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Khoa học và công nghệ

Religious architecture of Chams in Vietnam

Le Chien Thang

Abstract

Champa civilization lasted in long time from 2nd century AD and blossomed in the 9th and 10th centuries. In the process of developing its long history, the Chams has created a unique culture - art, rich in creativity. Creation of the Champa arts shown in both the architecture and building techniques as well as the decorative arts, harmony between the spiritual and the secular elements, between foreign and native cultures. The remaining architectural and art achievements of Champa are expressed mainly in the religious buildings which are scattered in the ancient sites from central to southern Vietnam nowadays. They are precious and uniqueness of cultural and artistic heritages of Vietnam.

Key words: *Champa civilization, religious architecture, sculpture, temple tower, Central Vietnam*

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1. Overview

The Cham people or Chams is the indigenous people in the area of the coastal Central Vietnam and relates to Austronesian ethnic group and once be a mighty nation in history in nearly 1700 years, from 192 AD to 1832 AD. The Champa territory ranges from Quang Binh province in the north to Binh Thuan province in the south and from the sea in the east to the western mountains of Laos today.

The Chams were descendants of the residents of Sa Huynh culture (Iron Age from 1.000 to 200 BC in Quang Ngai province). Their culture flourished especially in the 9th and 10th century. Located on “Maritime silk road” between the two main Asian ancient civilizations, the Chams has diversified their cultures and arts through interference with ancient India and China as well as a closed relationship with other Southeast Asian countries through maritime commercial activities from the 2nd century AD. From the 11th century onwards, the Champa kingdom weakened gradually over the war with Viet dynasties and the Khmer Empire, and finally merged into Viet territory in 1832. However, the arts of the Chams have left many legacies independently as well as in combination with other Viet dynasties’ arts from the Ly dynasty onwards. The Chams has three main religions (Brahmin, Mahayana Budhism and Muslim) being influenced of the outside religions which are Hinduism, Islam and Budhism. The Indian culture had influenced on the Chams from the early formative years of the kingdom: from trinitarian cult to unitary state organization, production experiences... Besides, the locations in the kingdom were also named as India such as Simhapura (Tra Kieu), Indrapura (Dong Duong)... Hindu religion had transformed and integrated into the local culture and formed a specialized religion to worship the Hindu God Siva. Buddhism was transferred and integrated to Champa but did not have a great impact as Hinduism. From 9th century, the imprint of Buddhism is clearly expressed in the architecture and sculpture, the most representative works of the Buddhist is the monastery Lokeskvara Laskmida (built in the late 9th century but destroyed). By 10th century, Buddhism had no longer affected. Muslim was presented in Champa about 10th century and had a significant impact on the religious consciousness of the Chams. Many elements of Islam have changed the Hindu thought in Champa as well as the economy, politics and culture. Finally, by 16th century, Islam became popular in Champa with two branches: Cham BiNi and Cham Islam. Despite of existing until todays, Islam has not much impact on the architecture and the art of temple towers. [1], [2], [3], [8]

2. Types of the Champa religious architecture

Architectural heritage remaining includes ancient temple towers, stelae and inscriptions, spread from Central region (Quang Binh province) to South region (An Giang province) of Vietnam nowadays. Major centers are Danang (Indrapudra), Quang Nam (Amaravati), Quy Nhon (Vijaya), Nha Trang (Kauthara), Phan Rang (Panduranga). Significant religious architecture includes the mosques of Cham Islam and temple tower of Cham Brahmins.

a. Mosque architecture of Cham Islam

Mosque consists of two types: Masjid of Cham Islam and Sang Mugik of Cham Bini with the broad differences in spatial organization, orientation, decoration...While the Masjid looks like other mosques worldwide with the orientation towards sanctuary Mecca, the Sang Mugik orients toward the sunrise. The external form of Masjid is highly domed with the crescent and the big star but Sang Mugik is without crescent, stars are often small as for decorative purpose only. The outside decoration of Sang Mugik has traditional Akhar thrah characters sometimes accompanied the Arab texts while the Masjid is decorated by Arabic texts only.

b. Temple tower architecture of the Cham Brahmins

The main function of temple tower is the house of Gods where ordinary people meet their Gods. With such function, the temple towers could be divided

Figure 1. Champa vestiges in Vietnam (source: Champa Museum in Da Nang) [1]

into two main regions nationwide: worshiping Hindu deities from Hue to Phu Yen provinces, and worshiping kings (Po Shanu, Po Dam, Po Klong Garai...) and spiritual deities from Nha Trang to Binh Thuan provinces. Two major sanctuaries are My Son (worshipping the God Siva) and Nha Trang (worshiping the Goddess Po Nagar). With those functions, premise design and decorations of towers play a particularly important role and are the focal point in the architecture and art of the Champa.

Temple tower locations are separated from residential areas in order to create sacred areas though different terrains such as on the vast plains, along the river banks and seashore, on the top of hills or mountains... The temple precinct usually includes some different big and small buildings. The whole precinct reflects perfectly Hindu cosmology: the world is a square and surrounded by mountains and oceans, the center has an axis upwards to the sun. Therefore the whole precinct must comply with strict regulations such as centripetal arrangement, cardinal points in which the main axis of the main tower and the whole precinct usually is in east-west direction, the main orientation is towards the East - the sunrise and the source of life, surrounding fence symbolizes mountains... [4], [5], [6]

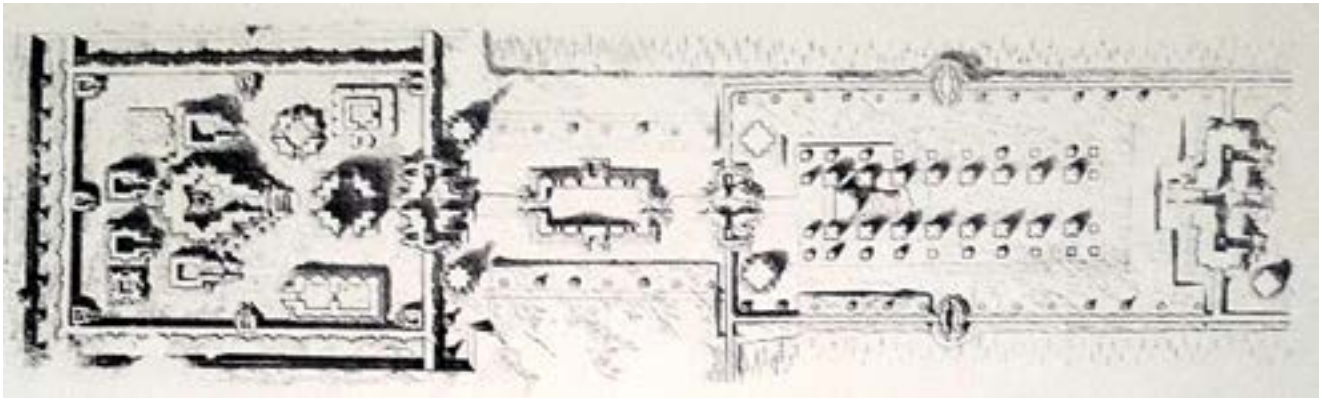

Figure 2. Dong Duong tower precinct (source: Champa museum in Danang) [1]

A typical precinct includes the Main tower (Kalan) in the center and symbolizes Meru peak where the gods live and the center of the Hindu universe), Gate tower (Gopura) in front of the main tower, Fire tower (Kosagraha) and Stele tower (Po Sha) after the main tower, Offering hall (Mandapa) and some other small towers worshiping stellar gods such as Navagrahas, Saptagrahas…. The whole precinct is surrounded by fence and the main gate orients the east.

In term of floor plan, the tower floor plan is convexo-concave rectangular or square and is divided in Mandala diagram with a small inner space in the center - the most sacred space dedicated only to the gods.

In term of architecture of the tower, styles are influenced from Hinduism (Indian), Khmer (Cambodian), Java (Indonesia)... Basically there are two main styles: group of three towers (Chien Dan, Duong Long, ...) worshiping three gods Brahma, Siva and Visnu, of which Siva tower is biggest; and one main tower (Poklong Garai, Po Nagar...) worshiping Siva – the God of the late Kingdom of Champa. Some group of towers such as Bang An, Hung Thanh have architectural features of North India with boat-shaped roof, others are mostly in South Indian style with a stepped pyramidal roof.

The Kalan typically is high, divided into three parts: pedestal (Jagati), body (Bhuwarloke) and roof (Swarloka), of which pedestal represents secular world, body - the spiritual world where people leave this world of dust to contact with the ancestors and integrate with gods) and the roof - the god world. Pedestal is built on a square or rectangle foundation and decorated around by motifs of animals, monsters (Kali, Makara, dancers, musicians... Tower body is solid and has gates at all four sides with one main door and three false doors often flanked by pillars and stone lintels. The tower elevation is decorated diversely: pillars (semicircular or half square), false doors and variety of sculptural objects. Most temples orient to the East except some face westwards. Tower roof has three stories with descriptive meaning of sacred mountain Meru, so the roof is decorated with many small models in form of temples, gods, holy animals… in Hinduism (holy birds, gooses, cows, elephants, lions)... as well as the decorated lines of wall, column and other patterns. The corners are emphasized by small towers or stone or brick decorative objects. There are two types of roof top: pyramidal shape (corbel shape influenced by the 12th and 13th-century Khmer architecture and stepped pyramidal shape) and boat shape.

Figure 3. Po Nagar temple tower, Nha Trang (source: author)

Figure 4. Nhan temple tower, Phú Yên (source: author)

Contrary to outside diverse decorations, the inner sanctum is small and does not decorate much except for few small niches. It also does not have windows, so the spatial atmosphere is dim, quiet and more sacred. Linga - Yoni is located in the center with narrow surrounding ways for ceremony which is performed by the Brahmins senior priests.

Besides the main tower, the supplementary towers usually have boat-shaped roof and small windows. Their internal spaces are also small. External decoration is similar to the main tower but simpler.

3. Styles of architecture and art of the temple tower

Styles of architecture and art of the temple tower were given by many researchers based on different criteria of decoration, location, historical periods... Base on the forms and decorative motifs, Henri Parmentier categorized two main periods: the first period includes three shorter periods respectively with three styles from 5th to 10th century: primitive art, cubic art and mixed art; and the second period includes three shorter periods respectively with three styles from 11th to 17th century: pyramidal art, classical art and derived art. Meanwhile Louis Finot, based on the inscriptions and historical documents, proposed four styles: Cambhuvarman (5th - 6th century), Prakacadharma (6th – 9th century), Harivarman I (10th – 11th Century), Harivarman II (11th – 13th century). Vietnamese researchers also suggested some style categories. Le Tuan Anh based on art characteristics and categorized in six styles: My Son E1 (classical style - built in the first half of 13th century), Hoa Lai (the first half of 9th century), Dong Duong (9th - the beginning of 10th century), My Son A1 (10th century), Po Nagar (11th century), Binh Dinh and Late style (12th – 13th century). Tran Ky Phuong and Shige-eda proposed seven styles based on the floor plan, construction technical analysis and structures at each stages at each heritage sites: My Son E1 (the beginning of 8th century to the beginning of 9th century), Hoa Lai (the first half of 9th century), Dong Duong (9th to 10th century), My Son A1 (10th century), Po Nagar (11th century), Binh Dinh (12th – 14th century), Late style (14th to 17th century). Of all above categorizations, those of Phillipe Stern (France, 1942) had much consensus and appreciation. He analyzed the process of eight architectural elements such as gate vault,

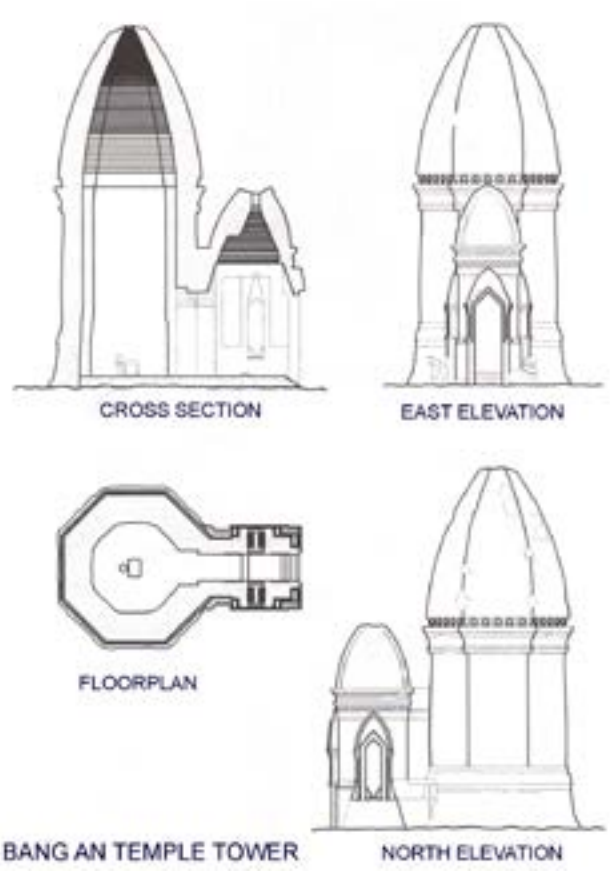

Figure 5. Bang An temple tower, Quang Nam (source: Tran Ba Viet) [7]

Figure 6. Hung Thanh temple towers, Binh Dinh. Left: Decoration on tower roof, right: Inside of the tower (source: author)

pilaster, frieze, colonnade, cornice, accent pieces, damping corner, and lintel. Along with the continuous development of the styles (especially focusing on the transition between styles), he gave out seven styles as follows: [4], [5], [6]

- Classical style (My Son E1): from 7th - 8th century, the style reflected the outside impacts of the pre - Angkorian culture, Dvaravati and the southern India. The inside altar was Linga - shaped made of sandstone, surrounded by carved decoration of priests who playing various musical instruments, taming animals or relaxing... The relief above the main gate is carved with motif of dawn time according to Indian mythology. The typical towers were My Son Tower E1, Phu Hai, Damrei (Cambodia).
- Hoa Lai: in the first half of the 9th century, with the rounded gate vault with sandstone octagonal pilaster with curved leaf. The typical towers were Hoa Lai, Po Dam, My Son F3, My Son A2, My Son C7.
- Dong Duong: in the late 9th century. The decoration turned into flowers with outward form, the pilasters and gate vaults with hard angles. The typical towers were Dong Duong, My Son B2, My Son B4, My Son A10, My Son A11, My Son A12, My Son A13.
- My Son A1: from 10th - 11th century, this was influenced by Java and also the heyday of the temple tower. The tower body was high, roof was stepped, many dynamic decorations and charming beauty. Decorating details included dancers and mascots both in real life and in myths such as elephants, tigers, holy bird... The typical towers were Khuong My, My Son A1, and the towers of B, C, and D group in My Son sanctuary.
- Transitional style of between My Son A1 and Binh Dinh styles: from the early 11th to the mid-12th century. Typical towers were Binh Lam, My Son E1, Chien Dan, Po Nagar, Banh It.
- Binh Dinh: the mid -12th century to the early 14th century. Typical towers were Hung Thanh, Duong Long, Thu Thien, Canh Tien, Phuoc Loc and Nhan tower.
- Late style: from early 14th century to the late 17th century. Typical towers were Po Klaung Garai, Po Rome, Yang Prong, Yang Mun.

4. Sculptural reliefs

Like the Hindu architecture and art, sculpture is inseparable part of temple towers, the relief decorative supplement to the architecture and increase the value of art and religion for temples. The temple is the abode of the gods, so decorative motifs throughout the architectural designs and decoration at the temples relating to the holy themes that here mainly Siva (Terminator God), besides Brahma (Creator God) and Vishnu (God of Preservation). The image of Siva is shown in the altar with two forms. One form is in human statue with different gestures and roles as Siva secularization, closer to the normal people or ascetic monks with long beard, holding a rosary... but more common is a form of dancing King Nataraja. The image of Siva also shows the influence of Buddhism over the artifact (Dong Duong) and sculpture in Binh Dinh style (the God holding the Lightning Range with his prime decision). However, the more common form of Siva is the Linga - Yoni set which consists of 3 parts: the base, the Yoni (with spout faces North symbolizing water and also represents the direction of the Fortune - Kuvera); Linga cylindrical portion (one of the main symbol of Siva). Besides Siva, the image of the goddess Po Nagar of the kingdom, a localized God Siva, who reigns southern part of kingdoms. This goddess is significant indigenous elements of the Chams, combining Hindu mythology and matriarchal indigenous beliefs. [1], [5], [7]

Figure 7. Towers of Duong Long, Binh Dinh (source: Xuan Tuyen)

Figure 8. Dancing Apsara on altar (source: Champa museum in Danang) [1]

Figure 9. Linga-Yoni (source: Champa museum in Danang) [1]

5. Building materials and construction techniques

Construction techniques of Champa tower consists of three stages: in the first stage (from 2nd – 6th century), the tower had the timber structure and only worship statue; in the second stage, the tower had brick walls and timber roofs and completed system of worship statues; in the third stage (6th – 12th century), the tower was completely made of brick and sandstone. Although being deeply influenced by Hinduism and the regions affected by Hinduism, the main building materials of temple tower were not stone blocks but bricks combined with sandstone. Some early towers had timber structure or other lightweight materials, usually used for secondary structures such as warehouse, house for clergy, musicians and dancers. Construction techniques with combination of brick and sandstone is an art of the Chams. The whole tower was supported by substrate solid foundation of large blocks or bricks, walls were made of brick with large thickness (about one meter). The roof is built with brick and decorated with sandstone. Arch and vault techniques with above stones projected out from below ones to make arch, so the arch has a narrow width and a great height. About brick technique, although there are a lot of assumptions, they are undecided despite the assumption of a wall from the kiln bricks associated with mortar or Rai oil was widely endorsed. [6]

6. Conclusion

The Champa religious buildings express profound interference between Hindu thought, cultures of neighboring countries and indigenous beliefs, expressed in almost fields such as spatial arrangement, architecture, decoration as well as symbolic meaning. Besides, Southeast Asian indigenous factors of the famous Sa Huynh civilization, which were formed in very long history, is also expressed deeply. That is the precious heritage of the Vietnamese cultural and artistic treasure which needs to be preserved and promoted continuously./.

