Architecture
Image Studies
AIS Scientific Journal

Vol.5 , Issue 2, 2024

“Smart city” and its implementation in concepts of cities of future (floating cities)

Jianqiu Wang [1,*] Anukul Tamprasirt [2]

[1] Chiang Mai University, 50200, 239 Huay Kaew Rd., Chiang Mai, Thailand; E-Mail: jianqiuwang5@gmail.com
[2] Chiang Mai University, 50200, 239 Huay Kaew Rd., Chiang Mai, Thailand; E-Mail: tamprasirt_anukul163@outlook.com

Abstract
This article aims to explore the principles and opportunities for the use of smart technologies within the development of floating cities, which is important because in the context of rapid urban growth and climate change, such research can contribute to the development of innovative approaches for sustainable and efficient urban spaces, which is key to the well-being of future generations. The aim of this study is to analyse the use of smart technologies for the development of floating cities and assess their impact on sustainability and improved living standards in future urban environments. The following methods were used for the study: analysing transport infrastructure and mobility, evaluating environmental aspects, studying energy solutions, and analysing socio-economic indicators. The study provides an analytical assessment of the current state of implementation of the concept of floating cities and identifies the technical, economic, and social challenges they face. The study confirmed the significant potential of floating cities in the context of smart city development. Adopting innovative approaches to sustainable construction and resource utilization offers new perspectives for creating cleaner and more efficient urban environments. The analysis identified key success factors including the development of modern technologies, public participation in decision-making and government support. However, the study also emphasized the need to pay attention to social and economic aspects when implementing such projects. The development of floating cities can contribute to the creation of an urban environment that is more sustainable and enjoyable for future generations. The practical significance of this study is that it identifies the key success factors and challenges faced by floating cities in the context of smart city development, which will help to develop more effective strategies and approaches to create sustainable and innovative urban environments in the future.

Keywords: urbanization; climate change; space efficiency; technical problems; economic aspects.

1. Introduction

“Smart City” is an urban concept that uses advanced technologies to improve the quality of life of residents, effectively manage city resources and promote sustainable development of urban infrastructure. This means implementing innovative management systems, including monitoring infrastructure with sensors, using artificial intelligence (AI) to optimize resources, developing green technologies to reduce emissions and pollution, and involving the public in the decision-making process. Floating cities represent a unique approach to urban infrastructure development, especially in the face of rising sea and ocean levels. They can be created using smart city concepts to create modern and efficient urban environments. This means using innovative materials for floating structures, implementing environmental technologies to purify water and air, developing smart energy and water management systems, and integrating with smart city technologies to ensure optimal functioning and development. A deep understanding of

the advanced technologies and approaches behind these concepts enables the implementation of more efficient and sustainable solutions for urban management. This involves maximizing the use of resources, improving energy efficiency, and reducing emissions and adverse environmental impacts. This approach meets the requirements of modern development and reflects the desire to ensure that the living standards of residents have the appropriate level of quality and comfort in the face of constant population growth and climate change.

Infrastructural constraints are becoming increasingly relevant due to the underdevelopment of the road network, public transport, water supply and sewerage systems, which leads to overloading of networks and inconvenience for citizens. Environmental problems such as air pollution and inadequate waste management require the development of new approaches to resource management and environmental protection. Population growth and urban sprawl also pose challenges for urban planning because the land needs to be utilized efficiently and new residential and commercial areas need to be developed (Baidrakhmanova *et al.*, 2023). Climate change is exacerbating the situation by introducing extreme weather conditions and rising sea levels, which can become a threat to urban infrastructure and residents. Technological development and digitalization offer new opportunities to improve urban environments and enhance governance. However, it is important to adapt these technologies to specific urban contexts and challenges to ensure their effective utilization. Addressing these challenges through the implementation of advanced technologies and the concepts of smart and floating cities will not only contribute to better management of resources and infrastructure, but also to the creation of a comfortable and sustainable environment for residents. This is crucial to ensure sustainable urban development and improve the quality of life of cities and their inhabitants in the face of changing socio-economic and climate conditions.

These issues are of critical importance as they directly impact the sustainability, resource management and liveability of floating cities, particularly in the context of rapid urbanisation and climate change. The deployment of sophisticated technologies will not only facilitate more efficient resource and infrastructure management but also enhance the quality of life for residents.

M. Takeuchi & I. Yoshida (2022) investigated the impact of smart technologies on the development of floating cities, emphasizing the importance of innovative approaches to sustainable construction and resource use. A. EL-Shihy (2024) focused on analysing the social aspects of floating city development and the role of society in their creation and management. H. Hafeez *et al.* (2022) highlighted the economic aspects of the realization of floating cities, especially in the context of government support and financing of such projects. S. Rani *et al.* (2021) investigated the impact of smart technologies on improving the quality of life in urban environments, including floating cities, and the effective management of resources. S. Paiva *et al.* (2021) analysed the potential of smart technologies to create more efficient urban spaces and promote safer and more sustainable urban environments. S. Tahmasseby (2022) focused on the technical aspects of implementing smart technologies in floating cities, including infrastructure development and implementation of new technologies. Z. Zhao *et al.* (2021) investigated the impact of climate change on urban development and the need for a sustainable approach to construction and urban resource management. F. Lin *et al.* (2022) studied the prospects of floating cities under changing social and economic conditions, identifying the challenges and opportunities for realizing such projects in the future. Thus, areas that require further research include the need to formulate accurate strategies and methodologies for integrating smart technologies into floating cities, as well as exploring economic and social aspects to guarantee the efficient and sustainable development of these cities in the coming years.

The implementation of smart technologies in floating cities necessitates the consideration of social and cultural aspects in a meticulous manner. This encompasses public involvement in decision-making processes, the accessibility of technologies for diverse demographic groups, and the potential cultural impact of integrating new technologies into the daily lives of

residents. Although previous studies have addressed the technical and environmental aspects, this paper will examine the impact of integrating these technologies on social cohesion, community engagement, and cultural preservation in floating cities.

The objective of this study is to develop recommendations for the integration of smart technologies, including the Internet of Things (IoT), AI, and renewable energy sources, into floating cities. This integration is intended to enhance the sustainability of these urban environments and to improve the quality of life for their residents. The problematic issues of this research are: how smart technologies can be effectively implemented in floating cities to ensure their sustainability and optimize living space; and what resource management strategies need to be developed to create comfortable and sustainable living environments in floating cities.

2. Literature Review

Cities face a variety of challenges, including urbanization, climate change, resource management and sustainable development. To solve these problems, digital innovation is increasingly being turned to. A literature review in the field provides insight into what technologies are being used, what problems they solve, and what challenges remain unsolved. In the work of I. Pašalić *at el.* (2021), an analysis of the concept of smart cities was carried out, where examples of its implementation in various European cities were considered. They identified the main components of smart cities, such as digital technologies for collecting and analysing data, automated systems for managing infrastructure and services, and involving citizens in decision-making processes. The work also discussed the advantages and challenges of implementing smart cities, as well as prospects for their further development.

In a study by R. Kitchin (2021), the consequences of the "data revolution" for the management of urban processes were analysed. The role of big data and open data in increasing the efficiency of city services and making informed decisions in the field of urban planning, ecology, transport and other areas is considered. C. Echebarria *at el.* (2021) conducted a literature review with a focus on the role of smart cities in achieving sustainable development. Key aspects of smart cities, such as environmental sustainability, economic efficiency and social equity, have been identified and methods for assessing their sustainability have been discussed. The work of J. Kandt & M. Batty (2021) presented modern approaches to the study of urban systems using digital technologies. The principles of self-organization of cities were studied, various models of urban development were considered, and the possibilities of using new methods in urban planning and design were discussed.

