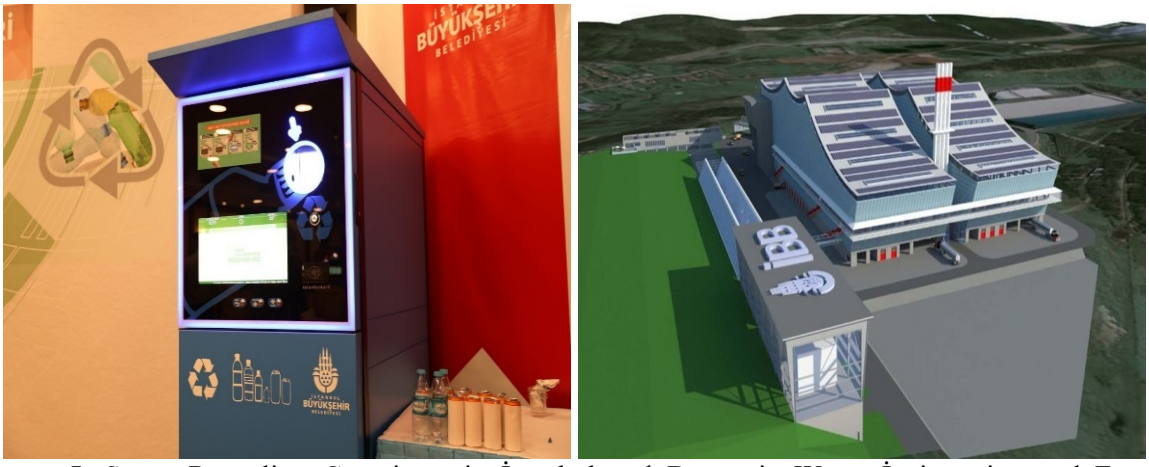

Figure 5. Smart Recycling Containers in İstanbul and Domestic Waste İncineration and Energy Production Facility Plan[10].

Figure 6. Energy Production Center From Waste Gas in İstanbul and Floating Solar Energy Power Plant in Büyükçekmece Lake[11]

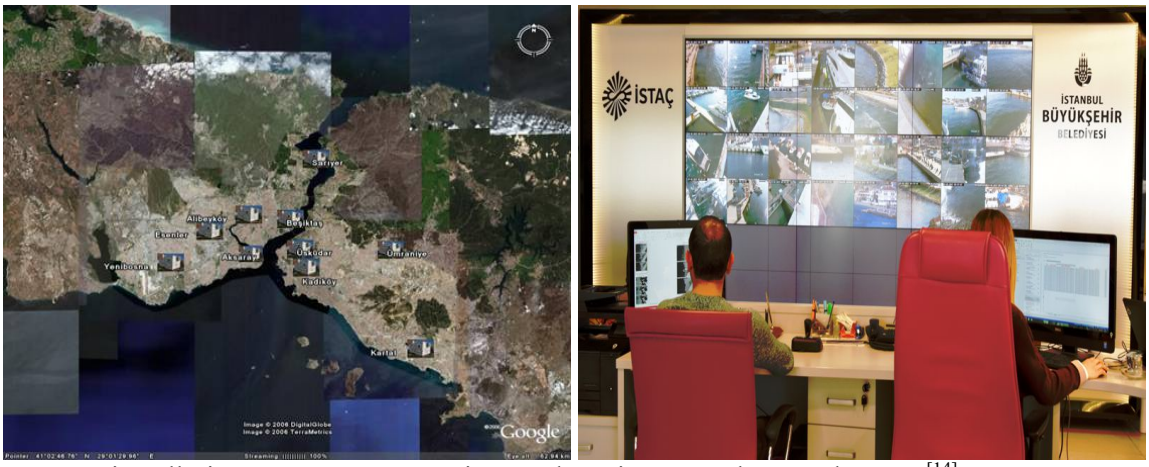

Figure 7. Air Pollution Measurement Stations and Environmental Control Center[14]