References

1. *Champa Museum in Da Nang.*
2. *Le Dinh Phung, Conversation with ancient Cham civilization, Publishing House of Social Sciences, 2015.*
3. *Ngo Van Doanh, Culture of Champa, Ethnic Culture Publishing House, Ha Noi, 2002*
4. *Ngo Van Doanh, Ancient Champa tower - myths and facts, Cultural and Information Publishing House, Ha Noi, 2005.*
5. *Tran Ky Phuong, My Son in Champa history of art, Da Nang Publishing, 1988*
6. *Tran Ba Viet, Research building technique of Champa towers to serve restoration and to promote the value of relics, Publishing House of Construction, Hanoi, 2005.*
7. *Tran Ba Viet, Champa towers – Construction Mystery, Publishing House of Construction, Hanoi, 2007.*
8. *Tran Ky Phuong & Bruce Lockhart, The Champa of Vietnam: History, Society and Art, NUS Press, Singapore, 2011.*

Smart city model and applying to Hanoi, Vietnam

Do Tran Tin

Abstract

The background of the urbanization as same as the explosion of the industrial revolution, the development of the smart city is the inevitable trend in many countries on the world. Besides that, other nations are also dealing with the challenges about depleted resources, polluted environment and economic degradation, etc. Thus, strategies, models and solutions for city development are offered to exchange and seek for intelligent, sustainable and appropriate options.

Smart city model – a creative city, using high technology, communication and other means to manage; urban operation; improve the quality of life; performance and urban services; It also meets the needs of the present as well as the future in terms of economic, social and environmental aspects. Researching and developing these smart, sustainable cities are very important; contributing to stabilizing and developing the economy for the regions; national and regional.

This presentation will introduce the smart urban formation process with ideas and operational models. At the same time, we will introduce a smart city rating system based on the role of urban government and the community; thus, we will find the existing and building of the development orientation. Finally, we will present a case study to applying smart city model in Hanoi capital, Vietnam in the trend of sustainable development in the future.

Key words: *Smart city; Sustainable development; Urban planning management; smart environment; smart living; smart mobility; smart government; smart people; smart economy*

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1. Introduction

The background of the urbanization as same as the explosion of the industrial revolution, the development of the smart city is the inevitable trend in many countries in the world. Besides that, other nations are also dealing with the challenges about of depleted resources, polluted environment and economic degradation, etc. Thus, strategies, models and solutions for city development are offered to exchange and seek for intelligent, sustainable and appropriate options.

Smart city model – a creative city, using high technology, communication and other means to manage; urban operation; improve the quality of life; performance and urban services; It also meets the needs of the present as well as the future in terms of economic, social and environmental aspects. Researching and developing these smart, sustainable cities is very important; contributing to stabilizing and developing the economy for the regions; national and regional.

2. Content

2.1. Smart City Definition

What is the Smart City?

Smart city is now regarded as a city with the application of science and technology into the management and coordination of social activities in urban areas.

Figure 1. Smart City Model. Source: Citywork

A smart city is an urban area that uses different types of electronic data collection sensors to supply information which is used to manage assets and resources efficiently. This includes data collected from citizens, devices, and assets that is processed and analyzed to monitor and manage traffic and transportation systems, power plants, water supply networks, waste management, law enforcement, information systems, schools, libraries, hospitals, and other community services. The smart city concepts integrates information and communication technology (ICT), and various physical devices connected to the network (the Internet of things or ICT) to optimize the efficiency of city operations and services and connect to citizens. Smart city technology allows city officials to interact directly with both community and city infrastructure and to monitor what is happening in the city and how the city is evolving.

A smart city must include: Smart economy (sustainable development, competitiveness), smart infrastructures (transport, integrated services, public welfare, safe environment education, culture, employment, distribution, etc), intelligent residents, natural resources, intelligent life (quality of life for all

Figure 2. Smart City Use Cases. Source: https://www.ameresco.com/customers/state-and-municipal-government/smart-cities/

Figure 3: Smart City Models in the World. Source: https://www.ameresco.com/customers/state-and-municipal-government/smart-cities/

residents) and indispensable Urban management is also smart management.

A smart city is a framework, consisting primarily of Information and Communication Technology (ICT), to develop, deploy and promote sustainable development practices to address the challenges of urbanization and increasing. A large part of this ICT framework are essential smart network of objects and connectors that transmit data using wireless and cloud technologies.

ICT-based cloud applications receive, analyze, and manage data in real-time to help cities, businesses and citizens make better decisions at a time of improving quality of life.

2.2. The essential elements of Smart City

The essential elements that make up the integrated smart urban framework are two-way impact and interplay.

Management - Organization: government must be electronic government, using modern information technology.

Technology: Smart City's key services and infrastructure are managed by intelligent computing.

Residential Communities: Smart City's main residents are modern citizens who are able to participate in monitoring and even coordinating city management.

Economy: Smart economy, is the main driving force to build Smart City,

ICT Infrastructure: affecting the quality of Smart City development,

Natural Environment: The core of Smart City is the application of technology to sustainable development, effective management of natural resources, as well as the fight against environmental change.

Among them, reality has proven that technology is a super-factor that strongly influences on all the other factors.

2.3. Development of the Smart City: Benefits and Challenges

2.3.1. Benefits

Smart city building is the synchronous application of information technology solutions in all areas of socio-economic life based on the six basic characteristics analysed, it brings a lot of the benefits in all fundamental features for the people and authorities:

a. Economic development: Smart cities provide the driving force for developing green-oriented economic sectors that will harness the strengths of local industries, ensuring good environmental control, exploitation effectively boosting and pushing the industry with high local gray content towards the knowledge economy. Smart cities will promote the connection of regional and international, encourage innovation and start-ups, that make the local economy more dynamic and innovative, develop industrialization and modernization, tend to develop a strong shift towards service structure and integration.

b. Providing services to the people: People living in smart cities in addition to living in a safe environment, not pollution, will also enjoy a full range of quality health services, health care, education, convenient transportation. In addition to the public administrative services provided, people will have

Figure 4. Essential elements of Smart City. Source: https://doimoisangtao.vn/news/2017/10/9/phn-1-tng-quan-v-th-thng-minh-smart-city

Figure 5. The Advantages of Smart City. Source: https://www.bajajelectricals.com/smart-cities/

access to many other public services such as health, education, insurance, travel. These services are offered equally to all levels of society due to the development of IT and socio-economic infrastructure.

c. Regarding urban planning management: The smart city allows synchronous connections in many areas in an urban space, thus integrating all information on infrastructure, socio-economic of the city. Firstly, this is to provide sufficient information for the planning of urban development in electricity and water infrastructure, transport to socio-economic infrastructure, ensuring a reasonable and scientific planning, this is the problem that dont have its solution. Due to traditional planning methods are lacking of objective information and forecast information. From the well-developed planning work, the issues of safety, transport and health have been developed with a well-balanced plan so that people everywhere have access to services quickly and equality.

d. On urban governance: The smart cities allow the government to operate and monitor infrastructure systems in the most intelligent way through 13 monitors automated management system. Transportation, environment, waste collection, electricity and water are all managed and monitored centrally. The supply monitoring system ensures the city is safer. Providing information for decision support: smart cities collect a lot of information (past, present, real time, etc) makes longer term forecasts, more comprehensive, more accurate, offer optimal solutions in relatively short time and thereby support decision-making in a more efficient, intelligent way. The last benefits of the smart city are to make people feel happier: better access to services, a safer and cleaner environment, and sustainable economic growth.

2.3.2. Challenges

Smart cities are still existing inevitable disadvantages. Will a city run entirely by information technology become an ideal model for the future? The answer is maybe yes, in a very great way, but it can also be in a very bad way.

We are constantly exposed to and use products related to information technology as well as telecommunications technology, but they are not always smooth. We can't guarantee that a system can be perfect or it has no errors. Bearing in mind that only a small hole collapzed a giant structure. If the smart city scenario is cloned around the world, it is also the kingdom of high-tech crime. Some software viruses can upset your life.

Another proof that security does not mean security, when you are a smart city dweller, you have to get used to the fact that your life is frozen, you can't be sure that all the behavior in Your private life is not monitored. Do we really feel comfortable with such a life?

Smart life in the city will not only create civilized, self-conscious lifestyles, it will also have a dependency on technology. Life is too easy sometimes not so good, just like having a dental check-up is very difficult for you to adapt to unfavorable environments.

The complexity and high specialization of this model will require residents in the city to adapt to it; currently, only high-income people can access. Smart city dwellers can get used to that lifestyle, but visitors or newcomers will feel a bit overwhelmed. It's not a big deal, but it paved the way for a new, fused image of the world.

One would have to call the "smart urban culture" instead of the old traditional way of living. If the model is replicated unchecked, it is possible that each country and city will be at risk of losing its identity. It is bad if we go around and see that they are exactly the same, which is certainly not the future prospect that people want.

It is very difficult to implement a smart urban project in old cities, such as the capital Hanoi in Vietnam, because it is very time-consuming to recreate a smart urban system. Its resources are many times greater than the construction of a new city. Thus, the complexity of the problem shows that not every place can apply this model. In fact, the model has only been tested

on a modest scale.

The next issue that related to energy, in the distant future, the price of electricity stopped at 0 coins is great, but think a little closer, it is not quite beautiful with everyone. Power markets generally operate on the merit order: they prefer to take electricity from the cheapest supplier, then the second cheapest electricity supplier until enough demand; the price paid to all suppliers is the price from the most expensive source. Because there is no fuel cost, the marginal costs of wind and solar power are low. Therefore, manufacturers have higher costs driven out of the grid, resulting in lower wholesale prices.

If the electricity generation process is continuous, renewable energy is really a big deal for other energy sources. Regarding to essence, renewable energy is not continuous, so it is still necessary to source that energy into the grid. If we shut down conventional power plants, we will not have the necessary supplies at the time of a lack of wind or solar power (due to winds do not blowing and the sun does not shine).

Moreover, as a very small part of the electricity system, renewable energy is subsidized, with only traditional power supplies, wholesale electricity prices will be reasonable so that people can buy. Renewable electricity fixed prices. However, theoretically, more and more renewable energy sources, the lower the price. At times, renewable energy sources can meet the power demand of a region, a country, leading to a loss of traditional energy - or sometimes lead to traditional sources of power. Get paid to be connected to the grid. The more renewable energy in the electricity system, the more likely it is that this will happen. Therefore, the application of renewable energy development model at the national level is difficult to implement, even affect the energy security.

2.4. Intelligent City Assessment System

Smart cities require a government that can combine six important roles. To be most effective, the city government must deliberately choose the combination of roles through which it addresses the challenges of the city in the most effective way. Each role must be developed at a mature level.

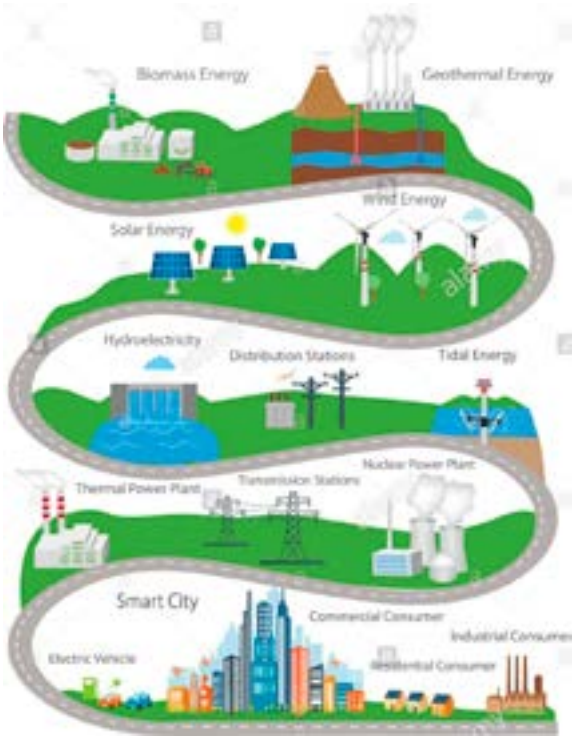

Figure 6: Renewable energies. Source: https://www.fotolia.com/id/106026819

2.4.1. Smart environment

Reduce energy use

Environmental impact

Carbon footprint

Entail competitive industries

Planned financial resources

New concepts

On the market and near to market solution

Example: Sydney City

The system is capable of gathering information on various environmental parameters such as temperature, humidity, CO_2, CO, NO_2, O_3, SO_2, and air pollution levels.

2.4.2. Smart living

Improve the quality of life of people on food, hygiene and safety

Improve the quality of urban infrastructure

Strengthen community cohesion

Security Monitoring

Community health

Example: Amsterdam

Today, the world attaches great importance to databases for all industries and jobs. Planning is always a front-runner and development direction for the next areas and with smart urban planning, this issue needs to be paid more attention, so the urban database from at the time of design

Figure 7. Six roles of city government. Source: https://www.slideshare.net/MSalihKANBER/mskanberdeloittenlpssmartcitiesreport

Figure 8. Sydney has a great opportunity to transform itself into a smart city in the coming years. Source: https://www.arup.com/perspectives/sydney-a-smart-city

Figure 9. Amsterdam Smart City is the innovation platform of the Amsterdam Metropolitan Area. Source: https://www.iamsterdam.com/en/our-network/municipal-government/amsterdam-smart-city

Figure 10. Creating a safe and pleasant living and operating environment for the completely renovated Amsterdam. Source: https://amsterdamsmartcity.com/projects/smart-light

and construction, the project must be digitized and stored for a long time. Applications for urban management on a smart device platform will access and use the database. Especially, building a large database for smart urban development planning noted.

Smart lighting system in the city of Amsterdam: In addition, for the water supply and drainage system, sensor sensors connected to the computer system will provide the user manager with the notes when the system is operating. For example, sensors will alert you when a water pipe is broken and the manager can fix it quickly. Similarly, the sensor will report the risk of flooding and start up rescue systems such as pump-suction, moving evacuation system.

2.4.3. Smart mobility

Recycled energy

Development infrastructure

Management is based on modern technology

Raise people's awareness

Example: Copenhagen

Vehicles will be electrically powered and fully self propelled. The traffic equipment will communicate with the control centre communicate with each other through the technology platform. In addition, the means of transport in the knowledge economy is also shared, minimizing transportation, saving energy.

Electricity generates electricity and is used primarily by solar and wind power. The fossil fuel generated by the combustion will be completely replaced by clean energy. In addition, the equipment used for the electrical system will be studied so that fuel consumption is minimized. Homes and buildings will use solar panels to cover the energy used by homes and buildings.

2.4.4. Smart Government

Clearly disclose specific information

Always update new text information

Create efficient data storage facilities

Example: China

China officially connected to the Internet from April 1994. Since then, the Internet has exploded and become an indispensable part of people's daily lives.

China has implemented the "Government Online" project jointly implemented by China Telecom and the Economic Information Center under the National Economic and Trade Commission. The overall goal of the project is to build a highly effective government that all citizens have access to available resources and facilitation of administrative work. The specific objectives of the project are as follows:

Move the functions of the government to the network including administrative management

Provide government documents, create online information store

Provide daily information on government activities

Implement online management


Figure 11. The smart city Copenhagen is a living laboratory for testing smart technologies to handle the challenges of urbanisation and climate change. Source: http://www.copcap.com/set-up-a-business/key-sectors/smart-city

activities (public services) using databases (database) and exchange electronic documents to increase management efficiency

Deploying online commerce generates electricity and is used primarily by solar and wind power. The fossil fuel generated by the combustion will be completely replaced by clean energy. In addition, the equipment used for the electrical system will be studied so that fuel consumption is minimized. Homes and buildings will use solar panels to cover the energy used by homes and buildings.

2.4.5. Smart people

Improve facilities such as schools and libraries

Create a platform for sustainable education

Combining theory and practice to create high educational effectiveness

Example: Melbourne

Melbourne is famous for its long-standing architecture and is home to many of Australia's most prestigious universities. Two of the Go8 schools are Melbourne University and Monash University. Other universities include: Deakin University, La Trobe University, Victoria University, Svvinburne University, RMIT University and Ballarat University are all located here.

These universities are internationally recognized with the best rank and have excellent reputation. It offers world-class education on a vibrant campus with a large international student community from 50 countries. Studying at one of the Melbourne universities, students are supported by excellent teachers from world-class campuses.