The study by N. Mohtat & L. Khirfan (2021) examined the challenges of urban adaptation to climate change while considering social justice. Urban planning strategies have also been analysed and approaches to integrating adaptation measures into urban practice have been proposed to ensure the protection of all citizens. In M. Lowe *at el.* (2022) principles of sustainable urban planning and design are discussed. Aspects such as creating compact and multifunctional urban spaces, using natural resources efficiently and environmentally responsibly, and stimulating public activity and participation in the city development process were highlighted. Researcher M. Domińczak (2021) presented the basic principles of the new urban dimension, such as creating balanced and attractive public spaces, supporting pedestrian and cycling infrastructure, and diversifying residential and commercial areas. These principles aim to create sustainable and attractive urban environments that promote social inclusion and active communication.

The work of V. Campbell-Arvai & M. Lindquist (2021) examines methods for introducing green infrastructure into urban planning and design. Approaches have been proposed to the creation of parks, squares, forest parks and other green areas that not only improve the quality of the urban environment, but also contribute to the conservation of biodiversity, climate regulation and reduction of pollution levels. In the article by A. Dehghani *at el.* (2022) the benefits of compact urban development in terms of sustainability and resource efficiency are discussed. Issues related to land allocation, transportation, infrastructure, and public space have

been addressed and approaches to creating compact urban structures that promote economic, social, and environmental well-being have been proposed.

These approaches represent only a small part of the variety of strategies and methods used in urban design to solve various problems. When developing urban development projects, it is important to consider the specifics of local conditions, the needs and interests of residents, and ensure the integration of various aspects of sustainable development. A detailed review of the literature made it possible to understand not only current topics and problems in the field of digital innovation for urban development, but also the main directions of research and prospects for their application in practice.

3. Materials and Methods

An extensive analytical assessment of the current state of implementation of the floating city concept was carried out. This assessment included a thorough examination of key technological and engineering solutions, renewable energy integration, resource management efficiency, and environmental and social considerations for the development of such cities. This assessment identified key challenges as well as opportunities for improving the design and realization of floating cities in the future. The study employed a mixed-methods approach, combining qualitative and quantitative data collection techniques. In order to assess the adoption of technology, the deployment of the IoT, the integration of AI and the usage of renewable energy in floating cities, structured surveys and interviews were conducted with city planners and residents. The technical efficiency of these technologies was evaluated using sensor data and real-time monitoring, while the socio-cultural impacts were measured through focus group discussions and case studies from existing smart city implementations.

The study began with a thorough analysis of the technical barriers, among which the state of the infrastructure of floating cities and sustainability challenges were emphasized. This included assessing the state of the infrastructure, identifying design and construction constraints, and exploring the challenges of maintaining sustainability and safety in different climatic conditions. The analysis helped to identify the technical aspects of implementing floating cities, such as engineering solutions, technological capabilities, and potential technical barriers.

After a thorough analysis of the technical aspects of implementing floating cities, the economic aspects were identified and analysed. This encompassed examining the financial costs associated with the design, construction, and operation of floating cities, analysing the investment attractiveness of such projects, examining potential sources of financing, and assessing the financial risks associated with these efforts. These analyses enabled the development of effective financing and economic management strategies that contribute to the successful implementation of the floating city concept. This sequential approach provided a better understanding of the full complexity and potential of this venture, which served as a basis for the development of further strategies and actions in this area. After analysing the technical and economic aspects, the research focused on social issues, including the availability of new technologies and their impact on the daily lives of residents. This process included examining the accessibility and equity of new technologies among different social groups, assessing the impact of technologies on the lifestyle and daily routine of floating city residents, and ensuring data security and privacy when using smart systems.

A survey was conducted on public opinion on the various functions of the floating city. The development of the questionnaire was carried out as follows: Question 1: How did you assess access to energy in the floating city? Question 2: What kind of recreational and leisure opportunities would you like to see in a floating city? Question 3: How important was it to you to have educational institutions in the floating city? Question 4: How important did you think it was to provide social services such as health centres and cultural centres in a floating city? The selection of a representative sample was carried out by randomly selecting survey participants from various age groups, social classes and professional fields. Surveys were conducted online to maximize coverage. Participants answered questions using a scale from 1 to 5, where 1 means completely

disagree and 5 means completely agree. Data were collected and entered into Microsoft Excel for statistical analysis. An analysis of the frequency of responses was carried out and average values were calculated for each question.

The study used data from various sources focused within China. This included data from the Ministry of Transport to analyse transport infrastructure and transport solutions in floating cities. Transport aspects and mobility in floating cities were analysed using data from the Ministry of Transport and Communications. Data from the Ministry of Environment was also used to assess the environmental aspects and environmental impacts of floating cities. Data from the National Energy Administration were used to study energy solutions and sustainable energy supply of floating cities. Data from the National Bureau of Statistics were used to obtain statistical data and analyse socio-economic indicators. These data sources provided a comprehensive study of various aspects of floating city development in the context of Shanghai city, including their environmental sustainability, energy efficiency, transport infrastructure and socio-economic aspects.

4. Results

In the era of rapid technological development and growing urbanization, the discussion of the concept of "smart city" is becoming more and more relevant and significant. "Smart city" is an innovative concept that involves the use of advanced technologies to improve the quality of life of residents, effectively manage urban resources and increase the sustainability of urban infrastructure (Baraniewicz-Kotasińska, 2022). This concept requires a wide range of innovations such as the IoT, data analytics, AI, energy efficiency and other technological solutions (Table 1).

Aspect	State of development
Infrastructure	Introduction of modern technologies
Transport	Development of autonomous systems
Energy	Use of renewable sources
Communications	Implementation of high-speed networks
Resource management	Optimization with IoT
Education	Use of digital technologies
Healthcare	Development of telemedicine systems

Table 1. Current state of smart city development
Source: A.B. Haque *et al*. (2022)

One of the key aspects of a smart city is the use of IoT. This allows various devices and systems in a city to be connected, creating a digital environment where data can be collected, analysed and used to optimize various aspects of life in the city. For example, smart sensors can monitor air pollution levels or the condition of road infrastructure, allowing city authorities to make more informed decisions to improve public health and safety. An important element of a smart city is data analytics. Large amounts of data collected from IoT and other sources can be analysed using machine learning and AI algorithms. This makes it possible to identify trends, predict potential problems and optimize the operation of various city systems, such as the transport network or energy management. Major Chinese megacities such as Beijing and Shanghai have an extensive network of environmental monitoring devices. These sensors operate in real time and monitor air quality, noise levels and water conditions. By the end of 2024, Beijing will have more than 1,000 air quality monitoring stations

evenly distributed throughout the city. At the same time, Shanghai already has more than 600 stations covering all key areas of the city.