Again included in the 2019-2022 National Smart City Strategy and Action Plan, Turkey's second largest city of Ankara uses an integrated solid waste management system (Figure 8). This includes many activities including rehabilitation of unregulated storage areas, creating projects for and operating regulated storage areas, energy production from gasification-incineration, waste-derived fuel (WDF) production, recycling of packaging and other waste, and disposal of hazardous and medical waste[16-17]. Additionally, Ankara municipality brought a zero-waste program to the agenda and attempted effective implementation (Figure 9). In order to provide better and more rapid water distribution services to city

inhabitants in Ankara, a remote-read water meter system is used. The SCADA center founded within ASKİ continuously monitors operating facilities (pumping stations, water depots, treatment facilities, water distribution network and required assisting facilities) with the aim of providing reliable water for the city[18].

Figure 8. Ankara Solid Waste İntegrated Assessment Recycling and Disposal Facility[17]

Figure 9. Ankara Municipality Zero-Waste Program Visuals and SCADA Center Founded by ASKİ[18]

Within the framework of the same action plan, solar energy power plants and solid waste integrated facilities in one of Turkey's important tourism centers of Antalya can be listed. As seen in Figure 10, solar energy panels (that can produce annual mean 2000 MW electric energy) with 1.24 MW power were placed on 12,000 m² area above Antalya stadium. These solar panels meet the electrical energy requirements for 575 residences. By constructing this facility, annually 1200 tons CO2 release and cutting of over 100,000 trees was prevented[19].

Additionally, Antalya integrated waste disposal facility separates 3000 tons of domestic solid waste into components daily. The result of this separation means that the remaining 1250 tons is transformed to methane gas in an organic waste fermentation facility in an energy production facility with 25 MW power and the electrical requirements of 60,000 residences are provided[20].

Figure 10. Antalya Stadium and Antalya Solid Waste İntegrated Assessment Recycling and Disposal Facility[19]

Renewable energy systems, smart park and garden irrigation, and smart distribution network systems were implemented in Gaziantep within the framework of the same action plan. With the aid of smart distribution network systems, in Gaziantep Organized Industrial Zone (OSB) 900 electricity meters can be read in real time with instant energy consumption and power data obtained on a subscriber basis. In this way, electric production and conduction required instantaneously and energy efficient use can be ensured. Within this scope, the 4% loss-leak rate was lowered to 0.5%. As seen in Figure 11, Turkey's largest solar carpark was founded within Gaziantep Water and Sewerage Administration (GASKİ) General Directorate. This solar facility has 1460 m² area, 56 vehicle capacity and 120 kW power. Gaziantep Metropolitan Municipality is the first public organization in Turkey to receive an ISO 50001 Energy Management System Certificate[21].

Figure 11. Gaziantep Water and Sewerage Administration (GASKİ) General Directorate Solar Car Park and Solar-Powered Drip İrrigation System [21]

Figure 12. Park Watered with Smart İrrigation System in Gaziantep[21]

Again, 400,000 m^3 water savings annually were targeted with a 'smart irrigation system' applied in the Botanic Gardens linked to Gaziantep Metropolitan Municipality Parks and Green Space Department and planned for implementation in the city in general. Due to applications aiming to ensure both energy and water savings, Gaziantep Metropolitan Municipality provided 80% water savings in the Botanic Gardens[21] (Figure 12).

As seen in Figure 13, within the framework of the same action plan, Konya implemented many smart environment applications. Konya Metropolitan Municipality founded an electrical energy production facility in 2011 with the aim of using methane gas produced by the Aslım Solid Waste Storage Area where the city's solid waste is stored. The capacity of the facility is 5.6 MW and when the facility operates at full capacity, it will provide the daily electricity requirements for 26,000 residences. Additionally, a greenhouse with 1,200 m^2 size was created with the aim of using the heat formed by the facility. Here, mean 30 tons of tomatoes are cultivated annually. With the aim of encouraging environmental sensitivity, awareness and understanding smart system applications, technical trips were organized for student groups from primary-middle schools and various university departments[22].