2.4.6. Smart economy

Applying modern technology in commercial transactions

Improve product quality

Trade exchange

Example: New York

New York is a global hub for international trading and trading, also one of the world's three "economic hub" centers along with London and Tokyo. The city is a major financial hub, insurance, real estate and the arts in the United States.

Major companies have their headquarters in New York City, of which 43 are listed in the Fortune 500. New York is also a special place in US cities because of the large number of foreign companies. One in ten private sector jobs in the city is with a foreign company.

The production sector is large in number, but there is a downward trend in employment. Apparel, chemistry, metal products, food processing, and home appliances are some of the key products. Food processing industry is the most sustainable sector in the city, valued at $ 5 billion, employing more than 19,000 New Yorkers. Chocolate is New York's leading export product with $ 234 million export annually.

2.5. Applying the Smart City in Hanoi

2.5.1. The reason of choosing Hanoi

Currently, Vietnam has 903 urbans including Hanoi and Ho Chi Minh City are the first rank cities. Therefore, the ability to apply smart urban model for megacities of Vietnam such as Hanoi, Ho Chi Minh City, Da Nang, etc focus on the development of infrastructure elements and high-tech applications that can help the city solve many of the current existence of society.

Hanoi is one of the cities with great potential for growth: young urban population, high Internet coverage, fast growing middle class and widespread international integration. It will be very attractive investment of large corporations.

The urban development status of Hanoi shows that the city has to solve many problems such as traffic, waste, environment, etc. Thus, we need to apply, learn smart urban model from developed countries in the world to improve the quality of urban life.

2.5.2. Proposing and directing Hanoi towards Smart City

a. Hanoi Smart Environment

* Target:

Intelligent Environmental Management System: Waste, Air, Water

Intelligent energy management system: grid electricity, renewable electricity, etc

Intelligent building management system: building standards for buildings in the city

* Actions:

Prioritize heavy use of solar power for public works, agencies, companies, and encourage people to use it. Towards the whole use of solar energy:

Emission monitoring solution

Meteorological monitoring solution

Automatic surface water quality monitoring solution

Groundwater quality monitoring solution automatically

b. Hanoi Smart Living

* Target:

Meet all the needs of people in daily life through technology

Increased connectivity between people

Intelligent application management in all aspects of life (consumer goods,

Figure 12. Applying model technologies

Source: http://www.chinaperformancegroup.com/2013/01/the-trend-of-developing-a-smart-city-in-china/

Figure 14. New York City is a leader when it comes to smart city technology

Source: https://www.techrepublic.com/article/how-new-york-city-plans-to-become-a-smart-city-leader/

Figure 13. Melbourne on smart city and human cities. Source: https://www.australiandesignreview.com/architecture/scott-adam-smart-human-cities/

services, public, health, education, etc)

Personalize security monitoring, increase response time before failure

Intelligent life includes solutions to improve the quality of life of people in terms of consumption (food hygiene and safety, etc), lifestyle (community attachment, multi cultural life, etc), security (surveillance, emergency detection, robbery prevention, etc) and health.

* Actions:

Deeply integrate high-tech applications into every aspect of everyday life: Use the internet as a foundation, build a diverse information network for individuals and communities. Continuously update the information related to consumption or health that is helping the parties shorten the processing time and complete the supply and treatment activities.

Ensure security by prompt surveillance and recovery: Installation of multiple street surveillance cameras along with a criminal identification system, rapid response measures, no need for direct contact from people such as traditional systems

Application of smart urban facilities: Road signs, intelligent signage, operating under human identity, saving on lighting costs, operation and maintenance

Increasing connectivity between people: To build comfortable and reasonable public spaces, to create places of play and live exchange between people

c. Hanoi Smart Mobility

* Target:

Uniform traffic information system

Intelligent technical infrastructure

The public transport network

Safe and convenient for city residents

Limiting emissions from vehicles

Traffic management information

Smart travel includes solutions to build and develop a secure, green and clean transport, transportation system, cost savings and reduced emissions.

* Actions:

Intelligent parking system: Use smartphone to find parking lot, payment via bank account. Convenient and transparent for the users.

Traffic information system: Provides information on road conditions and traffic conditions for highways users through electronic traffic signs, radio stations (FM) or on mobile information networks and the Internet.

Signaling system for traffic control: Use electronic traffic signs to flexibly control the speed limit of lanes and lane signals; close or open the reversible lane, section of the highway.

Magnetic card system for public transportation: Convenient in management as well as convenient for people using public transport in the city.

Car traffic management system: Collect, analyse, report and store statistics on data describing the status and performance of the road system; Detect bottlenecks or traffic incidents to automatically alert the operator.

Traffic camera system: Assist the operator to visualize the distance traffic on the large screen or screen

at the traffic management center; Provides video traffic visualization for organizations and the public as specified by the competent authority.

Traffic management center: Carry out the task of gathering, processing and storing centralized data; Provides user interaction to implement traffic management, administration and traffic control at the RTDM Centers or the Regional Centers for Regional Operational Management.

Event management system: Assist the operator to monitor traffic events taking place on the road, and provide automated tools that aggregate data from vehicle tracking systems, vehicle load monitoring systems, and information systems. Weather information provides data for automatically alerting operators to traffic safety events.

d. Hanoi Smart Governance

* Target:

Provide personalized services in a way that makes people feel special

Be active listening to people with the goal of continuous improvement

Reflect the views of people and the experience of the people and promote their participation in a comprehensive way

Simplify administrative procedures based on smart applications

* Actions:

Make contact and interact with people through smart applications: Introducing smartphone applications, enabling people to communicate, interact directly with government, to quickly reflect urban issues.

Acquire and consult people in visual and modern forms: Take and use some of the exciting forms currently in use in the world, such as Community PlanIt. Where people's input is used as a scoring method in the game, ending with a face-to-face meeting.

e. Hanoi Smart Citizen

* Target:

Highly qualified support

Lifelong learning support

Create a venue for cultural events and community events

Push the spirit of openness

Support a high quality lifestyle

Good housing, good schools, safe, dynamic and comfortable

Smart people include human development solutions that not only improve education and training

but also promote creativity and innovation as well as enhance interaction and exchange towards an open society of information.

* Actions:

Integrate high technology into education: Improve educational levels with technology, and increase interaction among students

Increase access to employment: Extensive search and job exchange applications, professional support

Increased connectivity with knowledge: Free internet access, upgraded public electronic library system, easy connection with each citizen

g. Hanoi Smart Economy

* Target:

Smart banking system

Limit the use of cash

Economic sharing

E-commerce development

* Actions:

Developing e-commerce is the impetus for the economy. Combined with shared economic models, it will connect directly to buyers and sellers through the internet, making it easier for both buyers and sellers to reduce costs.

Economy restricts the use of cash.

Providing services and payment points by card or using an electronic wallet.

Applying information technology to banks in order to create online banks with online services 24/7 and contributing to economic development.

Unification of e-commerce: Developing a Vietnamese e-commerce site next to big sites like amazon, lazada, etc.

Consistency between banking systems: Banks now participate in a local ATM card union called Napas. With this alliance, the user can deal with all ATMs and card terminals. POS in the whole territory of Vietnam.

Promote services that come with shared economic models.

3. Conclusion

- For Hanoi to become a smart city, there are many challenges for the government and the people.

- But this is a trend of the world, as technology is growing and helping people in all aspects of life.

- First of all, it is necessary to build human resources in information technology and an infrastructure to meet each stage of smart city development.

- Hanoi can solve every problem to move towards a smart city:

+ Stage 1: Focus on human resources and infrastructure.

+ Stage 2: Deploying items from the administrative agencies (such as e-government, e-hospital, e-school...) in order to meet the demand and help people familiarize themselves with them. with the new model.

+ Stage 3: Deploying environmental items and utilities such as intelligent transportation.

Besides that, Hanoi also need to care about smart transport system, information and communication technology system, building smart health system, building smart education system, smart urban light system, smart environment system, smart travel system, smart houses./.

References

1. *Batty, M. (2013) Big data, smart cities and city lanning, Dialogues in Human Geography Smart Nation Strategy Implementation-Ministry Foreign Affairs Singagore http://www.smart-city.kr/eng/main/main.do#this*
2. *Cristina Bueti, (2015). An overview of smart sustainable cities and the role of information and communication technologies - Focus Group Technical Report United Nations, Telecommunication Standardization Sector*
3. *Scientific American (2014) Designing the urban future: Smart Cities*
4. *Smart city strategies - A Global Review. London: Catapult Future Cities 2017.*
5. *Workshop "Smart Cities" organized by Ministry of Industry and Trade of Vietnam, German Embassy in Vietnam and Siemens Company in Hanoi on 27/9/2021.*
6. *Workshop "Smart urban development in Vietnam towards Green Growth and Sustainable Development" organized by the Ministry of Construction and the Dutch Embassy in Hanoi on March 29, 2022*
7. *Xây dựng, phát triển đô thị thông minh trong bối cảnh đô thị hóa & chuyển đổi số ở Việt Nam; Cổng thông tin điện tử Bộ Xây dựng, 30/01/2023.*

Establishing planning principles for urban parks in Vietnam

Nguyen Thi Dieu Huong

Abstract

Park plays a very important role in social and cultural life and becomes integral to urban spatial structure. It improves the environment, creates a beautiful green space, and takes cultural entertainment and sports activities place. People with no difference in age, gender, or income come to meet, exchange, rest, and relax. At the place, nature becomes familiar to people and becomes a crucial part of life. Furthermore, parks enhance the city's image, bringing tourists and significant economic activities. This paper studies setting up the principles of urban park planning in Vietnam, including eight general principles: sustainability and environmental principles; the principle of improving the quality of life; the principle of preserving cultural identity, spatial connection principle, park diversity principle, the principle of adaptation; safety principles, principles of education and three principles of spatial arrangement. These principles will be one of the bases for constructing and developing parks in Vietnam.

Key words: *urban park, urban planing, planning principle, functional areas*

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1. Introduction

Parks are essential in creating a healthy and health-promoting urban environment, making the city more beautiful, attractive, and worth living for everyone. In addition to its positive environmental contributions, it is considered as the city's green lung, reducing greenhouse gas emissions, minimizing the temperature reversal effect in urban areas, and flood prevention (through surface water infiltration, integrating ornamental lakes with water regulation and storage lakes, applying flood drainage sections to canals, or biological canal systems (bioswale)[1]. Urban park also allows people to rest, entertain, and do exercise after stressful working hours. Besides, urban park is the space for cultural activities and to create the community cohesion.

Therefore, many countries believe that an ideal city should have an interconnected green network, in which the park area target of 9- 15 m2/ person is ideal for balancing green space and construction space. They are very aware that parks and green spaces in the city are one of the factors that create a better living environment for people and contribute to sustainable urban development.

In China, they consider parks as an important factor in the development of cities. The Chinese government has set many policies and goals to build and manage parks in urban areas, such as:

- Park planning to meet community needs;
- Implement a program to build and upgrade urban parks;
- Aim to preserve and manage cultural and natural heritage in parks;
- Encourage private investment and public-private partnerships to participate in the construction and management of parks to enhance resources and management skills in park development.

Meanwhile, Japan aims to preserve the natural landscape and create a green environment in the city. Parks and gardens in Japan often place great emphasis on relaxation and peace. Japan also encourages using modern technology to maintain and manage green areas.[2]

Parks in the United States often have educational and experiential goals. Educational and tourism activities in the park aim to help people better understand the natural environment and contribute to the protection of the country's natural heritage.

Parks in England are often closely linked to the nation's history and cultural heritage. Many parks are located in historic areas but designed and preserved modernly to serve residents and encourage social interaction.

Each country, depending on its specific context and economic and socio-cultural development conditions, has different park planning strategies, policies, and principles.

2. General principles

In Vietnam, through many changes, along with development opportunities, there are pressures from socio-economic issues, pressures from mechanical population growth, making the system of green spaces and parks also affected, narrowed, and not able to promote its functions, not meeting the needs and expectations of the people. Recently, this issue has received much attention from the government, professionals, and social community. Many policies and documents have mentioned public space that recognizes the critical role of public space in contributing to the quality of urban life and appearance. And acknowledging that public space needs to be must be protected from deterioration and encroachment. Besides, creating public spaces and parks contributes to creating a sustainable living space.

Therefore, when applied in the Vietnam context, it is necessary to ensure general principles when planning urban park as follows:

- Sustainability and environmental principles
- Principles for improving the quality of life
- Principles for preserving cultural identity
- Principle of spatial connection
- Principles of park diversity
- Principles of adaptation
- Principles of security and safety
- Educational principles

● Sustainability and environmental principles:

According to the International Union for the Conservation of Nature and Natural Resources (IUCN), the concept of "sustainable development" is "development that can meet current needs without compromising the ability to meet needs of future generation... It is also understandable that sustainable development also means ensuring that effective economic development, society equality and that the environment is protected. Especially in urban park planning, sustainability and the environment play a vital role in balancing and improving the habitat, preserving natural features, preserving flora and fauna, and wild areas based on innovation. Ensuring the long-term maintenance of diverse ecosystems so that they keep fulfilling their various roles in the future. Urban park planning should not affect the natural environment and change the ecological cycle. That is one of the most successful approaches to addressing the environmental problems of urban spaces. In practice, sustainability in park design principles should require adapting to local conditions and contexts. Besides, sustainability is expressed in a self-resilient landscape that utilizes the least energy and can respond to ever-changing circumstances.

Core criteria to ensure sustainability and environmental principles in park design:

Environmentally:

Providing the green infrastructure: rain gardens, bioswales, bioretention ponds, constructed wetlands, water permeable pavers

Implementing water and energy conservation practices: greywater and rainwater harvesting systems, smart irrigation, water-wise plants, renewable energy in the construction of urban lighting and furniture, solar-reflective paving materials.

Waste management: centers for recycling, allowing for composting of the solid waste created in the park, producing urban furniture, pavements, and walls from recycled materials.

Promoting access to fresh, healthy, and low-cost food: local sustainable food production by utilizing community gardens.

Supporting and preserving biodiversity: preserving wildlife's migratory and breeding habits, creating habitat steppingstones.

Supporting disaster resilience

Socially:

Creating a place for people of all age: Establish spaces that accommodate activities for all ages and disabled people. Functional spaces meet appropriate physiological and psychological needs (for children, it is necessary to arrange age-appropriate play areas that can easily observed, ensuring high safety when exercising; For older people who need gentle exercise, it is essential to set quiet, resting spaces, shaded walkways combined with reasonable places to stop...)

Building connected park systems within walking distance: Establishing a street network can serve both pedestrians and cyclists, a traffic reduction strategy, creating multiple access to the park; To meet the needs of all users

Economically:

Parks must be designed to balance capital expenses with operating and maintenance expenses.

Developing policies to mobilize funding from many different sources: funding from the budget, funding from planning and development agreements, funding from other social resources

Organizations and businesses participating in investing in park construction will have support mechanisms such as loans with low-interest rates from development support funds, develop investment funds, and preferential policies to support businesses when investing elsewhere, other locations in the city, reduce contributions to investment in infrastructure construction, minimize income taxes for businesses, and exempt land use fees for construction land which is not for commercial purposes.

Quality parks serve community benefits, meet their needs, and become a tourist destination, make the city more attractive and creating an urban brand. It also increases the value of real estate in the surrounding area and improves tax revenue.

● Principles for improving the quality of life

It's important to note that the primary function of a park is to cater to the community's needs and interests, enhancing the quality of life. Therefore, the park's design must be attractive and appealing to users, providing good opportunities and amenities. It is essential to improve and upgrade these facilities when necessary. For example, the facilities in service areas should be enhanced and served... In addition, park design should also meet the needs with the lowest cost, striking a balance between usage demands and financial resources[3]. How can the park serve all individuals with different financial abilities? Applying modern scientific and technological advancements in designing functional areas or in operation and management is also one of the principles to enhance the quality of the park. That makes expands and improves the park's ability to serve. Specifically, integrates advanced technologies, IOT sensors, and AI artificial intelligence to bring the community the best experiential space solutions and effective management solutions. These technologies may include sensors to measure the air quality, traffic, and noise levels and systems that analyze data collected by these sensors in real-time. For example, suppose a specific park area has a high user density. In that case, the park's management system can adjust lighting, water usage, and other factors to optimize the use of the area, minimize environmental impact, and enhance the park's adaptability to user needs.

In the context of the Fourth Industrial Revolution and digital transformation, applying science and technology in planning and management is becoming a trend. Whether they like it or not, every organization must transform, whether

a design consulting company, construction contractor, supervision consultant, or state management agency in urban and construction fields. Therefore, applying intelligent design and management solutions to enhance the quality of park usage while improving the community's quality of life is one of the essential principles in park planning in Vietnam.

In addition, to enhance the quality of parks, especially when renovating parks, it is necessary to encourage and create conditions for the community to participate in park management, protection, and utilization by listening and meeting their needs and promoting social interaction activities. Observing and analyzing park usage based on experience can be an essential tool to bridge the gap between user needs and urban park planning, design, and management and improve the quality of park usage.

- Principles for preserving cultural identity

Organizing events and festivals in the park will create a sense of unity and interaction within the community and serve as a form of education to enhance awareness among the people. Each region and locality in Vietnam has its own cultural heritage and unique cultural characteristics. Formed during the French colonial period, the park flower garden system is integral to Hanoi's urban structure. It serves as a space for social activities and interactions, reflecting the perspectives, lifestyles, and culture of the people of Hanoi. Therefore, recognizing the distinctive features of cultural history in researching, planning, and renovating the park is one of the essential steps to promote and preserve cultural identity. The question is how to integrate and highlight them into a compelling story.