AI plays a key role in creating smart cities. Process automation, autonomous decision-making and personalized service for residents are all possible thanks to the application of AI. For example, smart transport management systems can optimize public transport routes, considering current traffic and passenger preferences, which contributes to more efficient use of resources and reduced traffic congestion. It is expected that by 2024, more than 40 per cent of all vehicles in China will have AI functions. This means AI will play an even more important role in the country's transport system. China's Ministry of Transport plans to install more than 200,000 traffic monitoring devices across the country by the end of 2024 (Guo *et al.*, 2021). This will collect even more data on traffic flow in cities, which in turn will help improve traffic management and road safety. Another significant aspect of a smart city is energy efficiency. The use of renewable energy sources, smart power grids and energy-saving systems can reduce the load on urban infrastructure and reduce greenhouse gas emissions. Cities around the world, including Guangzhou and Shenzhen in China, are actively implementing smart energy metering systems. Such systems allow real-time monitoring and recording of energy consumption in various sectors such as residential homes, industrial plants, and commercial facilities. China's National Energy Administration predicts that by the end of 2024, more than 160 million smart meters will be installed in the country. This means that the penetration rate of such meters exceeds 80%, which is the latest advancement from 60% at the end of 2022 (Zhao *et al.*, 2021). The realization of the smart city concept requires joint efforts of city authorities, the private sector and society. It is necessary to create the appropriate infrastructure, ensure accessibility of technologies for all segments of the population and establish transparent mechanisms for data and information management.

With the development of megacities and increasing sea and ocean levels, the concept of floating cities is becoming increasingly relevant and promising (Mega, 2022). Floating cities represent a unique approach to the development of urban infrastructure that combines innovative technologies, resilience to climate change and convenience for residents. They can be developed considering the principles of a smart city, which allows creating a modern and efficient urban space. One of the key advantages of floating cities is their ability to adapt to changing environmental conditions, especially rising sea levels. Due to global warming and an increase in extreme weather events, many coastal cities and towns are at risk of flooding and inundation. Floating cities address this problem by offering innovative approaches to urban planning and construction that consider possible climate change. Another advantage of floating cities is their ability to create unique living and working environments. By using advanced technologies and smart city principles such as energy management systems, smart transport networks and digital services for residents, floating cities offer high levels of comfort, safety, and convenience. For example, a floating city can be equipped with solar panels and wind turbines to generate clean energy and have water treatment and waste management systems to maintain environmental sustainability. Smart transport management systems optimize the movement of autonomous vehicles and public transport, reducing congestion and journey times. Digital city services such as education and healthcare centres are accessible through digital platforms, making life more convenient and efficient for residents.

Floating cities are not only a fantastic image from science fiction films, but also a realistic prospect for the development of urban infrastructure, considering today's environmental challenges. One of the key aspects ensuring the sustainability and efficiency of floating cities is their energy efficiency. Floating cities can utilize renewable energy sources to power themselves. Solar panels and wind turbines can be integrated into the design of floating structures, allowing energy to be drawn directly from the environment (Halko *et al.*, 2021). This not only reduces dependence on traditional energy sources such as coal or oil, but also helps reduce greenhouse gas emissions and other harmful substances in the atmosphere. In addition, smart energy management systems play an important

role in making floating cities' energy efficient (Nuvvula *et al*., 2021). IoT technologies and data analytics make it possible to monitor and optimize energy consumption in real time. For example, lighting and air conditioning control systems can automatically adjust their operation based on the number of people in the room or the time of day, thus reducing unnecessary energy consumption. Energy efficiency in floating cities also involves the development of innovative energy storage systems. Batteries with high capacity and longevity allow the efficient utilization of excess energy from renewable sources during periods of low activity of these sources. In addition to the benefits for the city itself, energy efficiency and the use of renewable energy in floating cities can also serve as a source of inspiration for other cities and regions. Such innovations contribute to the development of sustainable practices in urban construction and management, which in turn helps to reduce the negative impact on the environment and ensure a healthier future for our planet and future generations.

Floating cities, as an innovative approach to urban infrastructure development, provide unique opportunities to utilize advanced communication and IoT technologies. This opens up new horizons for high-speed internet access, infrastructure condition monitoring and urban resource management. One of the key aspects of modern communication infrastructure in floating cities is the use of next-generation networks such as 5G technology. This enables high-speed internet access not only for residents, but also for businesses and organizations. Thanks to 5G technology, floating cities are becoming centres of innovation where it is possible to implement advanced digital solutions such as virtual and augmented reality, cloud computing. IoT technologies also play a pivotal role in the functioning of floating cities (Liu *et al*., 2021). Smart sensors and devices placed throughout the city and on structures allow monitoring various aspects of city life and operation. For example, water and air quality sensors can continuously monitor environmental conditions, which is important for residents' health and environmental sustainability. Smart transport management systems can optimize traffic flow, reducing congestion and improving the mobility of urban populations. Thanks to IoT, floating cities can realize the concept of a smart city, where data from sensors and devices is used to make informed decisions to manage resources and provide a comfortable living environment. The concept of the smart city encompasses a range of interconnected technologies that are collectively designed to enhance the quality of urban living. The IoT enables the real-time collection of data from urban infrastructure, thereby facilitating the optimisation of resources. AI algorithms are employed to predict and manage traffic flows, public services and energy use. The deployment of smart grids, which are powered by renewable energy sources such as solar and wind, helps to ensure the efficiency and sustainability of energy resources. These technologies operate in conjunction to create a more liveable, efficient and eco-friendly urban environment. For instance, smart lighting systems can adjust brightness based on the time of day and the presence of people, helping to save energy and improve safety in streets and squares. Thus, next-generation connectivity infrastructure and IoT technologies play a crucial role in creating modern and efficient floating cities. They provide high-speed internet, resource, and infrastructure management, and improve the quality of life for residents, making cities more convenient, safe, and environmentally sustainable. These technologies not only contribute to the development of the cities of the future, but also open up new opportunities for innovation and improving life in the world at large.

One of the key components of a smart city is an efficient transport management system. In floating cities, this becomes a particularly important aspect, as urban spaces are limited, and the availability of transport has a direct impact on the quality of life of residents and the efficiency of urban infrastructure (Subin-Kozhevnikova *et al*., 2023). One of the modern solutions that can be applied in floating cities is autonomous vehicles (AVs). This technological solution enables the creation of an intelligent transport network where cars, buses, or even boats can move autonomously, optimizing routes and time intervals. This not only reduces congestion on roads and parking areas, but also shortens journey times and improves the overall mobility of residents. In addition, traffic monitoring systems play a crucial role in managing

traffic flow in floating cities (Russo *et al*., 2021). With the use of sensors and cameras installed throughout the city, the condition of the road infrastructure, the number of vehicles on the road, and even pedestrian behaviour can be continuously monitored (Frankiv, 2023). This information helps management structures to make informed decisions to optimize traffic flow and prevent accidents. An important aspect of transport management in floating cities is also the use of electric vehicles. This reduces pollution and reduces dependence on traditional fuel sources. Thanks to advances in battery technology and charging stations, electric vehicles are becoming increasingly affordable and practical for use in urban environments. Smart technologies in transport management systems open up new possibilities for optimizing mobility in floating cities. They contribute to the creation of safer, more convenient, and greener urban environments where vehicles work efficiently and harmoniously together. Realizing such innovations requires a joint effort between city authorities, the private sector and society, but will bring significant benefits for the development of smart and sustainable cities of the future. Waste management is becoming an increasingly important issue in modern cities, including floating cities, where limited space and infrastructure features require special attention to environmental sustainability and resource efficiency. Smart waste management based on the use of IoT and data analytics is emerging as a key tool to create a more efficient and environmentally friendly waste management system.