Figure 13. Konya Solid Waste Facility with Electricity Production From Methane Gas and Environmental Management Information System Center[22]

Due to the environmental management information system center founded in Konya, urban and regional environmental problems are identified and access is provided instantly to all data required to solve these problems. Due to this center, air quality monitoring, instant monitoring of pollution levels in different regions based on instant data from fuel checks, waste-noise and vehicle tracking systems, imaging of environmental values, and creation of pollution maps is possible. Data in the system can be associated with each other and interrogated and analysed.

Additionally, due to cycle paths and a smart bicycle system again created in Konya, reductions in traffic-sourced emissions were ensured for supporters of the important global problem of global warming[22].

Within the action plan framework, attempts were made to implement the Horizon 2020 Remourban Project in Eskişehir. The basic target of this project can be summarized as combining energy, transport, information and communication technology applications at a single point to offer innovative solutions and designs for problems, to apply and disseminate urban renewal models in counties and cities, to increase the quality of life for city dwellers, to create a sustainable city and to use innovative working models. The Remourban Project is a model including all developed infrastructure and technology with the necessary processes for urban renewal. This model includes the best smart solutions to ensure smart and sustainable urban renewal[23].

In Eskişehir again, the example smart city Tepebaşı project was attempted. In this example project, smart lighting systems, smart distribution network systems, energy-saving smart buildings, smart city observation portal, smart bicycle applications and smart transport systems were brought to the forefront[24].

The Eskişehir Ecotown project is an ecotown project begun in Eskişehir Kocakır with the aid of İstanbul Technical University (İTU). With the aid of a team from ITU, an 'ecologic city with zero energy, zero waste and self-sufficiency, fulfilling its own needs' was designed and operated in Eskişehir Kocakır. The project was begun with the 'protocol in relation to development of ecological settlement unit standards under the scope of the law about renewal of areas at risk of natural disasters and common service implementation about a pilot administration in Eskişehir province Odunpazarı county Kocakır locale' with the Ministry of Environment and Urban Planning[25].

In line with these strategies, as seen in Figure 14, Kocakır was designed as an ecotown in accordance with national ecologic settlement standard infrastructure to ensure zero carbon release from energy, areas with high carbon sink potential, efficient use of resources from the region, production of its own energy and use of waste within the region for zero waste[25].

Figure 14. Images from İTÜ Eskişehir Kocakır Ecotown Project[25]

Within the framework of the same action plan, as seen in Figure 15, smart environmental applications in Çanakkale include projects like smart junctions, a smart bicycle rental system (Çabis), Çanakkale cultural center building (Green local administration and culture center), and the advanced biological wastewater treatment plant (treated wastewater is used for agricultural irrigation[26-27].