Thong Nhat Park is one example, built on the voluntary labor of thousands of young people and students in Hanoi in the 1950s when the country was still divided by war. The design of Thong Nhat Park includes Bay Mau Lakes[1] (equivalent to 25 hectares), two peninsulas named Wind Island (representing the desire for freedom) and Coconut Peninsula, with many coconut trees - a species that reminds the image of the South (which was still not liberated at that time). Two islands, Thong Nhat Island and Hoa Binh Island, are connected to the shore by two small bridges symbolically connecting the two unified regions. Thong Nhat Park, which serves the needs of entertainment, rest, and relaxation, is an essential green space - a "green lung" and a "place" with historical and meaningful value culture for many generations of Hanoi people.

In Bach Thao Park, where various plant species from the French colonial period are nurtured and preserved, there is a temple called "Den Nui Sua" dedicated to Huyen Thien Hac De, a legendary deity who supported King Ly Thanh Tong in defending against foreign invaders, safeguarding the nation's independence and autonomy. He was also considered as a Tutelary God in the Ngoc Ha and Huu Tiep villages[2]. The name of the Sưa Mountain originates from the fact that this place is abundant with Sưa trees, a familiar type of tree in Thang Long land. The temple is currently structured in the style of "stacked roofs with two ridges" - a traditional architectural style of the Vietnamese people. It stands out with decorative panels on the door canopy skillfully painted and delicately carved motifs, which have been recognized as historical and artistic relics at the City level since 2015.

Another example is Thu Le Park- located in Thu Le village, an ancient village dating back to the Ly Dynasty (11th century) with the legend of Linh Lang deity and Voi Phuc Temple[4]- a temple that has existed for at least 600 years since the Ho Dynasty (1400-1407) and has undergone multiple renovations[5]. The current architecture bears the mark of the architectural style of the Nguyen Dynasty. Through many historical upheavals, the temple still retains several precious relics. In particular, "Voi Phuc Temple is also known as Temples of ancient Hanoi in the West - one of the four sacred towns of Hanoi" (Tứ trấn Thăng Long)[3][6]. Integrating cultural and historical values into parks can bring many benefits to the community, making parks a space for both tourism and education and preserving cultural and historical values of the country's nature.

Therefore, when designing a park, it is necessary to integrate the characteristic cultural elements into the organization of landscape architecture functions, incorporate traditional games, apply traditional architecture, exploit indigenous elements such as the use of local materials, the characteristic flora and fauna of the research area, etc. It will surely bring the attraction and contribute to promoting the cultural identity value while spreading the message of environmental protection in the city.

- Principle of spatial connection

Accessment to the park is one of the most critical issues related to its ability to meet its needs. This is reflected in the ability to walk (the radius of the parks) and accessibility for people with disabilities. For example, do the spatial organization, management in the parks, and multi-functional parks for the community have barriers or not? Is there a ticket to the entrance? or It is accessible for all people with different social statuses, sexes, and ages to join in the park activities. Research shows that distance influences park usage and the decision to visit. The farther and less accessible a park is, the less likely people are to use it. Furthermore, the connection principle also shows the connection between parks and residential areas, which are solutions to organize smart traffic systems, creating an easy and convenient network. Therefore, in researching and providing park design solutions in Vietnam, the principle of connection is also one of the general principles that needs attention. To implement this principle, it is necessary to consider the following issues:

Parks must be located in accessible positions, be usable, and serve the community's needs.

Parks can be arranged together or near essential community facilities such as schools, libraries, and community centers.

It is necessary to increase the connectivity between parks and residential areas through smart transportation

(1) Thong Nhat Park contributes 81% to the greenery structure of Hai Ba Trung district and has nearly twice the average green area compared to other inner districts.

(2) Prince Linh Lang, after being bestowed the title of "Đại Vương", ascended to become a saint. Linh Lang is one of the important deities in the Vietnamese religious system, revered in many places and serving as one of the protective gods for the capital city of Thang Long.

(3) "Tứ trấn Thăng Long" is associated with the birth of the capital Thang Long under the Ly Dynasty in the 1010s, a place to worship four gods who guard the four lifelines on the always peaceful land of Thang Long. Bach Ma temple in the East, worshiping the god Long Do; Voi Phuc Temple in the west, worshiping Linh Lang Dai Vuong; Kim Lien Temple in the south, worshiping the god Cao Son Dai Vuong; and Quan Thanh Temple in the North, worshiping Huyen Thien Tran Vu. These are the four most sacred temples in the capital because of their history and cultural beauty in Vietnamese beliefs.

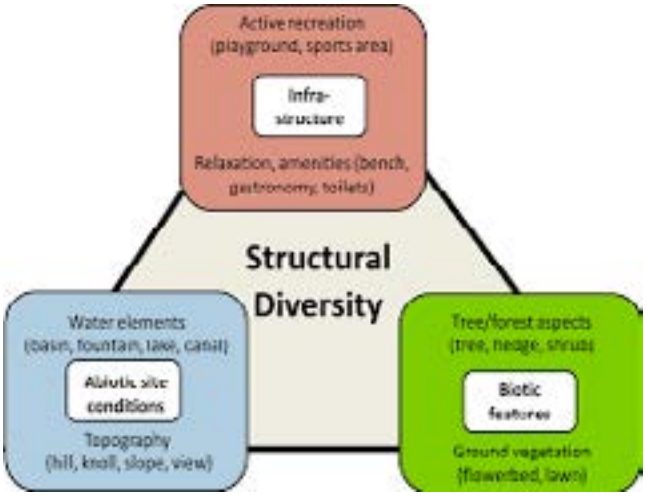

Figure 1. structural diversity of urban parks[7]

system solutions.

The park should be built alongside the major public transportation routes to increase the accessibility and convenience for the usage of public transportation, as well as for pedestrians and cyclists.

Implement traffic-calming strategies, provide multiple entrances to the park, and upgrade park entrances.

The park's location must have visibility (the ability to observe from main roads), as being visible from the street will create attraction and encourage usage.

- Principles of park diversity

This principle requires meeting users' diverse needs and abilities, especially those of minority ethnic groups, disabled people, and different age groups. This diversity is in the park's location (parks can be built on various terrains, creating richness and unique characteristics for each region or area).

The diversity of vegetation in the park

The layers of vegetation in the park help improving the city's air quality. Additionally, it adds beauty and provides shade for the park. However, the designer must understand the vegetation to ensure harmony and avoid disrupting the landscape.

In addition, diversity is in the functional structure (multiple functional spaces serving different purposes) and the variety of entertainment options: indoor or outdoor, modern or traditional games, etc. It is diverse in recreational, cultural, educational, and scientific activities. Furthermore, the principle of diversity lies in the richness of design forms and the flexible use of styles and materials.

- Principles of adaptation

If change is constant, the ability to adapt to that change is essential. Culture, entertainment habits, and lifestyle changes can impact how parks are used and developed. The ability to respond to these changes is the essence of the principle of adaptation.

Adaptability throughout the year

Adapt to change in density of usage

Park development plans to meet new changes mean being suitable for many conditions and proactively changing flexibly to adapt to existing conditions. For example, during the COVID-19 pandemic, cities were forced to implement lockdowns and practice social distancing, changing the social lifestyle (trends in living and working online). That change affected the demand for using parks and increased the role of parks. As the demand for remote work and working from home increases, people are spending more time (and paying more attention) to the spaces around their neighborhoods, especially parks or nearby ecological landscapes, to meet the need for physical and mental health, work-life balance, etc.In addition, the development of information technology infrastructure and the trend toward new work environments allow workers to work right in the park if the infrastructure meets their needs (with amenities such as free Wi-Fi). This transition promotes creativity and increases labor productivity compared to traditional office work environments.

Design solutions must ensure adaptation to climate change. For example, optimizing spaces, encouraging intelligently controlled and comprehensive, diverse development, ensuring minor encroachment on the natural environment, and trying to keep a closed ecological environment and balance…

- Principles of security and safety

Safety and security are often cited as issues related to park users. From a park management perspective, opportunities to address these issues lie in approaches including education, community involvement, and landscape design. Safety concerns extend to park maintenance, such as the safety of recreational equipment, traffic, and

Figure 2. Well-lit spaces without hidden corners ensure a safe and secure environment for the park.[8]

infrastructure systems. For example, ensuring the safety of playground equipment requires careful consideration of design, spatial organization, and functional layout. Materials used and games provided must minimize the risk of injury, while the playing surface should not be excessively rough or slippery. Similarly, security principles are implemented by avoiding dark corners or blind spots in park design. In addition to the CCTV system, designing functional spaces that everyone easily observes is also one way to ensure the park's safety and security. The above view shows that, if viewed from a larger perspective, safety and security in park design also affect the quality of community life, ensuring that people have safe, convenient, and effective ways to come to and enjoy the park. Furthermore, safety and security are also reflected in the balance between freely used and controlled spaces.

- Educational principles

Urban parks are the perfect locations for improving the residents' bond with nature and advancing their knowledge, comprehension, and appreciation of nature. Education on the environment advances citizens' knowledge and enhances their perception as much astheir behaviour for creating a resilient environment and community[9]. For instance,education on environment and guidance programs may include;

Urban parkactivity programs like walks in nature and exercising programs outdoors;

Voluntary works allow citizens to participate in routine activities and maintenance like cleaning, mowing grass, and planting;

Educational school trips, after school activities, outdoor events on a seasonal basis for both the youth and children;

Therapeutic landscapes and healing gardens for individuals who are challenged emotionally, physically, and mentally;

Developing a diverse park system is an opportunity for education, or, in other words, providing the community with information about the cultural history of an area, a period, or the values of the natural ecosystem and the relationship between humans and nature. Moreover, this is also a cultural bridge between regions, and if well organized, it can be a very effective tourism promotion product.

3. Principles of spatial layout

In addition to the general principles of multi-functional parks design in Vietnam, the author also proposed three basic spatial layout principles

Principles of free layout

Principle of taking advantage of natural conditions

Principle of natural simulation

Principles of geometry

Combined principle

Principle of taking advantage of natural conditions

In ancient times, when the concept of a park had not yet been formed, vague gardens only served the rest and recreation needs of the ruling classes. Utilizing natural conditions in park design is a common principle because it creates a harmonious relationship with nature. As society continues to develop with modern science and technology involvement, this principle has become one of the core components in organizing park spaces. Furthermore, its advantage is that it limits aggressive interventions into natural landscapes, thereby contributing to environmental protection, conservation, and ecological balance. In addition, it can take advantage of all the benefits of natural landscapes to create unique characteristics and intense attraction for participants.

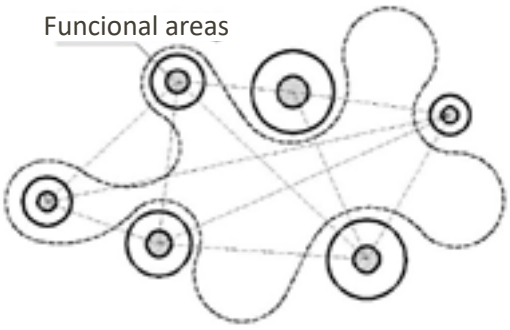

Figure 3. Principle diagram to take advantage of natural conditions[10]

Principle of natural simulation

Principles of natural simulation are also common principles in park layout. This principle is usually based on the idea, the desire of the designer: Get nature as the source of creative ideas. Moreover, it is essential to understand that the natural simulation here is not a random copy but rather a natural one. Nowadays, many parks apply this principle in design and are highly effective in sensing and using space.

Principles of Geometry

The principle of using convergent ray lines

This principle is used with functional subdivisions located on routes, with directions towards the center and the main gate; design principles with convergent ray often create

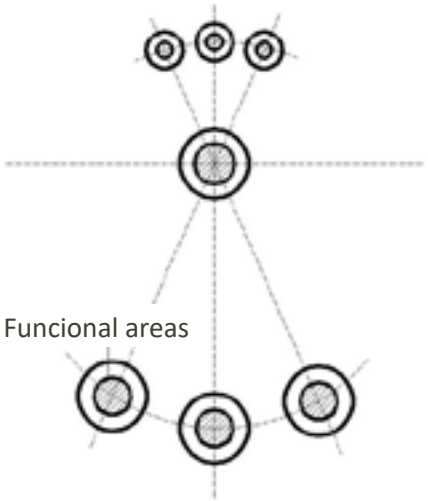

Figure 4. Principle of using convergent ray lines[10]

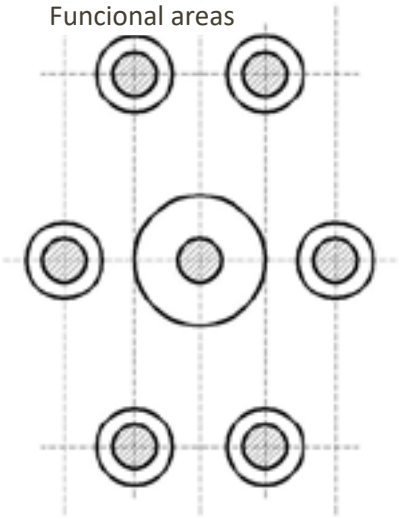

Figure 5. Principles of geometry with symmetry axes[10]

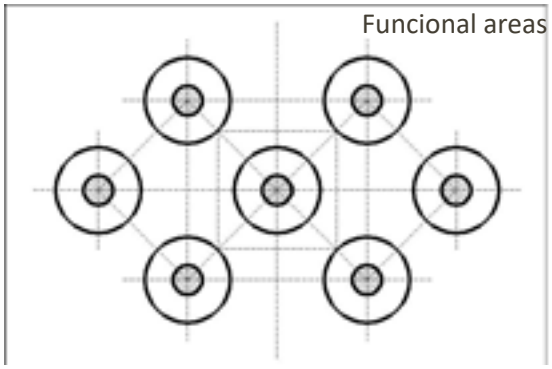

Figure 6. Principles of using regular geometric forms[10]

spaces with spectacular panoramic images. In the process of developing parks in the world and Vietnam, the principle of using convergent rays is one of the preferred principles

Principles of geometry with symmetry axes

In the world, the principle of geometrical arrangement with regular symmetry axes has appeared since ancient Egypt, with a garden layout having two axes of symmetry perpendicular to the center. In the Renaissance, Barcoo, the garden art reached its apex with expressive language using the multi-axial symmetrical forms with the variations of the circular line to create park spaces having unique characteristics. In Vietnam, this principle is also used in park layout, with functional spaces arranged symmetrically through the central axis. Even in separate functional spaces, this method is also used, especially the symmetry axis, which is used extensively in the central space, creating the space with distinct theme ideas.

Principles of using regular geometric forms

This principle is also a common principle in garden design, not only in the world but also in Vietnam. Geometric forms used in spatial design are primarily regular, such as square, circular, octagonal, and hexagonal. In the traditional design principle, squares and circles are two popular geometries. Derived from integrity in all social relationships, loyalty to the country, and family with gratitude, the square circle also reflects the Vietnamese people's philosophical view of human life. Therefore, the principle of using regular geometry is not only one of the principles commonly used in traditional garden design but also design principles that are still widely used.

Combined principle

In the design and construction of the park, combining design principles while respecting the natural terrain and using geometric techniques sometimes brings about high efficiency. For example, the principle of exhaustion, The system of backbones and symmetrical layout works, green trees, and water surface are arranged freely according to natural terrain conditions.

4. Conclusion

Parks is always a hot topic and often receives the attention of everyone. Therefore, besides assessing the actual situation, the development of the park through each period, the development of history to see the change of structural morphology and the trend of the park design. Setting up the principles of urban parks plays a very important role. These will be the basis for the research, design, construction, and planning of the park system in Vietnam./.

References

1. *T. Kien, "The importance and trends of park design in the post-pandemic period and some lessons from international experience," Architecture magazine of VietNam association of architects, vol. 6, 2022.*
2. *"https://thanhnien.vn/sua-luat-thu-do-luat-di-san-cho-phat-trien-ben-vung-cong-vien-185230807230311101.htm," [Online].*
3. *T. Bio, "The Smart Park Revolution: How Tech is Transforming Urban Green Spaces," https://www.tomorrow.bio/, 2023.*
4. *"A brief history of the Historical Relic Site (HRS) Voi Phuc Temple, Thuy Khue, Hanoi.," http://www.vacne.org.vn/, Hanoi, 2011.*
5. *U. Trieu, "The area of historical sediments and folk beliefs is called Thu Le," https://www.anninhthudo.vn/, Hanoi, 2018.*
6. *"Tứ trấn Hà Nội-A unique cultural and historical charm.," https://thanglong.chinhphu.vn/, Hanoi, 2018.*
7. *Annette Voigt, Nadja Kabisch, Daniel Wurster, Dagmar Haase, Ju¨rgen Breuste, "Structural Diversity: A Multi-dimensional Approach to Assess," Journal of the Human Environment, p. 482, 2014.*
8. *N. T. D. Huong, "Cultural factor in the organization of urban park in Bac Ninh," Hanoi Architectural University, 2018.*
9. *D. Dizdaroğlu, "Developing Design Criteria for Sustainable UrbanParks," Journal of Contemporary Urban Affairs, vol. 6, p. 70, 2022.*
10. *N. T. D. Hương, "Integrating traditional culture into the spatial organization of Urban park in Bac Ninh," Hanoi Architectural University, Hanoi, 2019.*

Objectives, Key Tasks, Orientations, Solutions, and Resources for Implementing National Comprehensive Planning during the Initial Stage of Digital Transformation in Vietnam

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Abstract

The achieved results in digital transformation have positively contributed to enhancing the capacity of state management, directing, and administering administrative reforms, providing convenient administrative procedures for citizens and organizations. Digital transformation has also influenced the perception of leaders, increased efficiency, productivity, improved collaboration among staff, and better risk management while ensuring safety and security.