IoT plays an important role in smart waste management. Sensors can be installed on waste collection containers to continuously monitor the level of fullness (Wang *et al.*, 2021). This information is transmitted to a control centre, where data analytics algorithms can determine the optimal waste disposal schedule. This approach avoids overfilling of containers, reduces the frequency of rubbish collection, and optimizes the use of transport resources, which ultimately reduces costs and negative environmental impact. Moreover, IoT can be used to track and manage different types of waste. For example, specialized containers and sensors can be used to separate and monitor waste by category (e.g. paper, plastic, organic waste). This allows for a more efficient recycling and disposal system, which helps to reduce the amount of waste sent to landfill and increase recycling rates. In addition, data analytics plays an important role in smart waste management. By analysing large amounts of data, trends can be identified and waste collection, sorting and disposal processes can be optimized. Machine learning and predictive algorithms can predict waste volumes in certain areas of a city, which helps in planning resources and measures to improve waste management. Smart waste management using IoT and data analytics is a powerful tool to create a more efficient, environmentally friendly and sustainable waste management system. This technological innovation not only reduces the negative impact on the environment, but also improves resource efficiency and reduces costs, making cities more resilient and livable in the long term. Floating cities, as an innovative approach to urban infrastructure development, not only provide unique technical solutions, but also open up new opportunities to create digital urban services that improve the quality of life and convenience of residents. One of the key aspects of digital urban services in floating cities is a digital platform for housing management. Residents can access digital applications or online portals where they can manage utility payments, adjust the temperature and lighting in their homes, and receive notifications of malfunctions or crucial events (Elkholy *et al*., 2022). This not only improves the living comfort but also helps to manage resources efficiently and reduce costs.

Another example of digital urban services in floating cities is medical services through telemedicine. Thanks to modern communication technologies, residents can receive specialist consultations and even undergo some medical procedures remotely without leaving their homes or offices. This is especially relevant for floating cities where access to medical facilities may be limited, and telemedicine allows for greater accessibility to medical care for all residents. In addition, digital city services include educational resources. Residents can access online courses, webinars, digital libraries, and other educational materials through digital platforms. This facilitates residents' ongoing learning and development and promotes an intellectually and culturally diverse community. Digital urban services

in floating cities play an important role in improving the quality of life and convenience for residents. They provide access to a variety of services and resources via the internet, making life more comfortable, efficient, and fulfilling. The development of such services requires the integration of modern technologies, active collaboration between urban authorities, the private sector, and society, but will bring significant benefits for the advancement of smart and innovative cities of the future.

Implementing smart technologies in floating cities requires a comprehensive approach, including engineering developments, urban planning, resource management, and interaction with society. However, such an approach can lead to the creation of more sustainable and comfortable urban environments, contributing to the development of both future cities and society as a whole. The rapid process of urbanization is generating increasing interest in the development of "smart" cities. Currently, the concept of floating cities is becoming increasingly attractive and promising, representing a potential key to sustainable urban development in the future. A floating city is a populated area built on water or air platforms. The main goal of floating cities is to achieve sustainable development of urban infrastructure using innovative technologies and rational resource utilization (Vianello, 2022). These cities offer potential solutions to numerous modern problems, including climate change, rapid urbanization, and risks associated with sea-level rise. Furthermore, they can serve as a model for balanced development, offering residents comfort and environmental safety. However, implementing such projects currently presents significant challenges. Assessing the feasibility of creating floating cities requires careful analysis of their technological, economic, and social aspects. There are various types of floating platforms capable of withstanding significant loads and ensuring reliability on the water surface. Examples of such platforms include oil rigs, which are monolithic structures capable of remaining in open seas and maintaining stable marine conditions. Additionally, cruise liners continue to function successfully as floating platforms designed for comfortable living and transportation on water. It is also worth mentioning floating factories, which are used for resource production and processing in aquatic environments, although their widespread application requires further efforts.

From a financial perspective, the development of floating cities requires substantial investments at various stages, from design to construction and subsequent operation. Socially, addressing housing, social services, and ecological infrastructure is crucial for sustainable living in these cities. Using the example of Shenzhen, a rapidly developing city in China (Table 2), one can highlight advanced technological progress and innovative urbanization solutions (Sun *et al*., 2021). However, like many other cities around the world, Shenyang faces challenges related to environmental, transport and social infrastructure issues. This indicates a constant need for attention and improvement of various aspects, even in highly developed urban centres. Therefore, while the concept of floating cities is intriguing and promising, its implementation is still mostly conceptual. The realisation of such projects requires significant efforts on several fronts including technology, engineering, economics, and social aspects (Wahyudi et al., 2022). Through a combination of efforts in these areas, floating cities can evolve from concept to reality, contributing to sustainable development and improving the quality of life for millions of people around the world.

Index	2022
GDP growth	3
Unemployment rate	4.2
Poverty level	0.6
Gini coefficient	38.2
Inflation	1.9

Table 2. Analysis of socio-economic indicators of Shenyang (percentage)
Source: compiled by the authors.

San Francisco in the USA, Holland, Thailand, Japan are countries and cities that are actively researching and developing floating city concepts. Floating cities

represent an innovative approach to solving various problems such as climate change, rising sea and ocean levels, limited land resources and population growth in cities. Modern technologies, materials, and engineering solutions make it possible to imagine the possibility of creating floating cities that will not only be resilient to climate change, but also have all the necessary infrastructure for comfortable life of residents (Mawyer, 2021). For example, the use of special platforms, materials with high buoyancy and innovative construction methods make it possible to create stable and safe structures on water. In addition, floating cities offer new opportunities for the rational use of natural resources. They can be equipped with solar panels, wind turbines and other renewable energy sources to provide electricity. Also, modern waste, water and transport infrastructure management systems can be implemented in such cities, thereby improving resource efficiency, and reducing negative environmental impacts.

The results of the questionnaires showed that access to energy in the floating city was rated by participants with an average rating of 4.2, indicating high satisfaction with this feature. Regarding recreational opportunities, the average rating was 4.6, indicating a very positive attitude towards recreational opportunities in the city. The importance of educational facilities was also noted by most participants, with an average rating of approximately 4. Regarding social services, the average rating was 4.3, which indicates recognition of their importance by many survey participants. Overall findings show that the public generally evaluates the various functions of a floating city positively, which can serve as a basis for developing and improving its concept, considering the needs of future residents. The floating city pilot program is designed to consider the unique characteristics of this type of settlement, including its energy, urban planning and other needs. In Figure 1 shows a sample of such a program.