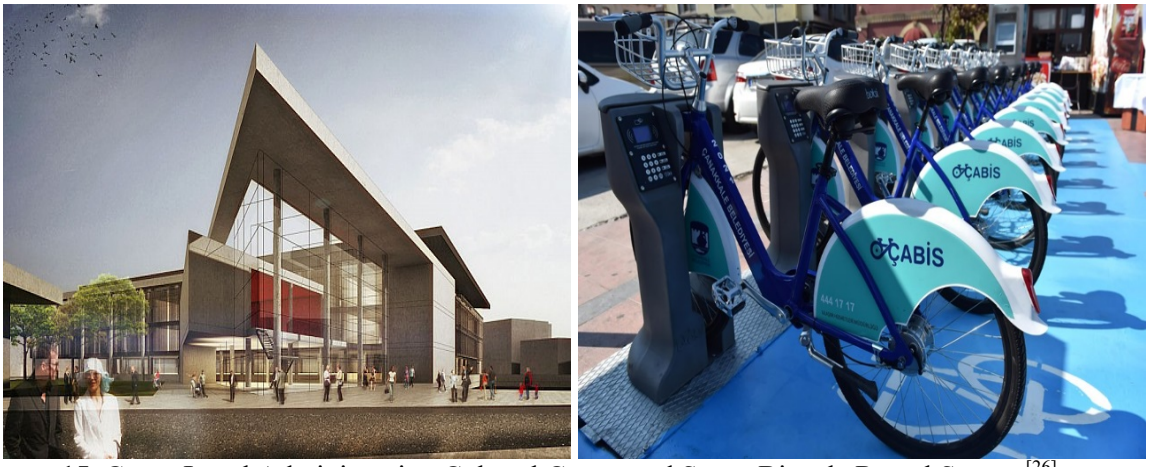

Figure 15. Green Local Administration Cultural Center and Smart Bicycle Rental System[26]

In Erzurum, a smart bus stop system and smart transport mobile application system began in relation to one of the smart city main headings of smart transport. It also has many smart applications in the Ejder 3200 ski resort, one of Turkey's most important ski centers. However, though smart environmental applications have begun to be attempted on the basis of the university and local administration, the implementation stage has not been reached.

Currently, one of the trend concepts is the smart city concept which is a concept widely encountered in the world in general in recent years and assisting the creation of the cities of the future. In the world in general, many studies and implementations related to this topic have been performed in many countries. Cities use many technologies like smart technologies, cloud computing systems, open source data sharing and the internet of things and take important steps on the path to becoming smart cities. Thus, with the use of a strong technologic infrastructure, more livable cities with less problems, able to produce more rapid solutions to possible problems and managed better begin to develop.

Currently, with the smart city concept we are entering a world where cities compete instead of countries. Due to smart city components and features, current cities have shown incredible developments in relation to topics like branded cities, sustainable cities and sustainable environment.

Both in the world and in Turkey, many cities use smart city applications. Though various cities have implemented important smart city applications, there is still no city which we can call a smart city in the full sense of all features. Technologies used and implemented applications focus on certain regions in cities. Among cities which have implemented most applications in the world, directing development of cities with technology and leading the way in relation to the topic of smart cities, we can list London, Singapore, New York, Seoul, Barcelona, Amsterdam, Paris, San Francisco, Dubai, Berlin, Santander, Moscow, Cape Town and İstanbul.

Many studies have been performed related to this topic in Turkey and there is rapid implementation of applications related to smart cities. Among the cities leading the way in relation to smart cities in Turkey, firstly we can list smart city applications in cities with crowed populations like İstanbul and Ankara. In addition to these cities, Kayseri, Konya, Antalya, Bursa, Çanakkale, Eskişehir, Kahramanmaraş and Gaziantep have completed many projects about smart city applications and continue to implement them.

Smart cities host important applications in relation to the environment and ecology. One of the most important subareas of smart cities of 'smart environment' applications target significant reductions in pollutant pressure on the ecosystem. These applications include designing smart buildings minimizing carbon release (carbon footprint), using smart transport techniques, keeping energy efficiency to the forefront, with broad green spaces. In addition to these, smart environment applications use renewable energy resources (solar, wind, etc.), and are sustainable applications ensuring minimization of waste and optimum recycling of waste in industrial symbiosis regions.

Within the scope of this study, firstly studies, reports and references related to public organizations and institutions were investigated in detail in line with example applications in Turkey in general. Within this scope, in February 2020, there were 78 smart city applications in the country in general and among

these 25 were determined to be suitable for assessment as 'smart environment' applications. Similarly, the distribution of these applications in our cities is summarized in Figure 16.