Regarding the National Comprehensive Planning, one of the crucial directions to create new development space is prioritizing the establishment of a framework for national transportation infrastructure, with a particular focus on urban network planning. In practice, these areas pose significant bottlenecks and barriers to current development. To overcome these challenges and promote economic growth, major policies and solutions need to be implemented.

This article discusses the development objectives, key tasks, orientations, and the current state of spatial organization and main content in National Comprehensive Planning, specifically focusing on urban network planning and transportation infrastructure. It also addresses the solutions, resources for implementation, and recommendations for the initial stage of digital transformation in Vietnam.

Key words: *Comprehensive Planning, Urban Network Planning, Transportation Infrastructure Framework*

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1. Problem Statement

1.1. The Necessity of National Comprehensive Planning

The enactment of the Planning Law in 2017 marked a significant institutional reform, fundamentally changing the mindset, approaches, content, and methods of planning. It aimed to enhance inter-sectoral and inter-regional coordination, minimize fragmentation and localism, and effectively allocate resources, including capital, human resources, and assets, to achieve common development goals. The Planning Law contributed to addressing the dispersal and proliferation of previous planning documents and established the "National Planning System," consisting of 111 plans from provincial to national levels, replacing 3,654 plans of the same kind, representing a reduction of 97% in the number of planning documents.

Within the National Planning System, National Comprehensive Planning holds a central position and serves as the fundamental basis for various purposes, including: (i) Formulating long-term (5-year) and annual social development plans; (ii) Deciding on the investment direction for important national projects in accordance with relevant laws (such as the Public Investment Law, Investment Law, Construction Law, and other legal documents); (iii) Developing national sectoral and regional plans; (iv) Serving as an effective tool for the state in managing economic and social development.

Therefore, the establishment and approval of National Comprehensive Planning are great significance as it lays the foundation for other planning documents as stipulated in the Planning Law. Additionally, it serves as a basis for identifying and deciding on investment projects to support the development of different sectors, regions, and localities.

1.2. The Necessity of Digital Transformation in National Comprehensive Planning

Digital technology in planning provides diverse information with open and highly interconnected data, which can be integrated into software for analysis and comprehensive evaluation in reports. This technology proves to be highly effective in sectoral planning, such as transportation, education, healthcare, waste management, water supply, drainage, power supply, markets, craft villages, cemeteries, water bodies, and road infrastructure data.

Through the digital transformation in the field of National Comprehensive Planning, databases will become vital sources of information, serving in the process of developing construction plans, information retrieval, and report generation. When a digitized database system, especially in planning, is fully established, it will provide better reference for planners, thereby enhancing the quality of planning. Additionally, the database will assist management authorities in monitoring and supervising plan implementation.

It can be asserted that digital transformation, the application of Geographic Information System (GIS), and digital platforms in construction planning, in particular, and National Comprehensive Planning, in general, are highly necessary for Vietnam's present and near future.

2. Current Situation of National Comprehensive Planning Development in Vietnam

2.1. Achieved Results

After more than 35 years of renovation, Vietnam has achieved significant and historically meaningful accomplishments. It has harnessed the potential and advantages of the country in various ways:(i) Developed and linked

regions, fostering positive transformation and establishing large economic regions in the country; (ii) Formed economic corridors across regions and inter-regions; (iii) Expanded urban spaces, gradually establishing an urban network, contributing to economic growth; (iv) Developed several large-scale concentrated production areas; (v) Focused on investing in economic infrastructure, giving the country a new look, especially in transportation, irrigation, energy, urban, information, and communication infrastructure; (vi) Paid attention to investing in important social infrastructure projects; (vii) Protected and expanded national parks, nature reserves, and contributed to biodiversity; (viii) Established relationships and development connections between sectors and industries, particularly between infrastructure sectors and production, business, and urban development at the local and sub-regional levels.

The digital transformation of the national planning information system has achieved certain results:

- Management of the national planning database: Initial management and public disclosure of plans at all levels in accordance with the Planning Law.

- WebGIS digital map platform: Ability to display planning maps and interact on the web platform.

- Integration of international standard data (OGC): Services according to OGC standards (WMS, WFS, GML, KML, GeoJSON, WCS, etc.) have been integrated.

- Data sharing: Flexible API set up for sharing the database.

- Planning utilities: Providing many utilities to support exploration, analysis, and spatial retrieval.

- Diverse coordinate system conversion: Easy data spatial conversion between different coordinate systems (WGS 84, VN2000, UTM, etc.).

- A comprehensive data repository is being developed for various sectors using a multidisciplinary, multi-domain integration approach (e.g., construction, transportation, water supply and drainage, industry and commerce, environment, etc.) to be integrated into a unified plan.

- The application of GIS systems, digital technology, and digital platforms has been implemented in planning and urban development, including building a database for sustainable smart urban development in Vietnam for the period 2018-2025 and toward 2030.

2.2. Main Limitations and Existing Issues

Alongside the achieved results, there are still significant limitations and existing issues:

a. Regarding National Comprehensive Planning: (i) Spatial development is fragmented based on administrative boundaries, and regional linkages still face numerous shortcomings; (ii) Investment and development are dispersed across different regions and areas, lacking a concentrated allocation of resources to establish dynamic regions that can lead and drive the country's economic growth; (iii) A comprehensive and modern national infrastructure framework has not been fully established. Transportation and energy infrastructure do not yet fully meet development requirements, and some important social infrastructure projects are slow to receive investments; (iv) Urban distribution is not rational, mainly expanding outward, with limited spreading impacts; (v) Large financial centers have not been well established. The development of economic zones, industrial zones, and tourist areas is dispersed, and the efficiency remains relatively low; (vi) Environmental pollution in large urban areas, craft villages, and some river basins has been slow to be addressed, while marine and island pollution is increasing; (vii) Infrastructure for climate change adaptation, disaster prevention, and mitigation is still limited; (viii) A close linkage between the development of sectors and fields to form priority areas for investment has not been well-established, leading to conflicts of interest in certain regions.

b. Regarding Digital Transformation in National Comprehensive Planning:

The construction industry lacks GIS standards for planning, urban development, and urban management. Extensive research and application of GIS at the central and local levels to ensure dynamic and effective urban construction activities have not been carried out.

A comprehensive national planning database system and direct information technology applications to support planning, evaluation, and urban management have not been established.

2.3. Causes of Limitations and Existing Issues

a. Main reasons related to professional planning practices leading to the limitations and existing issues in the country's spatial development include:(i) Development mindset of dispersion and lack of focus and concentration; (ii) Lack of a comprehensive national planning to clearly define the development model across the entire territory of the country; (iii) Insufficient attention and relatively low-quality in planning activities; (iv) Lack of mechanisms and policies to promote inter-sectoral and inter-regional economic development, addressing local and provincial fragmentation; (v) Inadequate allocation of resources for establishing a comprehensive national infrastructure framework and prioritized development areas such as dynamic regions, key economic regions, and economic corridors; (vi) Sustainable development has not become the dominant thinking in policy formulation and implementation.

b. Main reasons related to digital transformation leading to the limitations and existing issues in National Comprehensive Planning:

- Slow adaptation to change: The awareness of digital transformation among some leaders is not high enough, and digital transformation is not considered an urgent task. Insufficient investment in time and effort for digital transformation has resulted in delayed implementation.

- Insufficient resources to meet the requirements: Regarding human resources: There is a shortage of experts and practitioners with sufficient knowledge of digital transformation, and a limited number of personnel who are proficient in applying digital technology in their work. Regarding technology infrastructure: The technology infrastructure has not been adequately invested in, from hardware equipment to software integration during the digital transformation process.

- Inconsistent digital databases, inappropriate software choices: Digital transformation, particularly in building a digital government, digital economy, and digital society, relies on digital databases. However, Vietnam currently lacks unified regulations to determine coding, barcoding, identification codes, and formats for digital databases in a standardized manner between ministries, sectors, localities, and fields, from top to bottom, and horizontally. [3]

3. Main contents of the National Comprehensive Planning in the initial phase of digital transformation

3.1. Main Content of National Comprehensive Planning in the Early Stage of Digital Transformation

a. Development Perspective: The development perspective of the National Comprehensive Planning during the period of 2021-2030 is aligned with the "Market-driven mechanism plays a dominant role in mobilizing, allocating, and efficiently utilizing resources. Rapid and harmonious development of economic regions, with private economic development truly serving as an important driver of the economy."

b. Perspective on Spatial Development Organization:

- The national spatial development must be efficiently organized and unified on a national scale, ensuring internal and inter-regional connections and leveraging comparative advantages of each region to enhance the national competitive capacity.

- Development should be focused and centralized on some areas with favorable conditions in terms of geographical location, economic and social infrastructure, high-quality human resources, and other potential advantages to form dynamic regions, economic corridors, growth poles, creating ripple effects to drive the rapid, effective, and sustainable development of the national economy until 2030. Simultaneously, there should be appropriate mechanisms, policies, and resources to ensure social security for disadvantaged areas.

- Efficient and economical use of resources, especially land, water, forests, and minerals; ensuring energy security, food security, and water security; developing a green economy, circular economy, environmental protection, proactive response to climate change and natural disasters.

- The organization of national spatial development, regions, economic corridors, and urban systems must be linked to the development of a comprehensive, modern, and harmonious infrastructure network for urban and rural areas; the organization of national spatial development must be connected between land and sea spaces; efficiently exploiting and using underground, maritime, and airspace; effectively leveraging important economic corridors of the region and the world. Close combination of economic, cultural, and social development with security and defense assurance.

c. Development Objectives: Strive for Vietnam to be a developing country with modern industry, high average income, economic growth based on scientific and technological foundations, innovation, and digital transformation; having an efficient, unified, and sustainable organization model for national spatial development, forming economic regions, dynamic urban centers, with a network of comprehensive, modern infrastructure; ensuring major balances and enhancing the resilience of the economy; protecting the ecological environment, adapting to climate change; improving the material and spiritual life of the people; ensuring stable national defense and security until 2030.

d. Digital Transformation Development Objectives:

- Select specific subjects within the scope of state management to carry out digital transformation.

- Apply Geographic Information System (GIS) in planning and managing construction planning work.

- Apply Building Information Modeling (BIM) in construction investment activities.

- Apply digital technology and artificial intelligence in the management and operation of smart cities and digital enterprises.

3.2. Key Tasks During the Planning Period

a. Key tasks in digital transformation during the planning period:

- Establishing the fundamental framework of national infrastructure, with a focus on transportation, urban and rural areas, energy, digital infrastructure, cultural and social infrastructure, water management, environmental protection, disaster prevention, and climate change adaptation.

- Accelerating economic restructuring in line with innovative growth models, prioritizing the development of sectors with potential, advantages, and substantial potential for growth in new development areas.

- Developing dynamic regions and important growth poles to lead the country's development. Selecting specific locations, cities, and regions with special advantages to establish economic and financial centers, special administrative-economic units with breakthrough policies, and high international competitiveness. Implementing appropriate policies for the development of remote, border, and island regions to contribute to political stability and national security.

- Establishing and developing economic corridors along the North-South and East-West axes, coastal economic belts, and efficiently connecting major seaports, airports, international border gates, major trade hubs, economic centers, and growth poles. Developing industrial-service-urban belts in dynamic regions and large urban areas.

b. Key tasks in digital transformation:

- In the provincial planning system, key digital transformation tasks include: (i) Publishing approved plans in digital map format in accordance with the Planning Law; (ii) Enabling plan information retrieval on the digital map platform; (iii) Integrating plans at various levels; (iv) Establishing two-way linkages between planning documents and planning maps; (v) Providing various utilities to exploit planning maps for leaders, experts, and citizens.

- For the public, key digital transformation tasks include: (i) Retrieving information about plans/projects on the digital map platform; (ii) Developing multiple utilities to enhance functions such as land plot positioning on maps, stacking different planning layers, etc.; (iii) Allowing citizens to contribute their opinions during the planning process; (iv) Utilizing the platform on both web and mobile devices.

- For Mobile GIS in planning, key digital transformation tasks include: (i) Enabling plan information retrieval on mobile devices such as smartphones and tablets; (ii) Allowing administrators to actively create applications for updating data related to planning map layers, serving the planning process and operation.

- In planning management, key digital transformation tasks include: (i) Managing planning documents (drawings, documents, designs, etc.); (ii) Managing and building planning maps from standard spatial data formats (Shapefile, CAD, Geo Database, Postgre/PostGIS, KML, GML, etc.); (iii) Creating specialized maps using standard symbols/colors in accordance with specific sectors; (iv) Establishing two-way linkages between planning documents and maps, as well as spatial analysis and exploitation tools for planning purposes.

3.3. Orientation for Development, Organization, Spatial Distribution, and Utilization in the National Master Plan

To contribute to addressing the bottlenecks in urban network planning and national transportation infrastructure, let's discuss some of the following orientations in the early phase of the national master plan's digital transformation:

a. Development and spatial distribution orientation of key sectors:

- For production and business sectors:

In the industrial sector, industrial spaces should be planned in connection with urban systems and service centers to form economic corridors and dynamic regions. The development of industrial zones should expand to the western region of the North-South highway, the midland area, and the Trung du region to reduce land pressure in the delta and minimize the impact of climate change.

In the service sector, commercial and financial centers with regional and global significance should be developed in major cities, linked to the development of dynamic regions and economic corridors. Establishing large-scale, modern logistics centers linked to major seaports, airports, and international border gates. Developing competitive regional and international tourist centers.

For agricultural production, concentrated agricultural production areas should be planned in connection with the development of industrial processing centers. Increasing the proportion of aquaculture and fruits while reducing the proportion of rice cultivation reasonably in the Mekong Delta.

- For technical infrastructure sectors: Concentrate resources to develop the infrastructure network to support the formation of economic corridors and establish a synchronous and modern infrastructure system in dynamic regions.

b. Spatial organization orientation by region and territory:

- Development orientation of national dynamic regions and economic corridors: (i) Selecting a few areas with the most favorable conditions to form national dynamic regions, including the Northern dynamic region, the Southern dynamic region, the Central region, and the Mekong Delta, with corresponding growth poles being Hanoi, Ho Chi Minh City, Danang, and Can Tho. (ii) Developing prioritized economic corridors by 2030, including the North-South economic corridor and two economic corridors: Lao Cai - Hanoi - Hai Phong - Quang Ninh and Moc Bai - Ho Chi Minh City - Vung Tau. (iii) Gradually forming and developing long-term economic corridors: Economic corridors along the Hanoi-Ho Chi Minh City route and the West North-South route through the Central Highlands and the Southeast region.

- Organizing the development of regions and linking regional orientation: (i) The Northern Midland and Mountainous region: Develop the region in a green, sustainable, and comprehensive manner. Focus on protecting and restoring forests, developing sustainable forest economy, and exploiting and using mineral resources efficiently. (ii) The Red River Delta: Focus on developing modern industrial and service sectors. Develop agriculture with high-tech, clean, organic practices to serve urban areas. (iii) The North Central and Central Coastal region: Develop a strong maritime economy in combination with ensuring national defense and security. Improve the efficiency of seaports, coastal economic zones, and industrial zones. (iv) The Central Highlands: Protect special-use forests, protective forests at headwaters linked to water security. Strengthen the development of agroforestry, renewable energy industries, and sustainable bauxite mining, processing, and aluminum production. (v) The Southeast region: Become the most dynamic and largest growth driver in the country, a center for science, technology, innovation, high-tech industry, logistics, and highly competitive international financial center in the region. Lead in innovative growth model, digital transformation. (vi) The Mekong Delta: Develop the region into a sustainable, dynamic, and efficient agricultural economic center. Focus on agricultural production, develop green and renewable energy industries. Proactively adapt to climate change and rising sea levels.

c. Orientation for the development of the national urban and rural system: (i) Building the national urban system based on a network model, green, smart, sustainable, and adaptive to climate change. Developing and upgrading Hanoi, Ho Chi Minh City, and centrally-run cities into dynamic, innovative, leading urban centers that create ripple effects and link urban areas; competitive enough to integrate regionally and internationally. (ii) Developing comprehensive, modern, green, clean, and beautiful rural areas linked to the process of urbanization, with synchronized infrastructure and accessible to urban areas; preserving and promoting the cultural identity of ethnic groups; ensuring stable rural society; improving people's knowledge; and ensuring security and order. Planning settlement models suitable for each ecological region and the cultural and ethnic characteristics, economic and social conditions.

d. Orientation for resource use, environmental protection, disaster prevention, and climate change adaptation:

- Regarding resource usage: (i) Allocate water resources harmoniously and reasonably between sectors and localities, ensuring overall effectiveness in economics, society, and the environment in river basins. (ii) Restructure the exploitation of fisheries, gradually reduce the level of exploitation in line with the reserves, ensuring the protection and development of fishery resources. (iii) Conserve, protect, and sustainably use forest resources, combining harmonious development of the economy with environmental protection and climate change adaptation. (iv) Ensure a balance between short-term exploitation and use with long-term reserves of mineral resources. Form clusters of mines of sufficient scale to attract investment and apply modern technology from exploration to processing.