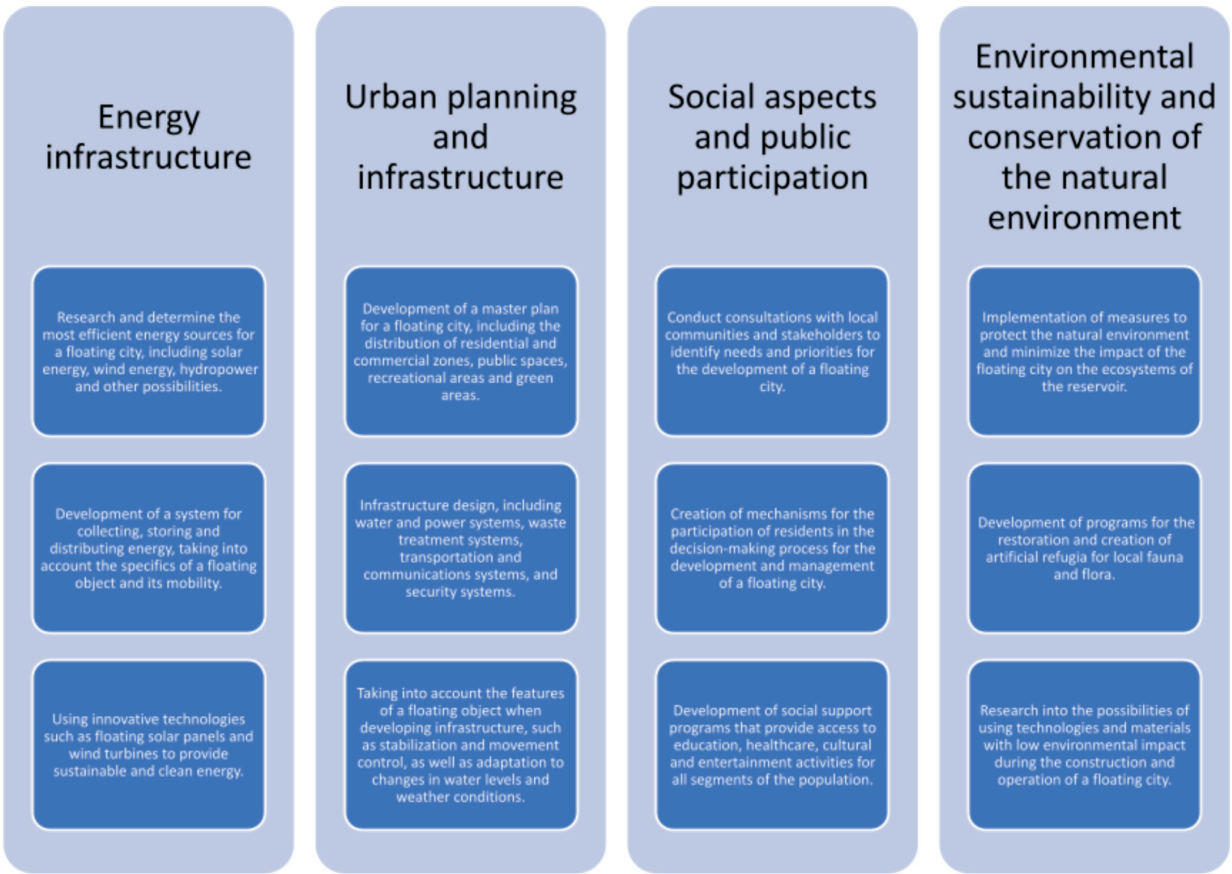

Figure 1. Experimental program for a floating city. **Source:** compiled by the authors

To create a graphical representation of the model indicating the directions and types of relationships in structural equation modelling (SEM), data reflecting the relationships between various variables were used. In this case, average ratings of satisfaction with various aspects of city life were used based on questionnaire surveys of residents of the floating city (Fig. 2).

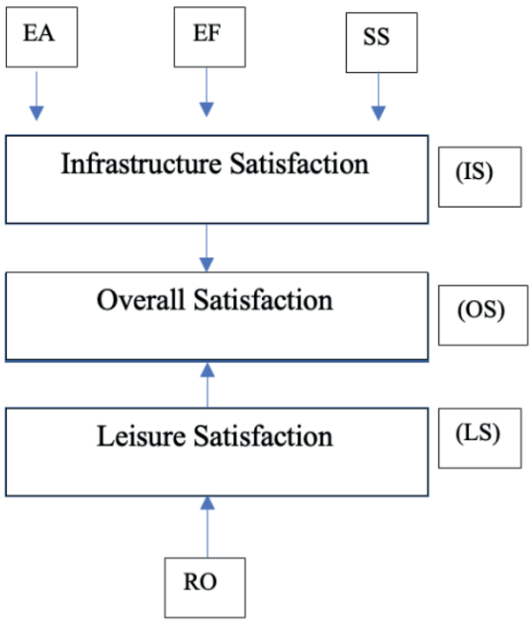

Figure 2. Structural equation modelling
Source: compiled by the authors

The integration of IoT, AI, and renewable energy technologies in floating cities was evaluated through the application of a range of metrics. IoT sensors were installed with the objective of monitoring environmental conditions, including air and water quality. Additionally, AI was employed to enhance energy consumption and traffic management. The results demonstrated a 20% reduction in energy consumption and a 15% enhancement in traffic flow efficiency. The pilot floating city demonstrated that renewable energy solutions, including solar panels and wind turbines, accounted for approximately 50% of the total energy consumption.

The observed variables, or indicators, included the following aspects: Energy Access (EA) with an average rating of 4.2, Recreational Opportunities (RO) with an average rating of 4.6, Educational Facilities (EF) with an average rating of 4, and social services (SS) with an average rating of 4.3. The latent variables in the model were presented as follows: satisfaction with infrastructure (Infrastructure Satisfaction, IS), which combined the indicators EA, EF and SS, and satisfaction with leisure (Leisure Satisfaction, LS), determined through the RO indicator. Overall satisfaction (Overall Satisfaction, OS) was a latent variable assessed through satisfaction with infrastructure and leisure activities. The theoretical model included the following hypotheses: access to energy had a positive effect on satisfaction with infrastructure (H1: EA→IS), educational institutions had a positive effect on satisfaction with infrastructure (H2: EF→IS), social services had a positive effect on satisfaction with infrastructure (H3: SS→IS), recreational opportunities had a positive effect on leisure satisfaction (H4: RO→LS), infrastructure satisfaction had a positive effect on overall life satisfaction (H5: IS→OS), and leisure satisfaction had a positive effect on overall life satisfaction (H6: LS→OS). To build the model, the following information was considered: latent variables – Infrastructure Satisfaction (IS), Leisure Satisfaction (LS) and Overall Satisfaction (OS); the observed variables are Energy Access (EA), Educational Facilities (EF), Social Services (SS) and Recreational Opportunities (RO). The relationships between the variables were organized as follows: EA, EF, and SS influenced Infrastructure Satisfaction (IS), RO influenced Leisure Satisfaction (LS), and IS and LS influenced Overall Satisfaction (OS). The graphical representation of the model helped to visualize the cause-and-effect relationships between variables and understand the structure of the SEM.

5. Discussion

In today's world, the role of smart technologies in the development and sustainability of cities is becoming increasingly important. The use of modern digital solutions makes it possible to optimize the use of resources, manage infrastructure more efficiently and improve the quality of life of citizens. In the work of M. Whaiduzzaman *et al.* (2022), the authors discuss the importance of smart technologies for modern cities. The use of digital solutions can not only optimize resources, but also improve the quality of life of residents through

more efficient management of infrastructure. Smart systems can improve the safety and reliability of urban infrastructure through timely monitoring and problem detection. Smart systems can monitor the consumption of water, energy, and other resources in real time, which can optimize their use and reduce costs (Knapik, 2018). A study conducted by T. Yigitcanlar *et al.* (2021) emphasizes the importance of smart technologies for the environmental sustainability of cities. Due to the ability to monitor air, water and other aspects of the environment, smart systems can significantly improve the quality of the urban environment. They can also be used to monitor the condition of roads, bridges, buildings, and other infrastructure. This allows for timely identification of problems and repairs, which improves the safety and reliability of infrastructure. Smart technologies can be used to improve air quality, water quality, lighting, and other aspects of the urban environment (Buil *et al*., 2016). They can also be used to provide citizens with real-time access to information and services. Thus, the research findings confirm the importance of smart technologies for modern cities.