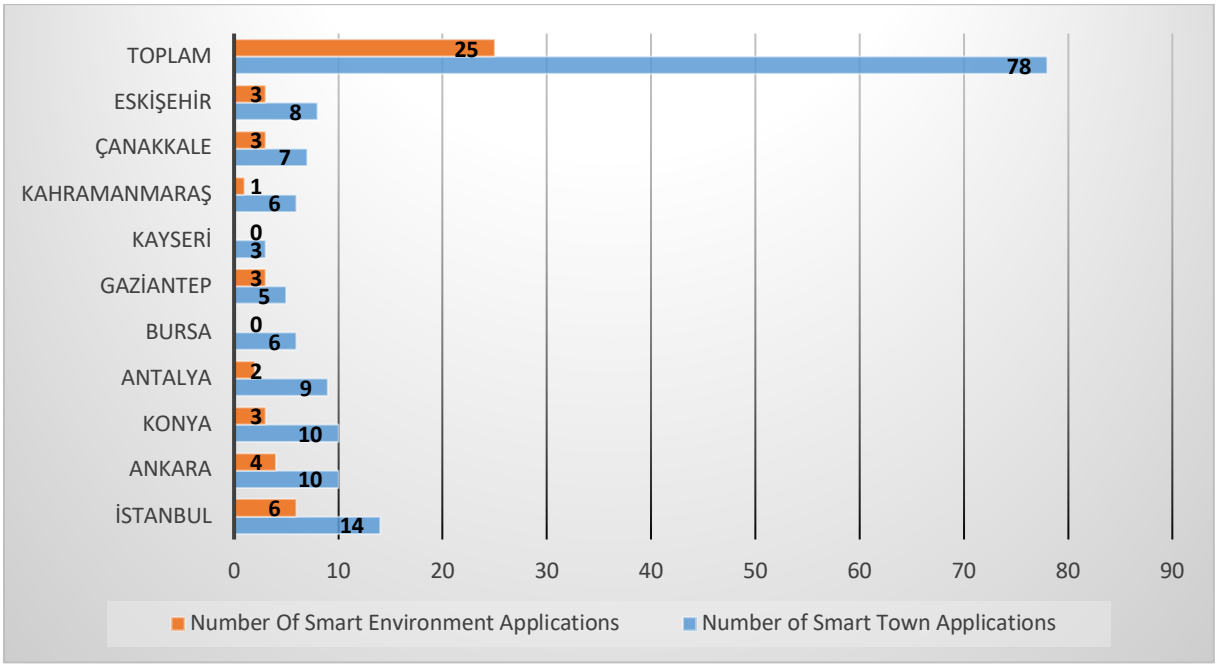

Figure 16. Distribution of Smart Environment Application Projects and Smart Town Application Projects in Turkey

As seen in Figure 16, among cities with most 'smart city' applications were İstanbul with 14, Ankara with 10, Konya with 10, Antalya with 9 and then the other cities.

Among these smart city applications, the cities with most 'smart environment' applications were again İstanbul in first place with 6, followed by Ankara with 4, and Konya, Gaziantep, Çanakkale and Eskişehir with 3 each (Figure 16 and 17).