-Regarding environmental protection: Prevent the increasing trend of pollution and environmental degradation; solve urgent environmental issues; gradually improve and restore environmental quality. Conserve, protect, and expand the system of natural reserves, wetland areas, important ecological landscape areas, and biodiversity corridors.

- Regarding disaster prevention and climate change adaptation: Proactively adapt to climate change, gradually manage natural disaster risks, and create conditions for sustainable development. Strengthen and upgrade the system of disaster prevention and control works. Implement greenhouse gas emission reduction in all sectors, aiming for net-zero emissions by 2050.

4. Planning urban network and national transportation infrastructure in the initial phase of digital transformation

4.1. National Urban Network Planning to Create Development Space and New Growth Drivers

Based on the guidance of the Politburo on planning, construction, management, and sustainable development of Vietnamese urban areas until 2030 and the vision towards 2045, urbanization is an objective necessity and an important driving force for fast and sustainable socio-economic development in the early phase of digital transformation. The target is to achieve a minimum urbanization rate of 45% by 2025 and over 50% by 2030. The percentage of urban land on the total natural land area should be about 1.5 - 1.9% by 2025 and 1.9 - 2.3% by 2030. The vision towards 2045 aims to build at least 5 cities that meet international standards. The economic structure of urban areas will develop in a modern direction, with a significant share of green and digital economies. [1]

a. National urban network: The existing network will continue to be maintained and developed, with adjustments to basic urbanization areas, major urban areas, large cities, mega-cities, economic border areas, coastal areas with the role of leading growth centers, or secondary national growth centers. The development of key economic-urban corridors from North to South will be promoted, as well as the dynamic East-West economic-urban corridors, the fan-shaped corridors, and the border belts, coastal areas, and island areas linked to maritime and border economy.

b. Adjustment of basic urbanization areas: This will be in line with the projected national socio-economic restructuring to create new economic-social spaces: (i) Mountainous areas in the North will develop based on their local potential, utilizing resources from land, cultural heritage, and economic border areas; (ii) The Red River Delta and North Central region will develop mainly based on the Capital region, (iii) The North Central and South Central regions will develop mainly based on the Economic Central region with Thanh Hoa, Vinh, Hue, Da Nang, Quy Nhon as the chain of dynamic urban areas; (iv) The South Central Coast will develop mainly based on the Southern Economic Center with Ho Chi Minh City as the high urbanized region, the main growth driver; (v) The Mekong Delta will develop mainly based on the Mekong Delta's economic focal points.

c. Formation of large urban areas (economic-urban regions): Besides the capital city Hanoi and Ho Chi Minh City, which have basically become large/very large/leading growth center urban areas in the overall structure of the national urban network, having a great impact on the domestic and international competitive environment, additional urban areas like Da Nang and Long Thanh International Airport will be supplemented. Hanoi, Ho Chi Minh City, and Da Nang are the three cities meeting international standards (global cities), acting as the nucleus of three large urban areas, major urbanized regions with high competitiveness and importance for Vietnam. Long Thanh Airport area plays the role of an important air gateway in the Southern region of Vietnam and internationally.

d. Formation of leading growth centers: Large and vast cities play the role of central urban areas, leading growth centers and secondary national growth centers such as Hanoi, Ho Chi Minh City, Hai Phong, Vinh, Hue, Da Nang, Quy Nhon, Can Tho, Long An... Additionally, Bac Ninh and Vinh Phuc urban areas will be added and developed according to the multi-center model, green, intelligent, and sustainable growth. In addition, due to the unique characteristics, Hanoi will continue to be developed in the cluster of urban areas model. Hanoi, Ho Chi Minh City, Hai Phong, Hue, Da Nang, Can Tho, and Phu Quoc are cities that meet international standards, acting as the connection and development hub with the regional and international network.

e. Formation of central economic-urban corridors:

- Corridors in the North-South direction: (i) Economic-urban corridor along the coastal and island areas; (ii) Border corridor linking socio-economic development, economic border areas with ensured national defense and security; (iii) Support corridor along the Ho Chi Minh Highway... The main economic-urban corridors in the North-South direction play a crucial role in connecting regions, major growth centers, leading dynamic urban areas, and secondary centers, forming the backbone and main arteries of the country...

- Corridors in the East-West direction: (i) Con Minh - Hanoi - Hai Phong, Lang Son corridor; (ii) East-West corridor/ QL19; (iii) QL22 corridor... In addition, there are other support East-West corridors like QL8, QL19, QL26... The East-West corridors have many potentials, advantages, creating strong connections or "flow" with attractive resources and investments in national and international relations, creating attractive coastal gateways for the Western region...

f. Formation of urban clusters and chains: Depending on natural conditions, relationships, resources, and development situation, the development of urban clusters and chains in the Northern coastal region; Urban chain in the North Central region; urban chain in the Central coastal region; Urban chain in the Central South coastal region; Urban cluster in the Central Highlands; Urban cluster in the Mekong Delta...

4.2. National Transport Infrastructure Planning to Connect Development Spaces and New Growth Drivers

The planning and development of national transport infrastructure play a crucial role in the process of industrialization and modernization, in line with the three core breakthroughs to promote fast and sustainable socio-economic development. The national transport infrastructure serves as the framework defining the territorial space and the connecting backbone between development spaces and new growth drivers within the country and internationally.

a. Road transport network: The planning of the road transport network covers the period from 2021 to 2030 with a vision towards 2050. [2]

- The planned highway network consists of 41 routes with a total length of about 9,014 km, including the North-South vertical axis, such as the North-South highway (from Huu Nghi Border Gate to Ca Mau City) with a length of about 2,063 km and a width of 4 - 10 lanes; The West of the North-South highway (from Tuyen Quang City to Rach Gia City) with a length of about 1,205 km and a width of 4 - 6 lanes... These highways ensure interregional connections, linking international seaports, international airports, major international border gates with significant import and export demands, special and type I urban areas, and facilitate convenient connections with national highways to type II seaports, international airports, major inland waterway ports, and urban transportation hubs of type II and below.

- The national highway network includes 172 routes with a total length of about 29,795 km. The North-South vertical axis includes: National Highway 1: From Huu Nghi Border Gate to Nam Can District, Ca Mau Province, with a length of about 2,482 km, meeting level III standards, with 4 lanes; The Ho Chi Minh Road: From Pac Bo to Dat Mui, with a length of about 1,762 km, meeting minimum level III standards, with 2 - 4 lanes...

b. Railway network: The planning of the railway network covers the period from 2021 to 2030 with a vision towards 2050. [3]

The national railway network until 2030 includes 7 existing routes with a total length of about 2,440 km; Planning for 9 new railway routes with a total length of 2,362 km. Among them, the high-speed railway from the North to the South from Ngoc Hoi station to Thu Thiem station is a double-track, 1,435mm gauge, with a length of about 1,545 km.

The planned national railway network until 2050 will include 25 routes with a total length of 6,354 km. The railway network of Vietnam will connect across Asia, link Asia and Europe through the Chinese railway at Huu Nghi Border Gate and Lao Cai; connect with the ASEAN railway through Laos and Cambodia.

c. Aviation network: The planning of the aviation port network follows a spine-like model with two main hubs in Hanoi and Ho Chi Minh City, forming 28 airports, including 14 international airports (Van Don, Cat Bi, Noi Bai, Tho Xuan, Vinh, Phu Bai, Da Nang, Chu Lai, Cam Ranh, Lien Khuong, Long Thanh, Tan Son Nhat, Can Tho, and Phu Quoc); 14 domestic airports (Lai Chau, Dien Bien, Sa Pa, Na San, Dong Hoi, Quang Tri, Phu Cat, Tuy Hoa, Pleiku, Buon Ma Thuot, Phan Thiet, Rach Gia, Ca Mau, and Con Dao).

The vision until 2050 aims to form 29 airports, including 14 international airports (Van Don, Hai Phong, Noi Bai, Tho Xuan, Vinh, Phu Bai, Da Nang, Chu Lai, Cam Ranh, Lien Khuong, Long Thanh, Tan Son Nhat, Can Tho, and Phu Quoc); 15 domestic airports (Lai Chau, Dien Bien, Sa Pa, Cao Bang, Na San, Dong Hoi, Quang Tri, Phu Cat, Tuy Hoa, Pleiku, Buon Ma Thuot, Phan Thiet, Rach Gia, Ca Mau, Con Dao). Especially, during this period, the second airport to support Noi Bai International Airport will be established in the southeast of Hanoi, and some airports and airfields on islands or archipelagos with favorable natural conditions for economic and social development, ensuring national defense and security will be developed.

d. Waterway network: The planning of inland waterway infrastructure structure covers the period from 2021 to 2030 with a vision towards 2050. [4]

By 2030, the planning includes 9 waterway transportation corridors, including 1 coastal corridor, 4 corridors in the Northern region, and 4 corridors in the Southern region. Planning for 54 clusters of cargo ports with a total capacity of about 361 million tons: 25 clusters in the North with a total capacity of about 199 million tons; 8 clusters in the Central region with a total capacity of about 9 million tons, and 21 clusters in the South with a total capacity of about 153 million tons. Planning for 39 main passenger ports with a total capacity of about 53.4 million passengers: 10 clusters in the North with a total capacity of about 10.9 million passengers; 14 clusters in the Central region with a total capacity of about 2.5 million passengers, and 15 clusters in the South with a total capacity of about 40 million passengers.

The vision until 2050 aims to complete a modern, coherent, safe, and high-quality inland waterway infrastructure, significantly contributing to reducing logistics costs and becoming one of the major means of transportation for cargo.

4.3. Solutions and Resources for Implementing the Comprehensive National Master Plan in the Initial Phase of Digital Transformation

In the National Master Plan for the period 2021-2030, with a vision towards 2050, the total demand and investment capital structure required to implement the plan have been forecasted. To mobilize resources, the plan outlines a system of solutions that involve pooling resources from different economic regions. It also forecasts labor demand for the economy and proposes measures for human resource development and utilization. The plan emphasizes prioritizing the development of large-scale infrastructure networks in national growth-driving regions and promoting the establishment of priority economic corridors. Additionally, it focuses on supporting underprivileged areas and ensuring access to basic social services. Furthermore, the plan also includes solutions for advancing science, technology, environmental protection, and enhancing international cooperation.

The digital transformation in the National Master Plan involves several measures in the planning sector, including the establishment of a national planning information system, provincial planning systems, urban planning, planning management, and applications for the public.

The planning solutions are implemented based on several key legal foundations:

- Identifying priority sectors for digital transformation according to the "Construction Sector Digital Transformation Plan for the period 2020-2025, with orientation to 2030" [5].

- The digital database includes standards, regulations, norms, and unit prices to serve the state management of the Ministry of Construction; Implementing the Ministry of Construction's E-government; Planning for construction, urban development, and urban technical infrastructure. [5]

4.4. Some Recommendations for Urban Network Planning and National Transport Infrastructure in the Initial Phase of Digital Transformation

Urban network planning and national transport infrastructure development are essential aspects of the Comprehensive National Master Plan to create development spaces and new growth drivers, such as the formation of basic urban areas, large urban areas/economic-urban regions, major growth poles - large and mega urban areas, economic-urban corridors, coastal economic zones, and border gates. Additionally, planning and developing the national transport infrastructure play a crucial role in addressing bottlenecks and enhancing connectivity between development areas and new growth drivers through synchronized and modern road, rail, waterway, and aviation systems. This contributes to completing the national territorial structure and creating development spaces and new growth drivers to meet the country's development needs.

However, to effectively implement these two critical aspects (urban network planning and national transport infrastructure) of the Comprehensive National Master Plan, the following core recommendations should be considered:

a. Prioritize and focus on the planning and investment in developing the national transport infrastructure, especially resolving bottlenecks and enhancing connectivity between development areas and new growth drivers according to the Comprehensive National Master Plan.

b. The national urban network planning must create development spaces and new growth drivers. Planning involves organizing and distributing the space for economic, social, defense, and security activities, along with infrastructure development, resource utilization, and

environmental protection within the designated territory to effectively utilize the country's resources for sustainable development during the defined period (Article 3, Planning Law).

c. Innovate the urban development model that suits Vietnam's specific natural, economic, social, cultural, and historical conditions. Develop compact urban areas in major and mega urban areas to save and enhance land use efficiency. Promote urban development towards green, smart, and sustainable growth, adapting to climate change and rising sea levels.

d. Continue to improve the institutional framework, innovate mechanisms, policies, and complete the system of legal documents on urban development. Research and develop the "National Urban Network Management Mechanism" based on the establishment of the Planning Law, Construction Law, Urban Development Management Law, and related legal documents, programs, plans, and schemes during the country's urbanization and industrialization-modernization process.

e. Manage the urban network following a "hierarchical model" at the provincial, regional, inter-regional (or zonal), and national levels. Build a management model with connectivity and integration, replacing the local and regional approach, based on the National Planning Database (GIS) for urban development planning.

f. Mobilize maximum resources and attract investment capital from all economic sectors, including foreign investors participating in various forms of investment in developing the transport infrastructure, such as BOT, BT, BTO, PPP. Revise and supplement regulations on financial support policies, taxes, prices, fees, charges, and concession rights to increase the commercial viability of transportation projects and user contributions.

g. Complete the urban government model based on the spirit of the Law on Organizing Local Governments. Urban governments operate in an e-government environment and a smart urban platform suitable for the urbanization and socio-economic development process of each region and locality.

5. Conclusion

The benefits of digital transformation, both in general and within the context of the Comprehensive National Master Plan, are demonstrated in two fundamental aspects:

a. On the aspect of government management:

Having a complete, scientific, and accurate database system creates favorable conditions for the successful implementation of digital transformation in the Comprehensive National Master Plan.

- For citizens, digital transformation in the master plan provides opportunities to: (i) Access comprehensive database information in various sectors; (ii) Move towards "100% contactless" delivery of all planning and construction services.

- For sector management: (i) Having a comprehensive data system as a solid foundation for developing analytical systems that support decision-making; (ii) Enhancing management capacity and advisory work for leaders, minimizing the time spent on data synthesis and reporting.

- For sector leaders: (i) Obtaining a clear overview of the overall picture, achievements, shortcomings, completeness or incompleteness of information, strengths, weaknesses in the operation of various departments, and the level of citizen satisfaction; (ii) Gradually increasing the percentage of decision-making based on digital technology data.

b. On the technical aspect:

- Ensuring the connectivity between various systems (regional development planning, interlinked regions, economic-urban corridors, urban spaces, economic infrastructure systems, infrastructure with production and business sectors, urban development within the national and local scope); building a comprehensive data repository shared among multiple sectors through integrated and multi-disciplinary approaches (e.g., construction, transportation, water supply and drainage, ecology, environment, etc.), especially concerning the ability to communicate during future adjustments and the development of sustainable smart cities.

- Providing databases for various sectors in the form of services so that other systems can exploit, use, and implement data efficiently, avoiding redundant construction of information in specialized sectors. This includes: National planning database management; Integration of international standard data and services according to OGC standards; Access to and interactive use of planning maps on the web; Flexible data sharing and establishment of APIs; Providing multiple utilities supporting exploration, analysis, and spatial retrieval; Easy data transformation between different coordinate systems (WGS 84, VN2000, UTM, etc.); Convenient access to GIS systems./.

References

1. *Politburo (2022) Resolution 06-NQ/TW dated January 24, 2022, on planning, construction, management and sustainable development of Vietnamese urban areas until 2030, vision to 2045.*
2. *Prime Minister (2021) Decision No. 1454/QD-TTg dated September 1, 2021 on Road network planning for the period 2021 - 2030, vision to 2050.*
3. *Prime Minister (2021) Decision No. 1769/QD-TTg dated October 19, 2021 on Railway network planning for the period 2021 - 2030, vision to 2050.*
4. *Prime Minister (2021) Decision No. 1829/QD-TTg dated October 31, 2021 on Inland waterway infrastructure planning for the period 2021 - 2030, vision to 2050.*
5. *Ministry of Construction (2020) Decision No. 1004/QD-BXD dated July 31, 2020, approving the "Digital Transformation Plan for the Construction Industry for the period 2020-2025, orientation to 2030".*
6. *Le Hoang Trung, Nguyen Hoang Minh "Urban development approach to-wards smart cities", Jounal of construction 01-2023, 86-92.*
7. *Luu Duc Minh (2022) Smart City – An important motor for Vietnam's comprehensive development, Construction and Urban Magazine, Academy of Managers for Construction and Cities*
8. *Luu Duc Minh (2021) Chapter 4: Some technology solutions in management and Smart City development, Training materials on Smart City development management, Academy of Managers for Construction and Cities.*

Smart city management and development by applying technology

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Abstract

Along with the development of science and technology and the application of the achievements of the 4th Industrial Revolution, many countries around the world have succeeded in building a smart city model that contributes to improving the quality of life, improving the service quality of the city government, reducing energy consumption, and enhancing the effective management of natural resources. Smart city development is one of the important driving forces to realize the goal of turning Vietnam into a modern, high-income industrialized country by 2045, while promoting national digital transformation, digital economy development on the basis of science - technology and innovation. This article aims to propose technological solutions in smart city management and development associated with digital transformation.

