Sustainable Cities: Advanced Technological Development Trends

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Introduction

According to the United Nations Human Settlements Programme (UN-HABITAT), the population distribution by city size is categorized as follows: 1 to 5 million - medium-sized cities; 5 to 10 million - large cities; and 10 million or more - mega cities. The Market Intelligence & Consulting Institute (MIC) estimates that the populations of Taiwan's bigger cities in 2025 will be as follows: 4.1 million in New Taipei City; 2.8 million in Taichung City; 2.6 million in Kaohsiung City; 2.5 million in Taipei City; 2.3 million in Taoyuan City; and 1.8 million in Tainan City. All of them are classified as medium-sized cities, based on the UN definition. The Taipei-Keelung metropolitan area can be considered as a mega city from the perspective of regional planning.

"Urbanization" has become an inevitable trend in the development of today's space. However, it has brought about many problems, such as inadequate infrastructure that is unable to meet demands; various types of pollution (air, water, soil, noise, etc.) resulting from the intensive development; waste dumping, resource wasting and scarcity, and other phenomena such as social inequality. The concept of the "sustainable city" was developed to prevent the worsening of the existing problems and the formation of new ones. "Sustainable development" refers to a method of development that meets the needs of the people in the contemporary era without compromising the needs of future generations. A "sustainable city" is defined as improving the quality of life in a city, including environmental, economic, political, and social components, without increasing the burden on future generations. With this in mind, this study defines the technological scope of present-day sustainable cities as grounded in information communication technology to build livable and convenient cities, in the areas of energy, resources, transportation, disaster prevention, healthcare, education, social equality, and other fields.

Sustainable City Technologies: Development Goals and Scenarios

A vision of a future sustainable city life comprehensively shared among major international organizations, pioneering enterprises and advanced countries is one that concerns the following six aspects: "resource recycling," "disaster prevention and resilience," "smart mobility," "low carbon and energy saving," "health and leisure," and "culture, education, and social equality." The technological development goals of each aspect are described as follows:

Resource recycling: To build a resource recycling system that links industries, products, and waste together, to provide sufficient supply of food and water resources, and to create innovative business models.

- Disaster prevention and resilience: Adopting both engineering and non-engineering methods to build a future urban disaster mitigation and management mechanism, to construct an infrastructure capable of reducing disaster impacts, to design internet platforms, and to provide life support energy.
- Smart mobility: To promote smart and green mobility and the use of such vehicles and related devices, including smart cars, the Internet of Vehicles (IoV), electric vehicles, their peripheral environments, as well as vehicle-sharing and other business models.
- Low carbon and energy saving: To enhance

the energy efficiency of building and transportation departments (including public facilities, buildings, public transport, personal vehicles, etc.) and to reduce emissions of greenhouse gases.

- Health and leisure: To assist the medical and healthcare environment by means of information communication technology, to improve the accessibility of the natural and ecological environment, and to enhance the overall quality of life.
- Culture, education, and social equality: To ensure equality and universality of education, employment, infrastructure, and services, and to realize environmental conservation.

The features of sustainable cities cover a wide spectrum. To meet its own need, each city is constructed into a sustainable city with certain local features. In general, they can be classified into four types, including resilient cities, livable cities, clean cities, and resource cities. The scenario for each city type is described as follows:

- Resilient cities: In the face of potential natural disasters, such as typhoons and earthquakes, resulting from future climate change, resilient cities are equipped with solid infrastructure, including strong buildings, railways, highways, and bridges, and a stable energy reaction system. Their resilience minimizes losses incurred due to compound disasters, such as power loss, signal interruptions, casualties, and suspension of commercial and lifestyle services, further caused by floods or collapsed buildings.
- Livable cities: In response to the arrival of an aging society and declining birth rate, cities should build a comprehensive public transportation system with networks of pedestrian and bike lanes, and create green recreation spaces. Equipped with advanced medical and health care, education and learning, and other software and hardware facilities, they are cities with high mobility in which every generation can enjoy urban life.
- Clean cities: After COP21 (the 2015 Paris Climate Conference), the world has been committed to reducing future carbon dioxide emissions. The construction of urban buildings, infrastructure, and transportation systems is high-efficiency, energy saving, green energy, and low carbon-oriented, which will create many green job opportunities. In the future, there will be low carbon cities with high-efficiency solutions.
- Resource cities: Whether resources are sufficient determines a city's basic living condition, industrial activities, and economic growth. When a city can use waste to produce, recycle, and regenerate resources and adopt an urban agriculture model, it can achieve its own self sufficiency as far as material resources, water resources, and food resources are concerned.