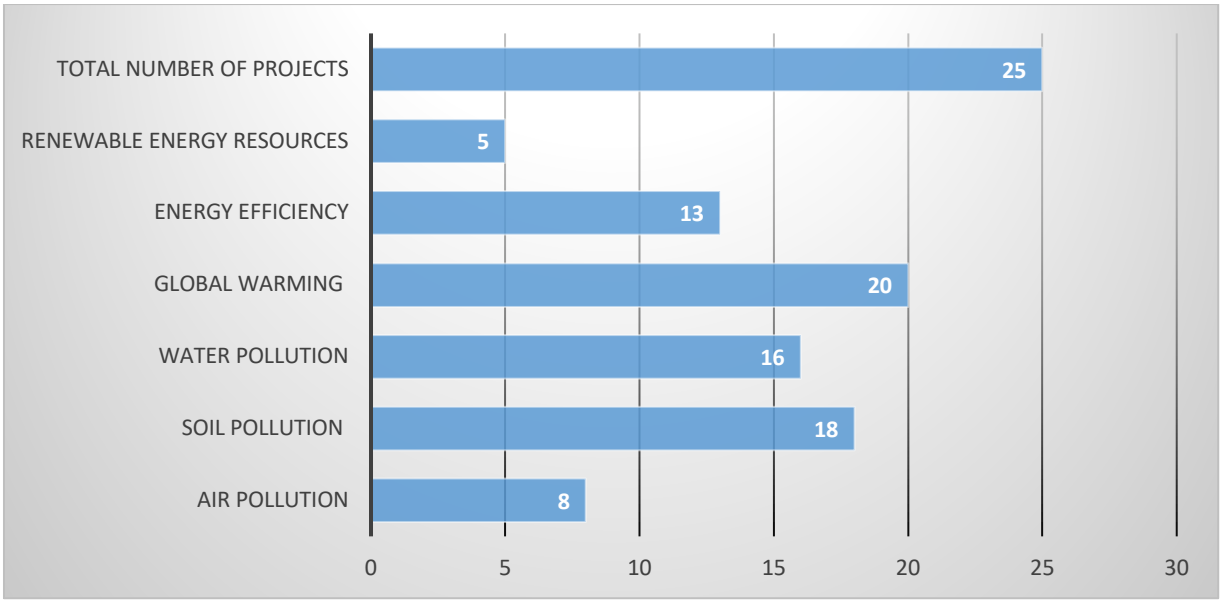

Figure 17. General Distribution of Smart Environment Applications According to Environmental Main Headings in Turkey

As shown in Figure 17, as of February 2021; although the total number of smart environment applications in turkey is twenty-nine, a smart environment application can cover multiple smart environment sub-area applications. For example, domestic waste incineration and energy production

facility in İstanbul is included in air pollution, solid and hazardous waste management and energy efficiency smart environment sub-areas.

CONCLUSION

The concept of green production and industrial symbiosis forms the basis of smart environment applications and are two important concepts supporting the development process. These three important basic concepts have been simultaneously adopted by the whole world in the present day, with the development process continuing.

Applications encompassing all three concepts naturally reduce the impacts of pollutants on the ecosystem and positively affect ecologic footprint, carbon footprint and water footprint. With the aid of smart technologies used in the smart environment area, attempts are made to reduce ecologic pollution with development of environmental designs to create more ecological, environmentally-friendly buildings. Life cycle analysis begins with the environmental effects of products ands services from production until destruction in the ecosystem to reveal all stages and ensure disposal without harming the ecosystem due to waste. Thus, integrated pollution prevention and control methods are designed to develop the best smart environment application techniques in terms of the environment.

On one hand while some cities continue with smart environmental applications, on the other cities without smart environment applications are in the preparation stage.

If we are to summarize the contributions of smart city and smart environment applications for city dwellers;

1. Due to smart city centers created or to be created in our cities, data is collected instantaneously and rapidly sent to the necessary units and smart city plans will be implemented.
2. With smart environment applications, our cities will more effectively manage environmental pollution and the environmental problems causing this pollution
3. Smart environment applications on one hand will reduce noise, waste and hazardous waste, carbon release, radiation, light and similar pollutants and even destroy them at the source, while on the other will contribute to reduction of two important global problems of global warming and climate change.
4. Due to implemented applications, Ecocities compatible with nature will be created.
5. With the aid of smart environment applications, green economies will be created with integrated waste management, industrial symbiosis and life cycle analysis.
6. With the use of renewable energy resources, cities will use their natural resources more efficiently and more economically.
7. With the aid of all smart city applications and smart environment applications, the quality of life in cities will increase.
8. Due to rapid and effective management of environmental problems, significant contributions will be made to the ecosystem and public health. A cleaner, more liveable environment will allow the opportunity for healthier and happier individuals and leave a cleaner ecosystem for future generations.
9. With smart environment applications, control of the green space per person in cities will be completed in more sustainable manner.

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