Key words: *Smart city, Management and Development, Technology solutions*

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1.Introduce

Currently, facing global issues such as economical use of resources, energy, response to climate change, towards green growth and sustainable development strategies, smart city development strategy is an inevitable trend being applied by many countries. In the context of the Fourth Industrial Revolution, according to the direction of the Politburo's Resolution No. 52-NQ/TW dated September 27, 2019 on a number of guidelines and policies to actively participate in the 4th industrial revolution [6]; Resolution No. 50/NQ-CP dated April 17, 2020 of the Government promulgating the Action Program to implement Resolution 52/NQ-TW [1], the Ministry of Construction, the Ministry of Public Security, the Ministry of Information and Communications, the Ministry of Science and Technology, the relevant localities are assigned the task of researching, building and completing the legal framework on sustainable smart city development; system of national technical standards and regulations; the data infrastructure system, the system of criteria for evaluating the operational efficiency of smart cities; allow pilot implementation of a number of specific mechanisms in the pilot implementation of smart city development, ensuring efficiency and suitability with actual conditions. In particular, the project "Sustainable smart city development in Vietnam for the period 2018 - 2025 and orientation to 2030" according to Decision No. 950/QD-TTg dated August 1, 2018 approving the scheme, assigning the Ministry of Construction to assume the prime responsibility for, and coordinate with central and local ministries, branches in implementation. The project aims to implement the national socio-economic development strategy and plan through sustainable smart city development in Vietnam. [2]

Smart urban development must be based on the guidelines of the Communist Party of Vietnam, State laws, orientations, strategies, master plans, plans and programs for socio-economic development, etc. At the same time, this is an important content of the 4th Industrial Revolution, using means of supporting information and communication technology (ICT) and other means to improve the efficiency, quality of urban development, increase the living environment, and improve the quality of urban life, economic and social development. On that basis, in order to realize the above content, it must be people-centered, making an important contribution to the implementation of the National Strategy on green growth and sustainable development goals, based on scientific and technological achievements with many platforms, ensuring network information safety, network security, protecting personal information, ensuring the synchronization between technological and non-technological solutions.In the implementation process, it is necessary to ensure the consistency and optimize the existing technical and ICT infrastructure based on the ICT reference framework for smart city development, technical regulations and standards to ensure the interoperability and synchronous operation of smart cities as well as between smart cities; using key performance indicators (KPIs) for smart cities. In addition, in order to organize the implementation of sustainable smart city development, it is necessary to encourage investment participation from socialized sources on the principle of correct calculation, adequate calculation of costs and risks, harmonization of interests of stakeholders, and encouragement of the use of domestic products and services. Organize typical pilot implementation, ensure short-term and long-term investment efficiency, do not develop spontaneously, rampantly, following the movement.

The most important tasks and solutions today are to perfect institutions and policies to facilitate the process of urbanization, planning, construction, management and sustainable urban development; To soon build a legal

framework for smart city development, management of urban technical infrastructure, urban underground space; Improve the quality of urban planning to meet the requirements of construction, management of sustainable urban development, comprehensive innovation in methods, processes and contents... Building a national data system on urban development planning; widely apply geographic information system (GIS) and technology, digital foundation in urban development planning and management; Focus on building and developing a national urban system in a sustainable and synchronous manner through the effective implementation of national projects and programs on urban development in Vietnam in response to climate change, natural disaster and epidemic prevention and control; Urban renovation, embellishment, reconstruction and upgrading; Building and developing smart cities; New rural construction in line with urbanization orientation. Promote housing development, synchronous, modern, connected urban infrastructure system and adapt to climate change [3]. Promote investment in synchronous digital infrastructure development in urban areas equivalent to developed countries in the region and the world; integrate measurement systems, sensors, data systems, effectively exploit digital platforms and apply digital technology to essential infrastructure in urban areas; promoting the smart management model in the operation, management and exploitation of urban technical infrastructure systems. To build and perfect the urban government model in order to improve the effectiveness and efficiency of management, the quality of urban life, to ensure security, social welfare, security, safety and urban order; Building e-government towards digital government in urban areas closely linked with smart city development; Renovate financial mechanisms and policies, urban development investment. Developing service economy, circular economy, sharing economy, night economy, tourism economy, sports... in special urban areas and big cities...

This article will present researches on new technologies in urban planning and development management, technical infrastructure system operation management, thereby proposing new technological solutions in planning management and smart city development.

2. Research methods

2.1. Technology application in urban planning and development management

Geographic information systems (GIS) have been widely applied in urban planning and development management in the world since the 1960s. Currently, many technology companies in Vietnam have built a number of application systems that allow the integration and management of Planning Documents with full layers of data for management (spatial planning, land use, traffic, water drainage and drainage, and ground level, water supply, etc.), With a database built synchronously on the same national coordinate and elevation system, it allows to support spatial analysis to support planning, collect public comments, publish planning, look up, and provide planning information to stakeholders. In addition, the urban development and planning information management system allows linking with state management application systems of the construction industry at the provincial and urban levels in management of investment project licensing, construction permits, housing and real estate market management, management and operation of technical infrastructure systems, and inspection, inspection and supervision of construction investment activities. [4]

Although the effectiveness of the geographic information system (GIS) as well as a number of technology solutions for planning management have been initially applied, currently neither Vietnam nor the Ministry of Construction have issued a standard framework for the planning geodatabase, so the current applications are still single, standardized on the basis of a system of regulations on drawings and symbols of planning schemes according to the method of Circular 12/2016/TTD dated June 29, 2016/TT. In addition, there is a current problem when construction and urban planning projects are made on the basis of topographic survey maps, while the practice of land management of the natural resources and environment sector is managing on the basis of cadastral maps and there is a certain deviation in the locality. With the orientation in Project 950/2018, the development of urban spatial data infrastructure, consolidation of land, construction data and other data on GIS basis, along with the early research and issuance of a standard framework of planning geodatabase are indispensable requirements for synchronous urban planning & development management.

2.2. Technology application in management and operation of technical infrastructure systems

a. Smart Traffic management and operation

The intelligent traffic system is set up to support the management, control, operation, exploitation and maintenance of the external, urban, bridge and tunnel traffic network during the operation and use; allows to collect, process information, control decisions to the management department and control network of traffic signals. A number of solutions have been deployed such as automatic weighing system, automatic toll collection without RFID, traffic monitoring system, traffic information board system, traffic measurement, weather monitoring, inner city traffic signal control system. Advanced technology in the recent research phase has used 2D, 3D laser scanning systems, artificial intelligence (AI) in identification.

On the basis of a synchronous and unified management system, it allows can automatically assist in handling and operating traffic to help reduce traffic congestion and reduce emissions into the environment; capable of real-time management, intelligent analysis, creating diverse traffic scenarios and situations in reality, increasing flexibility, and simplifying traffic management. Some main functional components system: traffic surveillance camera system, vehicle flow metering system, event management system, vehicle load control system, traffic information supply system, traffic control signaling system, weather information system, communication system, emergency telephone system, equipment monitoring system, toll collection control system, traffic control center, toll collection system traffic signal, automatic traffic incident detection system. [4]

These systems are built on the basis of digital map technology (GIS), mobile technology and cloud computing with full information of various types of map data, field data (location, images, information) using mobile devices (tablets, smartphones) capable of correcting location on the basis of field maps, synchronizing and interlinking with road search and navigation tools.

b. Management and operation of the water supply network

Managing the water supply network for water supply enterprises effectively on the basis of building a geodatabase

Fig. 1. Real-time simulation model provided from the network of monitors and sensors[7]

system on the water supply network, modernizing the management of plant assets, equipment assets, asset maintenance, monitoring the operation of the smart water supply network with the Dashboard system, meter life cycle management, and inventory management; incident management system, property maintenance, repair, management and customer care of water use, support for water loss prevention as well as integration of value-added service solutions: VOIP 1900 customer care switchboard, SMS, e-invoice and electronic payment into the customer management system.

A number of operational management solutions for businesses have been implemented such as: customer management software system, Dashboard to monitor production and business activities, VOIP customer care switchboard, electronic portal, customer care to look up: water bill, installation registration; Indexing on mobile devices, issuing and paying bills electronically.

With a WebGIS-based solution, water supply network assets and data are updated from as-built records, capable of accurately updating information and GPS location from the field in the field, can be connected from anywhere via the Internet.

c. Managing the tree system in the city

Currently, the management, inspection and care of trees in urban areas is still quite manual. Advanced technology application solution allows building GIS database of overall tree map to visually control trees: information, location, image; control the total number of trees, increase, decrease over time; track tree history during growth, development, tree movement history; develop a plan for periodic care, special care according to the condition of the tree; assigning and supervising the implementation of tree care work in the field.

Tree database with information on attributes, locations, images, status of trees in the field updated via applications installed on mobile devices; In addition, setting up a system to receive incidents and request treatment of trees between people and management units. [5]

d. Management of lighting systems and electrical networks

The system allows to build and manage a GIS database of the overall status of the lighting network, the power supply network (street lights, power poles, electrical cabinets, power supply networks, substations, transformers, etc.) link with application control systems on property, increase or decrease the number of lights; control safety, leakage of electricity of each asset in the system, record the index by mobile device; synchronize data between mobile devices into the management system; track equipment repair and replacement history; make periodic maintenance and replacement plans; In addition, there is the ability to connect to the system to receive and respond to lighting troubleshooting requests from the people, to integrate the monitoring and remote lighting control system. The database is updated directly in the field through devices and smartphones. [5]

Currently, customer management, issuance and electronic invoice payment services have been integrated into the payment systems of banks through providers such as Viettel, VNPT, BKAV, VNIs...

e. Drainage Management

The system allows building and managing a GIS database of the overall status of the urban drainage system, modernizing the management, inspection and maintenance of the drainage system; improve the use efficiency, asset life from the strict management of the operation and maintenance of the drainage network assets. Database of drainage system from sewer network, location of manholes, discharge gates, pumping stations, drainage connection points, etc. in the field by mobile application. The collected data is synchronized directly from the mobile device to the database system for mapping and management of the drainage network.

The contents of property management and equipment are displayed visually on the map:

- Manage information, images, documents,... associated with visual assets on the map of the drainage network.

- Allows monitoring and recording of content and results of inspection and maintenance associated with each asset and equipment

- Provides the ability to allow users to actively adjust and expand management information for existing assets and equipment, add new assets and equipment to meet future management needs.

- Detailed management of devices in an asset unit

- Provide the ability to query assets, schedule maintenance, assets need maintenance

- Synthesize, inventory and report on the management and use of assets and drainage network equipment according to the report templates, output to formats according to different filter conditions. In addition, the system allows receiving information requested and reflected by people about the status and problems on the drainage system. The results of the field inspection are updated accurately about

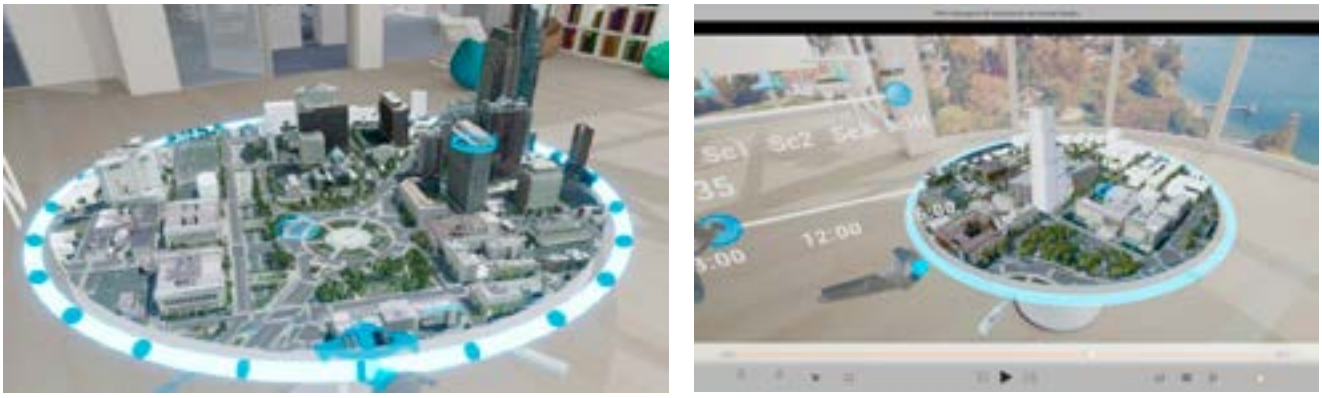

Fig. 3. Building 3D city model on GIS platform[7]

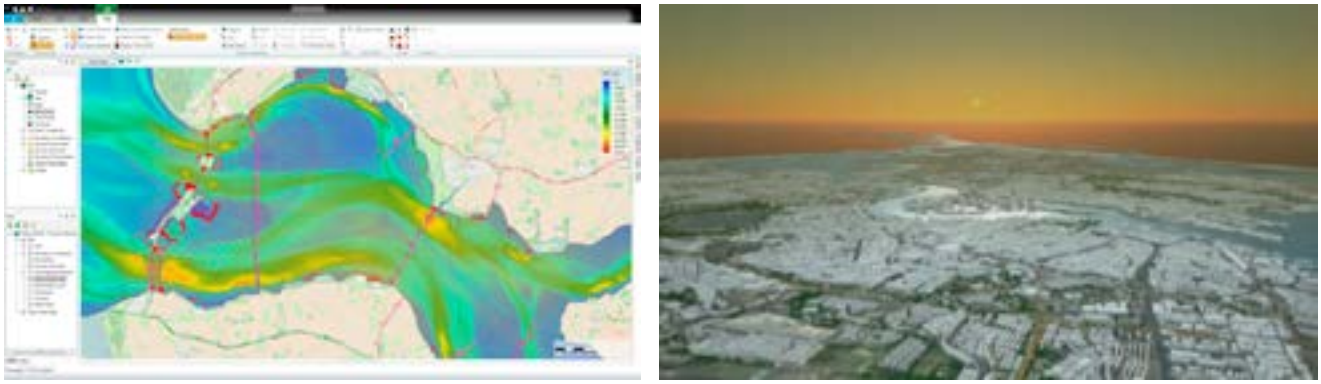

Fig. 2. Analytical model of infrastructure based on spatial development[7]

the location, images, and the situation of troubleshooting.

2.3. Smart technology to support spatial planning

The parallel existence of the digital city, which allows to provide up-to-date status information of the city, allows the construction of master plans and plans to be tested and simulated. Challenging urban problems such as environmental pollution, noise, traffic overload in the city center, the requirements of creating a better and more attractive living environment pose requirements for situational solutions for each area related to many factors and fields. The parallel digital city is a bridge between the digital model and the real city, allowing researchers and policy makers to experiment with adjusting solutions, parameters, and evaluate solution effectiveness through simulation of traffic patterns, noise pollution, gas environment based on interaction with real-time data provided by monitoring and sensor networks.

Many solutions and analytical models of infrastructure related to other spatial development orientations such as hydrological analysis, simulation of flooding and drought due to the impact of climate change, high tide,..., dike system, drainage basin, planning of ground elevation impact on urban space.

In addition to GIS-based technology solutions combined with 3D simulation that have been applied in planning and architecture, recently many virtual modeling and augmented reality applications have been developed to a higher level for urban spatial planning. Users use GIS databases to build 3D city models and have options to design spatial architecture, landscape, and simulation according to their ideas from adding or subtracting buildings or streets. In virtual reality, users can observe urban space from many different perspectives, and have the ability to simulate observations according to the time of day to evaluate the shaded area of the building.

3. Research results

3.1. Proposing smart solutions on technical infrastructure systems

a. Smart Traffic

Types of transport such as electric cars, electric bicycles, mini electric bicycles are a new trend in the development of green, environmentally friendly, people-centered means of transport, safer and more convenient to participate in traffic. Smart technology is researched to integrate multimedia traffic in the direction of approaching public transport to people, to everywhere: connecting from the subway system, sky train, bus, shared electric bicycle network. To form parking lots, bike gathering points at public transport transit points at train stations and bus stations. Information on the operation of vehicles participating in traffic, information on weather, traffic status on each route, information to support traffic participation, status of stops, parking lots, stopping and parking status of the shared e-bike network is updated in real time on the mobile application system.

In addition, the specific information of the traffic sign system is updated to calculate the time, compare the travel routes, and link with the positioning data of the user of the positioning device (smartphone) to calculate the navigation. The integration and continuous updating of maps, sign systems and navigation data of vehicles on the road will optimize traffic management efficiency and navigation.

On the basis of the navigation system of the network of vehicles participating in traffic to provide a large database,

serving to analyze traffic participants' habits, thereby improving the Services and Adjusting the smart traffic network planning of the city. From the mobile application, road users can choose from a variety of public and shared transport connectivity options in real time. With the trend of developing advanced technology, autonomous vehicles are also being researched and developed. These models have been developed in many pioneer cities such as: Barcelona, Amsterdam, London,...