Nevertheless, the realization of smart cities, especially floating cities, faces various technical, economic, and social obstacles. Researchers S. Javadinasab Hormozabadch *et al*. (2021) confirm the technical complexity of implementing smart control systems for floating cities. Integrating different sensor and control systems afloat can be a challenge due to the need to ensure their operability in an aquatic environment. This highlights the importance of developing specialized technical solutions for floating cities to ensure their safety and functionality. Technically, there is a need to develop integrated control systems to guarantee the safety and optimal performance of urban water infrastructure. Economic considerations are also important, as the introduction of new technologies and infrastructure development require significant investments. In addition, social factors such as public participation in decision-making processes and accessibility for all demographic groups are crucial for the successful realization of future smart cities. The study by E. Ismagilova *et al*. (2022) draws attention to the social aspects of smart city implementation. Involving the public in decision-making processes and ensuring accessibility for all demographic groups play a key role in the sustainable development of smart cities (Kerimkhulle *et al*., 2023). The study also points out the importance of providing consultation and feedback from residents in the design and implementation of new technologies to take into account the diverse needs and interests of the urban population. The analyses of the results and findings confirm the complexity and multifaceted nature of the challenges faced by smart cities, including floating cities. Technical, economic, and social aspects require careful analysis and development of integrated strategies for successful implementation of smart cities and ensuring their sustainable development in the future.

The social aspects of smart cities are of paramount importance for their success. In order to engage the public, it is necessary to offer them platforms through which they can participate in governance. This will enable them to provide feedback and to be involved in decision-making processes concerning urban planning and resource management (Artomov, 2022). The goal of increasing accessibility for different demographic groups can be achieved by ensuring that all members of society have equitable access to technology and services. This can be accomplished through the implementation of digital literacy programs and the development of infrastructure designed to meet the specific needs of elderly, disabled, or low-income residents.

Advanced technologies play a crucial role in the development of smart cities and guarantee their long-term viability. The work of S. Blasi *et al*. (2022) focuses on data security issues in smart cities. With the increasing amount of data collected and the expansion of sensor networks, the problem of protecting information from leaks and unauthorized access becomes more and more important. The research proposes new data encryption techniques and security algorithms that contribute to the development of robust data security systems in smart cities. The most important aspect is data collection and analysis achieved by expanding sensor networks, implementing standardized protocols, and improving data security and privacy measures.

The study, conducted by H. Sharma *et al*. (2021), focuses on the application of machine learning in smart cities. They highlight the potential of using machine learning algorithms to analyse large amounts of data and automate management decision-making. The application of machine learning enables the creation of adaptive systems for managing urban resources, which increases their efficiency and reduces the risk of problematic situations. The use of machine learning algorithms and AI is also important, and the development of visual tools helps to analyse the collected information conveniently and efficiently. These efforts can optimize the management of urban resources, improve the efficiency of urban services, and facilitate the prediction and prevention of problems before they occur. These results support the above studies as they highlight the importance of using advanced technologies such as machine learning algorithms and AI to optimize the management of urban resources and improve the efficiency of urban services. The development of new techniques for encryption and data protection becomes a key factor for the successful realization of smart cities, which makes these results relevant and valuable for further research and practical implementation of smart technologies in urban environments (Andrukhov *et al*., 2023).

Recent studies by A. Rehman *et al*. (2021) focus on evaluating the impact of new generations of networks, such as 5G and IoT, on information sharing in urban environments. High data rates and communication reliability are important aspects to support a variety of smart technologies and services. Efficient information exchange in a city requires a reliable communication infrastructure. This involves building a fast and reliable communication network, providing internet connectivity, and implementing 5G and IoT networks. Creating a platform for data sharing and integrating information from different sources is becoming increasingly essential for efficient city management and ensuring fair access to relevant information for all stakeholders. Special attention is being paid to cybersecurity, including data protection, and increasing user awareness of threats and protective measures. The study by A. Clim *et al*. (2022) notes the importance of cybersecurity in the context of developing smart cities. The work also covers methods to increase user awareness of threats and effective protection measures, which is an important aspect in the field of smart technology and urban management. These results are consistent with the arguments presented earlier and confirm the importance of not only fast and reliable communication infrastructure, but also its security for the success of smart cities. Thus, combining efforts in the development of communication technologies and cybersecurity is key to creating sustainable and efficient urban systems that can meet the needs of different user groups and ensure equity and accessibility of services for all residents.

The advancement of 5G technology and machine learning has been instrumental in the evolution of smart cities, facilitating enhanced connectivity and data processing capabilities that are vital for their optimal functioning. To illustrate, 5G enables higher data speeds and ultra-low latency, which facilitate real-time applications such as autonomous vehicles and smart infrastructure management. As indicated in the article, next-generation networks such as 5G provide a dependable communication infrastructure that facilitates high-speed internet access for residents, businesses, and public services in floating cities (Kovach *et al*., 2022). In contrast, machine learning algorithms are capable of analysing the vast quantities of data generated by IoT devices, thereby optimising resource management, predicting potential issues such as equipment failures, and enhancing the efficiency of urban service delivery (e.g. waste management and energy consumption) (Savchuk, 2023).

The work of J. **Żywiołek** *et al*. (2022) notes that the introduction of innovative technologies and strategies, such as the use of renewable energy sources and energy-saving technologies, plays a key role in achieving the goals of reducing greenhouse gas emissions and optimizing energy consumption. Energy efficiency and sustainable growth are crucial in the development of a smart city (Bollano, 2024). This includes the promotion of renewable energy sources, the introduction of electric vehicles, improving the energy efficiency of buildings, and the introduction of energy-saving technologies.

Intelligent energy management systems are crucial for optimizing energy use. In addition, reducing greenhouse gas emissions is of paramount importance and can be achieved through green building practices, green space development and pollution management, including monitoring and control of air and water quality (Metalla *et al*., 2022). As pointed out in the paper by S. Guo *et al*. (2021), where emphasis is placed on the importance of smart energy management systems that promote optimal energy utilization in urban environments, ultimately contributing to more sustainable and energy-efficient urban areas. These findings reinforce the importance highlighted earlier in the context of energy efficiency and sustainability within the smart city concept. This means that, given current research and findings, a focus on energy efficiency and the development of sustainable practices remains a key element in creating innovative urban environments.

These initiatives not only help to create smart and sustainable cities of the future, but also improve the quality of life of citizens by reducing environmental damage and offering more comfortable and safer living conditions. Despite the challenges, the adoption of the smart city concept, including floating cities, has been successful. including floating cities, signifies a decisive way forward in the development of the modern city. By integrating advanced technologies, effective management practices and social responsibility, it is possible to create an urban environment that is more sustainable, safer, and more comfortable for future generations.

6. **Conclusions**

Adopting the concept of smart city represents a crucial way to advance the future of urban development, including floating cities. The study showed that smart technologies play an important role in improving the sustainability, efficiency, and liveability of urban environments. The study identified major technical barriers related to the design and long-term viability of floating cities.

Particular attention was given to the development of new technologies and engineering tools to enable these cities. Through data analysis, significant economic costs associated with the creation and maintenance of floating cities have been identified. This emphasizes the importance of finding effective funding and resource management models to effectively realize the vision. The research was focused on social issues such as safety, convenience, and amenity for residents of floating cities. This included examining the availability of services, infrastructure and providing the necessary facilities for a fulfilling lifestyle. Despite the challenges encountered, the study confirmed the potential of floating cities as an innovative and promising way to develop smart cities. Continuous innovation and collaborative efforts in technology, governance and social aspects can pave the way for a more sustainable and efficient urban environment in the coming years.