Yi-Fang Wang's research areas include transportation planning and simulation, industry technology screening and evaluation, blueprint planning of industrial technology development, and hometown development. Miss Wang has participated in the projects of "Carbon Evaluation Platform for Master Plan and New Buildings", and "Research of Taiwan Industry and Technology Foresight", responsible for evaluating low carbon construction index, and the research of foresight environment and energy technology. Miss Wang holds a Master's degree in transportation management from National Cheng Kung University.

Sustainable City Technologies: Development Directions

Ten common development directions for technological applications are listed below in response to the above mentioned scenarios. They are "climate and disaster prevention," "resilient buildings," "smart green transportation," "low carbon and energy saving," "new energy application," "energy positive and energy saving buildings," "zero waste of resources," "food production," "water resources," and "medical and health care." Each technological development trend is explained in detail below.

Due to climate change and changes in the natural environment, such as that of geographical and geological conditions, the losses and damages caused by natural disasters have been magnified. Other accompanying factors include social and economic development, human activities, high urbanization rate, and changes in society's population structure. Considering these, the technologies developed for "climate and disaster prevention" are those designed for: climate and disaster observation, simulation, forecast, and crisis management, as well as for city resilience against disasters.

In the face of drastic climate changes in the future, buildings must be equipped with high earthquake resistance, fire resistance, and flood resistance capabilities. Therefore, technologies used for constructing resilient buildings are required, including building material application, structural design and construction method, and smart notification and response systems.

As far as smart green transportation is concerned, future vehicles will use different types of energy. Moreover, the communication and connection of actual information will be provided through integrating advanced computer, information, electronics,

communication, and sensing technologies. They help to improve the interaction among different transportation systems, including "road users," "vehicles," and "roads." In doing so, the transportation process will become safer, more efficient, and more comfortable. This will be an integrated transportation model, which works to minimize negative impacts on the environment.

Following the green thinking concept mentioned above, the world in recent years has been active, for the sake of human sustainability, in promoting all kinds of clean energies and developing technologies that enhance energy efficiency. By using more clean energies, reduction of environmental pollution and reduced consumption of fossil energy are expected. Besides green energies, such as solar power, wind power, and ocean energy, non-fossil energies, including biomass energy, hydrogen energy, and solar thermal power, as well as energies produced by other methods (e.g. vibration, electromagnetic waves) are the focus of future new energy technologies.

Energy positive and energy saving buildings are buildings that emphasize the development and promotion of energy saving, waste reduction, and health. They meet different environmental needs, such as daily energy saving, CO2 reduction, and energy production. The technologies involved concern the development of products, materials and equipment, smart spaces, housing environment control and management, etc.

For resource cycles, cities are developing a zero waste model of "Rethink, Reduce, Reuse, Recycle" in contrast to the traditional one of "Recycling, Incineration, Landfilling." That is to say, the technologies for reducing trash production and pollution emissions are particularly important.

In addition, urbanization has changed urban and rural population structures, which further forces a change in the sources of food under the condition of rural population decrease. Meanwhile, climate change has put great pressure on water resources. As heat waves and torrential rains happen more frequently, they will damage crop production and make fatal impacts on food harvest. Therefore, the technologies used for producing food in a highly efficient and energy saving way are the focus for future development.

Water resources include surface water and groundwater that humans can control and use directly for irrigation, power generation, water supply, shipping, and husbandry. Rivers, lakes, water wells, springs, tides, waters of ports, and husbandry waters are also included. Closely related to the development of human civilization, they are an important natural resource indispensable for the development of the national economy. According to the United Nations, a country is defined as experiencing water shortage when annual water supplies drop below 1,700 m3 per person. As Taiwan ranks 18th in terms of water shortage among the countries of the world, it is important for Taiwan to develop the technologies related to water saving, water regeneration, and water cleaning.

Lastly, concerning medical and health care, the development of the following two types of technologies will be required. The first type of technology is used for maintaining the long term health condition of people, including disease and physiology research, disease prediction, and preventive healthcare. The second type of technology is used in response to an aging society, including research on cancers, genes, neuroscience, and bioinformatics.

Since the technologies applied to building sustainable cities are diverse, it is important for a city to understand its strength to develop its own sustainable features before pursuing any technological development. On the one hand, this can be considered from the perspective of supply, because a city's existing resources are the capability indicators for a city to formulate its future technological development direction. On the other hand, this can also be considered from the perspective of demands through exploring a city's future tasks and the corresponding technologies in need. In doing so, comprehensive evaluations will be generated for developing sustainable cities with distinctive local features.