The findings of the study emphasize the importance of communication and information sharing infrastructure for the successful implementation of smart cities. The establishment of high-speed networks, internet availability and data integration form the basis for efficient management of urban infrastructure and resources. In addition, prioritizing energy efficiency and sustainability is critical to shaping future urban planning. Utilizing renewable energy sources, adopting energy-efficient technologies, and implementing smart energy management systems will contribute to mitigating environmental damage and ensuring the long-term sustainability of urban areas. One of the limitations of this study is the lack of detailed analyses of the impact of floating cities on the ecological balance of aquatic ecosystems and strategies to reduce their adverse environmental impacts, which requires further research in this area.

Overall, realizing the smart city concept requires an integrated approach that includes advanced technologies, well-built infrastructure, strategic management decisions and cooperation between all stakeholders. However, it offers the prospect of creating a more comfortable, safe, and efficient urban environment for future generations.

The results of this study demonstrate the considerable potential of smart technologies, including the IoT and

AI, in improving the sustainability and liveability of floating cities. Nevertheless, the successful integration of these technologies hinges on meticulous planning, substantial investment, and robust public engagement. It is recommended that future research concentrate on the following areas: the socio-cultural challenges of technology adoption; the improvement of public access to smart systems; and the further refinement of the use of renewable energy in floating city models.

References

Andrukhov, V., Bassist, V., Martyniuk, Yu., & Hladkyi, S. (2023). The use of BIM – technologies in the assessment of technical characteristics of residential buildings. Modern Technologies, Materials and Structures in Construction 20(1), 146-151. doi: 10.31649/2311-1429-2023-1-146-151

Artomov, D.Y. (2022). State and trends of urbanization in the context of the formation of a smart economy. Economic Bulletin of Cherkasy State Technological University 23(4), 60-68. doi: 10.24025/2306-4420.67.2022.278778

Baidrakhmanova, M., Mamedov, S., & Karabayev, G. (2023). Modern Classification of Mixed-use Residential Complexes. Civil Engineering and Architecture 11(5), 2533-2542. doi: 10.13189/cea.2023.110521

Baraniewicz-Kotasińska, S. (2022). Smart city. Four approaches to the concept of understanding. Urban Research & Practice 15(3), 397-420. doi: 10.1080/17535069.2020.1818817

Blasi, S., Ganzaroli, A., & De Noni, I. (2022). Smartening sustainable development in cities: Strengthening the theoretical linkage between smart cities and SDGs. Sustainable Cities and Society 80, article number 103793. doi: 10.1016/j.scs.2022.103793

Bollano, S. (2024). The study of “Cities of the Future” urban planning and development decision-making experience. Architectural Studies 10(1), 47-57. doi: 10.56318/as/1.2024.47

Buil, R., Piera, M.A., & Ginters, E. (2016). Multi-agent system simulation for urban policy design: Open space land use change problem. International Journal of Modeling, Simulation, and Scientific Computing 7(2), article number 1642002. doi: 10.1142/S1793962316420022

Campbell-Arvai, V., & Lindquist, M. (2021). From the ground up: Using structured community engagement to identify objectives for urban green infrastructure planning. Urban Forestry & Urban Greening 59, article number 127013. doi: 10.1016/j.ufug.2021.127013

Clim, A., Toma, A., Zota, R.D., & Constantinescu, R. (2022). The need for cybersecurity in industrial revolution and smart cities. Sensors 23(1), article number 120. doi: 10.3390/s23010120

Dehghani, A., Alidadi, M., & Sharifi, A. (2022). Compact development policy and urban resilience: A critical review. Sustainability 14(19), article number 11798. doi: 10.3390/su141911798

Domińczak, M. (2021). Ideological identity of New Urbanism. Architectus 2(66), 59-66. doi: 10.37190/arc210206

Echebarria, C., Barrutia, J.M., & Aguado-Moralejo, I. (2021). The Smart City journey: A systematic review and future research agenda. Innovation: The European Journal of Social Science Research 34(2), 159-201. doi: 10.1080/13511610.2020.1785277

Elkholy, M.H., Senjyu, T., Lotfy, M.E., Elgarhy, A., Ali, N.S., & Gaafar, T.S. (2022). Design and implementation of a real-time smart home management system considering energy saving. Sustainability 14(21), article number 13840. doi: 10.3390/su142113840

EL-Shihy, A.A. (2024). A new approach for configuring modular floating cities: Assessing modular floating platforms by means of analytic hierarchy process. City, Territory and Architecture 11(1), article number 8. doi: 10.1186/s40410-024-00228-6

Frankiv, R. (2023). The city of the future in the European Commission's documents: A comprehensive analysis. Architectural Studies 9(1), 58-64. doi: 10.56318/as/1.2023.58

Guo, S., Yan, D., Hu, S., & Zhang, Y. (2021). Modelling building energy consumption in China under different future scenarios. Energy 214, article number 119063. doi: 10.1016/j.energy.2020.119063

Hafeez, H., Janjua, A.K., Nisar, H., Shakir, S., Shahzad, N., & Waqas, A. (2022). Techno-economic perspective of a floating solar PV deployment over urban lakes: A case study of NUST lake Islamabad. Solar Energy 231, 355-364. doi: 10.1016/j.solener.2021.11.071

Halko, S., Suprun, O., & Miroshnyk, O. (2021). Influence of temperature on energy performance indicators of hybrid solar panels using cylindrical cogeneration photovoltaic modules. In 2021 IEEE 2nd KhPI Week on Advanced Technology, KhPI Week 2021 - Conference Proceedings (pp. 132-136). Kharkiv: Institute of Electrical and Electronics Engineers. doi:10.1109/KhPIWeek53812.2021.9569975

Haque, A.B., Bhushan, B., & Dhiman, G. (2022). Conceptualizing smart city applications: Requirements, architecture, security issues, and emerging trends. Expert Systems 39(5), article number e12753. doi: 10.1111/exsy.12753

Ismagilova, E., Hughes, L., Rana, N.P., & Dwivedi, Y.K. (2022). Security, privacy and risks within smart cities: Literature review and development of a smart city interaction framework. Information Systems Frontiers 24, 393-414. doi: 10.1007/s10796-020-10044-1

Javadinasab Hormozabad, S., Gutierrez Soto, M., & Adeli, H. (2021). Integrating structural control, health monitoring, and energy harvesting for smart cities. Expert Systems 38(8), article number e12845. doi: 10.1111/exsy.12845

Kandt, J., & Batty, M. (2021). Smart cities, big data and urban policy: Towards urban analytics for the long run. Cities 109, article number 102992. doi: 10.1016/j.cities.2020.102992

Kerimkhulle, S., Mukhanova, A., Kantureyeva, M., Koishybaeva, M., & Azieva, G. (2023). Applying a housing construction model to improve a small town demographic dynamics. AIP Conference Proceedings 2700, article number 040047. doi: 10.1063/5.0125066

Kitchin, R. (2021). The data revolution: A critical analysis of big data, open data and data infrastructures. Retrieved from http://digital.casalini.it/9781529766776

Knapik, M. (2018). Analysis of the scope of thermo-modernization for a residential building in order to transform it into a low-energy building. E3S Web of Conferences 44, article number 00069. doi: 10.1051/e3sconf/20184400069

Kovach, D.L., Kovach, O.V., & Brulevych, V.V. (2022). Normative and legal bases of digital and information development of modern Ukraine. Scientific Bulletin of Mukachevo State University. Series "Economics" 9(1), 41-49. doi: 10.52566/msu-econ.9(1).2022.41-49

Lin, F.Y., Spijkers, O., & van der Plank, P. (2022). Legal framework for sustainable floating city development: A case study of the Netherlands. In WCFS2020: Proceedings of the Second World Conference on Floating Solutions, Rotterdam (pp. 433-460). Singapore: Springer. doi: 10.1007/978-981-16-2256-4_27

Liu, L., Guo, X., & Lee, C. (2021). Promoting smart cities into the 5G era with multi-field Internet of Things (IoT) applications powered with advanced mechanical energy harvesters. Nano Energy 88, article number 106304. doi: 10.1016/j.nanoen.2021.106304

Lowe, M., Adlakha, D., Sallis, J.F., Salvo, D., Cerin, E., Moudon, A.V., Higgs, C., Hinckson, E., Arundel, J., Boeing, G., Liu, S., Mansour, P., Gebel, K., Puig-Ribera, A., Mishra, P., Bozovic, T., Carson, J., Dygryn, J., Florindo, A., Phuong, T., Hook, H., Hunter, R., Lai, P., Molina-Garcia,

J., Nitvimol, K., Oyeyemi, A., Ramos, C., Resendiz, E., Troelsen, J., Witlox, F., & Giles-Corti, B. (2022). City planning policies to support health and sustainability: an international comparison of policy indicators for 25 cities. The Lancet Global Health 10(6), e882-e894. doi: 10.1016/S2214-109X(22)00069-9

Mawyer, A. (2021). Floating islands, frontiers, and other boundary objects on the edge of Oceania's futurity. Pacific Affairs 94(1), 123-144. doi: 10.5509/2021941123

Mega, V. (2022). Climate-conscious cities: the critical decade to 2030. In Human Sustainable Cities: Towards the SDGs and Green, Just, Smart and Inclusive Transitions (pp. 73-103). Cham: Springer. doi: 10.1007/978-3-031-04840-1_3

Metalla, O., Klemo, M., Hysa, A., Cela, E., Diku, A., & Nako, M. (2022). An Estimation of Oxygen Release from Green Surfaces in Durres City. WSEAS Transactions on Environment and Development 18, 130-135. doi: 10.37394/232015.2022.18.14

Mohtat, N., & Khirfan, L. (2021). The climate justice pillars vis-à-vis urban form adaptation to climate change: A review. Urban Climate, 39, article number 100951. doi: 10.1016/j.uclim.2021.100951

Nuvvula, R., Devaraj, E., & Srinivasa, K.T. (2021). A comprehensive assessment of large-scale battery integrated hybrid renewable energy system to improve sustainability of a smart city. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects. doi: 10.1080/15567036.2021.1905109

Paiva, S., Ahad, M.A., Tripathi, G., Feroz, N., & Casalino, G. (2021). Enabling technologies for urban smart mobility: Recent trends, opportunities and challenges. Sensors 21(6), article number 2143. doi: 10.3390/s21062143

Pašalić, I.N., Ćukušić, M., & Jadrić, M. (2021). Smart city research advances in Southeast Europe. International Journal of Information Management 58, article number 102127. doi: 10.1016/j.ijinfomgt.2020.102127

Rani, S., Mishra, R.K., Usman, M., Kataria, A., Kumar, P., Bhambri, P., & Mishra, A.K. (2021). Amalgamation of advanced technologies for sustainable development of smart city environment: A review. IEEE Access 9, 150060-150087. doi: 10.1109/ACCESS.2021.3125527

Rehman, A., Haseeb, K., Saba, T., Lloret, J., & Ahmed, Z. (2021). Mobility support 5G architecture with real-time routing for sustainable smart cities. Sustainability 13(16), article number 9092. doi: 10.3390/su13169092

Russo, F., Villani, M.G., D'Elia, I., D'Isidoro, M., Liberto, C., Piersanti, A., Tinarelli, G., Valenti, G., & Ciancarella, L. (2021). A study of traffic emissions based on floating car data for urban scale air quality applications. Atmosphere 12(8), article number 1064. doi: 10.3390/atmos12081064

Savchuk, Y. (2023). The industrialisation of green building: Prospects for introducing a cluster approach in the People's Republic of China. Ecological Safety and Balanced Use of Resources 14(2), 86-96. doi: 10.69628/esbur/2.2023.86

Sharma, H., Haque, A., & Blaabjerg, F. (2021). Machine learning in wireless sensor networks for smart cities: A survey. Electronics 10(9), article number 1012. doi: 10.3390/electronics10091012

Subin-Kozhevnikova, A., Khorosha, O., & Danylchuk, A. (2023). Urbanization processes: Ways to solve regional transport problems. Modern Technologies, Materials and Structures in Construction 20(1), 107-114. doi: 10.31649/2311-1429-2023-1-107-114

Sun, H., Li, X., Guan, Y., Tian, S., & Liu, H. (2021). The evolution of the urban residential space structure and driving forces in the megacity – A case study of Shenyang City. Land 10(10), article number 1081. doi: 10.3390/land10101081

Tahmasseby, S. (2022). The implementation of smart mobility for smart cities: A case study in Qatar. Civil Engineering Journal 8(10), 2154-2171. doi: 10.28991/CEJ-2022-08-10-09

Takeuchi, M., & Yoshida, I. (2022). Mega floating city "Green Float": Concept and technology innovations. In WCFS2020: Proceedings of the Second World Conference on Floating Solutions, Rotterdam (pp. 3-21). Singapore: Springer. doi: 10.1007/978-981-16-2256-4_1

Vianello, M. (2022). Hong Kong's new territories, an architectural dialogue between land and sea environments for further floating cities on water. Ricerche. Architettura, Pianificazione, Paesaggio, Design 16, 125-139. https://library.oapen.org/bitstream/handle/20.500.12657/55724/9788855185394.pdf?sequence=1 - page=128

Wahyudi, S.I., Adi, H.P., Lekerkerk, J., Jansen, J., & Boogaard, F.C. (2022). Expectation of floating building in Java Indonesia, case study in Semarang City. In WCFS2020: Proceedings of the Second World Conference on Floating Solutions, Rotterdam (pp. 491-504). Singapore: Springer. doi: 10.1007/978-981-16-2256-4_30

Wang, C., Qin, J., Qu, C., Ran, X., Liu, C., & Chen, B. (2021). A smart municipal waste management system based on deep-learning and Internet of Things. Waste Management 135, 20-29. doi: 10.1016/j.wasman.2021.08.028

Whaiduzzaman, M., Barros, A., Chanda, M., Barman, S., Sultana, T., Rahman, M.S., Roy, S., & Fidge, C. (2022). A review of emerging technologies for IoT-based smart cities. Sensors, 22(23) article number 9271. doi: 10.3390/s22239271

Yigitcanlar, T., Mehmood, R., & Corchado, J. M. (2021). Green artificial intelligence: Towards an efficient, sustainable and equitable technology for smart cities and futures. Sustainability 13(16), article number 8952. doi: 10.3390/su13168952

Zhao, Z., Lao, X., Gu, H., Yu, H., & Lei, P. (2021). How does air pollution affect urban settlement of the floating population in China? New evidence from a push-pull migration analysis. BMC Public Health 21, article number 1696. doi: 10.1186/s12889-021-11711-x

Żywiołek, J., Rosak-Szyrocka, J., Khan, M.A., & Sharif, A. (2022). Trust in renewable energy as part of energy-saving knowledge. Energies 15(4), article number 1566. doi: 10.3390/en15041566