Along with the development of friendly and shared means of public transport, solutions to encourage urban people to walk through urban design solutions and connecting transport networks play an important role. Analytical models ensure that people can access public transport and the nearest service points in an average time of 15 minutes, urban design solutions create attractive landscapes, green space systems, roof systems, building setbacks with shade to ensure convenience for pedestrians, and at the same time increase the health of the community.

b. Smart Water management

- Water supply management: With the rapid urbanization and migration to big cities, the demand for urban water increases and is also affected by climate change, a new requirement is posed towards the method of integrated management of water resources in a smart and efficient way. Issues for a smarter water management approach include:

+ Diversify and effectively manage water supply sources: Take advantage of many water sources from rain water, sea water and reuse treated wastewater; Remove pollutants and algae from the river system; non-pollution management from the very beginning of the water source.

+ Production and supply of clean and safe water: Upgrading the water treatment technology process; Real-time, remote quality monitoring via sensor system; Automating water treatment processes

+ Efficient water supply and monitoring: Remotely monitor and avoid pipe leaks

+ Integrated management: Integrated monitoring of water management in terms of volume and quality; Integrated management of water production, supply and consumption; Water treatment infrastructure asset management

- Water supply network management: More efficient water supply management through the application of information technology that provides real-time data on water use from water consuming units and devices, from households to integrated watershed management, water treatment plants and transmission networks, for example:

+ Reuse of water from collection and treatment sources

+ Leak monitoring system: A system of sensors and leak detection technology connected to real-time automatic monitoring software

+ Smart sensor and meter system: Upgrade and install a water meter system capable of measuring normal flow and monitoring water quality

+ The application automatically connects the clock network to the monitoring system.

- Sidewalk surface water collection system for urban water circulation management:

Low-impact development technologies are a new trend in developed countries. The creation of urban spaces with the function of managing water circulation rather than simply using water as traditionally is a trend of interest. In traditionally developed urban areas, about 70% of the urban surface is impermeable, of which an average of 50% is pedestrian or sidewalk traffic. The management of rainwater collection for most of the traffic surface impervious to water, requiring rapid drainage due to unusually heavy rains or an increase in heat island phenomena during the summer months imposes a requirement for a system of green spaces, temporary water storage areas, and groundwater recharge capacity. The proposed solution, besides increasing the surface of green space along the sidewalk, can form a water tank under the walking pavement surface. Parallel to the traditional water collection system along the road, rainwater is absorbed and replenished from the increased green space system along the sidewalk, naturally filtered through the soil layers and filtration system before overflowing into the collection tank system under the sidewalk. The storage tank system acts as a temporary water storage source, and at the same time, the filtered water can be used to circulate for watering plants on both sides of the road. [5]

- Automatic management and monitoring of river water level warning system:

Sensors are often used to monitor and measure river water levels or at sluice gates and send information to a monitoring center. However, after using the sensor system, it may malfunction and lead to false alarms. With the popularity in the installation and use of surveillance cameras in recent times, it is possible to combine high-resolution traffic and bridge surveillance cameras to read river water levels from painted elevation landmarks of bridges and culverts. Building an automatic monitoring system that integrates information and data from a sensor system or a network of security surveillance cameras (in appropriate locations) will optimize efficiency for water level management, flood warning, as well as assist in regulating river water levels when storms and floods occur.

c. Smart energy management

- Smart urban energy management system:

Towards the goal of green growth, low carbon emissions, in addition to solutions to balance supply and demand for energy use at the national level, urban governments need to have their own energy management system, efficient use and saving of energy at the urban scale and in each region. The system considers the current state of energy demand as well as the future direction of urban expansion, synthesizes energy supply data from different sources (grid electricity, gas, solar power,...), especially considering the supply from renewable energy sources, and at the same time optimizes the energy demand of urban areas from these sources. The analysis of energy demand and consumption is displayed on the basis of a physical GIS database. In addition, the system allows real-time monitoring and forecasting of energy demand; at the same time connected to the weather forecasting system related to the renewable energy supply to coordinate the supply.

- Optimization of power supplies:

Faced with the problem of global warming, implementing the Paris agreement on climate change, countries must develop their own plans to reduce greenhouse gas emissions and reduce fossil energy consumption. Many policies to encourage the use of renewable energy have been issued recently. Some systems that optimize power supplies such as:

+ Self-sufficient energy system for remote areas and islands: General supply from solar power sources, small wind power, mini hydroelectricity can be supplied to remote areas and islands serving a population of about 1,000/person; Optimally collecting rainwater, groundwater, pumping from the storage tank system to generate hydraulics and generate hydroelectricity; Develop solar and wind power farms on the basis of optimal research on weather conditions of each region.

+ System for collecting piezoelectric effect energy from roads: Road technology with the collection of energy from the piezoelectric effect through elastic materials allows the conversion of energy collected from pressure to electricity. PZT ceramic material is applied under the road material allowing to collect energy when there is traffic passing above. With product prices falling in recent years, and at the same time higher energy efficiency (increasing from an average of 0.33 mW/cm2 in the past to 5mW/cm2 now), this will be a promising trend in the near future.

+ Geothermal development: besides solar and wind energy which have been widely applied, access to geothermal energy is a new trend of developed countries.

3.2. Proposing smart solutions in construction and construction management

a. Smart construction management

Construction management is one of the topics of interest in smart development. From the technology aspect, the application of IT in construction management of a project starts from the planning, design and construction steps to the operation, maintenance and maintenance steps. The technologies considered, researched and integrated include: flying equipment, 3D printing, infrastructure BIM, big data, IoT, BIM-GIS integration, sensor systems, virtual reality, augmented reality, unmanned vehicles, etc.

- Integrated BIM/GIS system

The problem of integrating the building information management system (BIM) with the geographic information system (GIS) is necessary for smart city development on the basis of urban modeling. BIM allows to provide full information throughout from progress, construction techniques, activities from planning, design, construction, maintenance, repair, and operation to construction on the basis of 3D spatial model with a high level of detail. Meanwhile, the GIS system has a lower level of spatial detail, based on the large-scale geospatial background, 2D geometric data on the survey map. Currently, there are many studies to close the gap towards integrating 02 BIM & GIS systems. BIM application helps to solve the content related to the building and geographical information inside the building, GIS manages the geographical data outside the building. The BIM/GIS connection platform allows the integration of 3D BIM/GIS information from processing related information from diverse geographical data of the city. The project management information can be managed, operated, linked with the utility service systems of the city, such as energy management system, real-time traffic management, fire prevention, security system, property management in the area... [4]

- Management of construction geotechnical information with an information database (geological survey drill bits, geological information, administrative information) stored and integrated with the Integrated Underground Space Map, including the information system of utilities (water supply, drainage, lighting, heating, ventilation, communications, gas pipelines); underground works system (walkway, underground traffic, subway, underground parking, public space and underground commercial services) and related thematic maps and information.

- Building a 3D model of the construction surface through 3D laser scanning technology with a surface dot matrix with geographic coordinates and linking attributes of soil type, moisture, relative density, groundwater level,... supporting analysis for earthworks.

- Using flying equipment to build 3D models of works, support rescue work, overcome blind areas that are not within the field of view of conventional camera systems.

b. Smart building energy management

Besides the connected building equipment management system (BMS), common smart device management systems in the home, specialized energy management systems are continuously being developed such as:

- Managing energy used in the house, synchronizing equipment such as air conditioners, heating equipment, water heaters, standardizing synchronous equipment in the house from lights, door locks, curtains, gas lock valves, indoor ventilation system, heat sensor, water heater, security system, main circuit breaker, air conditioning system, etc.

- Developing analysis models for each device's energy use, thermal models between indoor and outdoor, automatic control of temperature and indoor equipment to ensure optimal energy efficiency.

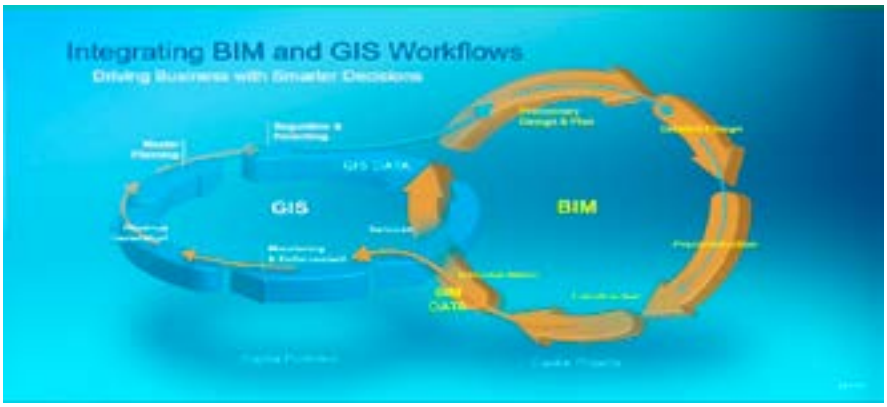

Fig. 4. The combination of BIM and GIS systems in smart city management[4]

3.3. Practical application: GIS application in urban planning in Hanoi, Vietnam

The geographical information system (GIS) has been researched and piloted into a number of planning projects to support the formulation and management of urban planning; The pilot research contents in the Hanoi Capital Construction Master Plan are integrated throughout the planning process, including:

- Investigate, survey and collect data on the current status of the fields: socio-economic, social infrastructure, technical infrastructure & environment.

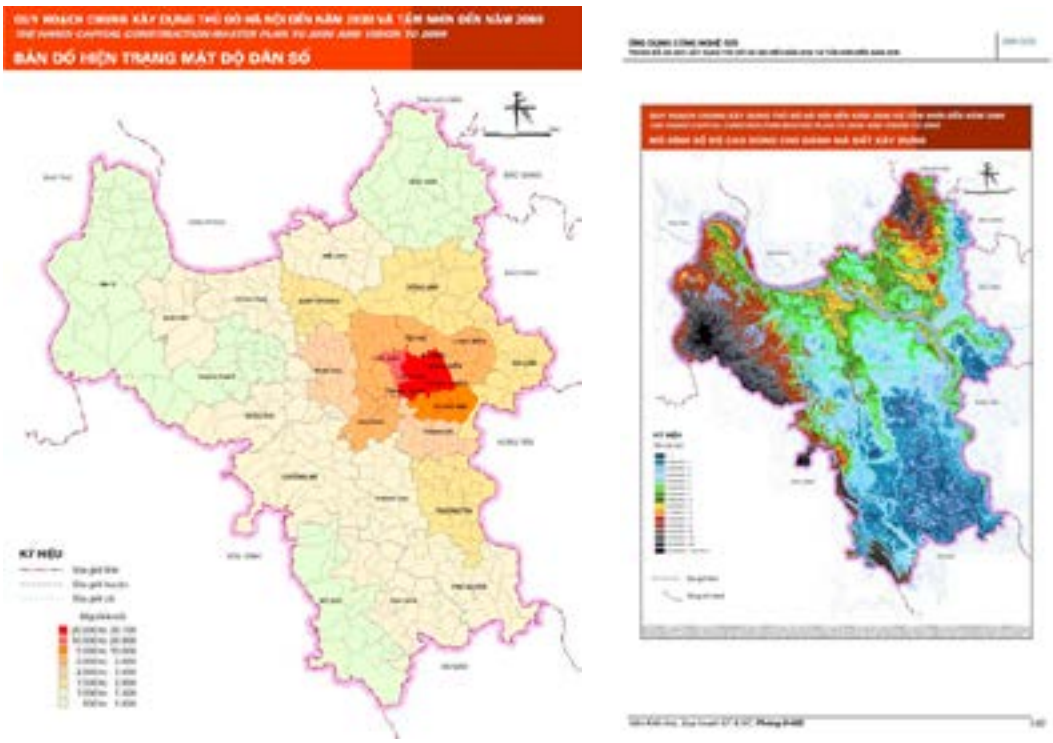

Fig. 5. Some analysis when applying GIS in general urban planning of Hanoi capital[4]

- Building the current status database on the collected data.

- Develop diagrams to analyze and evaluate the current status of the fields based on the current status database of the fields: socio-economic (population distribution, population density, economic development by sectors, network and information on the network of industrial zones, industrial zones, agricultural development, trade and service network), current status of distribution and serviceability of the network of technical infrastructure, health care, and information technology system (prices of the system of urban infrastructure, health, and environment) environment (traffic, water supply, rainwater drainage, ground elevation, power supply, wastewater treatment, solid waste, environment).

- Building a number of analytical models to support the assessment of the current status: digital elevation model for topographic analysis for urban construction land assessment, drainage basin zoning, assessment of service coverage of the social infrastructure network by distance, analysis of distribution status and current status information of each field.

- Statistics of data by field, current status of land use, land use planning based on GIS database.

- Urban 3D simulation according to basic information about density and height.

- Build a database for urban planning management according to approved planning documents.

*Advantages:

- From the GIS application approach, in the process of surveying, collecting current data is collected in a more integrated and systematic view, thereby allowing to perform analysis of current data on the map system quickly, saving time, and highly convincing analysis.

- GIS allows to overlay many different types of maps and data as well as to perform complex spatial analysis that cannot be done by planning support software; especially the analysis of digital elevation model, slope analysis, drainage basin division are simulated clearly.

*Disadvantages:

Planning units still mainly apply traditional design support technologies to build basic map data (mainly Autocad), do not have systematic thinking and thinking about geographic data management, showing drawings without the management method of geographical features, so it is difficult to standardize, convert and build GIS geodatabases; There are no guidelines & standards for geographic data framework planning to build a synchronous and unified database.

4. Conclusion

Facing global issues such as economical use of resources, energy, response to climate change, towards green growth and sustainable development strategies, smart city development strategy is an inevitable trend being applied by many countries. In the period of 2018-2025, the development of smart cities in Vietnam will prioritize the construction of the following contents: Smart urban planning; Building and managing smart cities; Providing smart urban utilities for organizations and individuals in urban areas with the basic infrastructure of technical infrastructure and ICT infrastructure system, which includes a spatial database of smart cities that are interconnected and integrated with the above two systems. [2]

The research of the article includes applications such as: Technology in urban planning and development management, technology in management and operation of technical infrastructure systems, new technologies to support

(*continue reading page 86)*

Information Technology Application in Building New Livelihood Strategies for People in Urban Areas of Vietnam after the Covid-19 Pandemic

Tuan Anh Nguyen, Thanh Thuy Cu

Abstract

This research was carried out to examine how changes in people's earnings in Vietnam's urban areas have affected their lives in the post-Covid-19 peried. The study's data were gathered from 206 families in urban Vietnam directly affected by the outbreak. The distinction exam technique the T-Test is used in this study to compare income differences before and after the Covid-19 epidemic in Vietnam. According to data analysis, the income difference between before and after the epidemic is approximately 7.6189 million VND each month. Based on the study findings, the author proposes recommendations for developing new livelihood strategies for people in Vietnam's urban regions based on the use of information technology systems in the context of the country's ongoing digital transformation.

Key words: *Income, employment, Post Covid 19, urban residents, digital transformation, technology 4.0*

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1. Introduction

The Covid-19 pandemic has had an influence on people's lives in nations and territories ranging from urban to rural settings. The increasing waves of the Covid-19 epidemic have had a devastating influence on work, social security, and individual income in countries all across the world (SotyaTresnaAnggita, Irham& Lestari RahayuWaluyati, 2021; Ivan Bamweyana et al, 2020; Bach Xuan Tran et al, 2020).

According to statistical results of GSO (2022), in the first quarter of 2022, Vietnam has a total of more than 16.9 million persons aged 15 and over who are negatively impacted by the Covid-19 epidemic. Out of a total of more than 16.9 million people affected by the pandemic, 0.9 million people lost their jobs, accounting for approximately 1.2%; 5.1 million people had to temporarily stop/suspend production and business, accounting for roughly 6.7%; 5.7 million people had their working hours cut or forced to take time off work, accounting for approximately 7.6%; and 13.7 million workers had their income reduced, accounting for about 18.3%. The Red River Delta and the Southeast region, Vietnam's two main urban areas, continue to have a greater number of employees impacted than other regions. The proportion of workers in these two locations who claimed their occupations had been affected by the epidemic was 25.7% and 23.9%, respectively; According to Statistical results of GSO (2022), urban regions continue to have more employees suffering than rural areas: 25.8% of workers in urban areas are badly impacted by the Covid 19 epidemic, compared to 20.5% in rural areas.

According to GSO data (2022), unemployment is an unavoidable result of the Covid-19 pandemic's influence on urban workers, the young unemployment rate in urban areas is roughly 9.3%, with youth unemployment in some of Vietnam's major cities exceedingly high. For example, the youth unemployment rate in Ho Chi Minh City in the first quarter of 2022 is about 11.30%, while the youth unemployment rate in Hanoi is approximately 10.31%. Rising unemployment and plummeting income in Vietnam in general, and in urban areas in particular, are visible evidence of the pandemic's negative effects. The effects of the Covid 19 epidemic appear to be more severe in urban areas (GSO, 2022; SotyaTresnaAnggita et al, 2021; Bhagat, Reshmi, Sahoo, Roy &Govil, 2020). The effects of the Covid 19 epidemic caused severe harm to people's lives, including physical and mental ailments, a decline in income, job loss, and a physical impact on people's health (Guo, Feng, Wang &IJzendoorn, 2020).

The Covid 19 pandemic has had diverse degrees of influence on people's lives; different methodologies and calculations have been used in past research to quantify the impact of the Covid 19 pandemic on people's lives. According to the GSO's data statistics (2022), the research focuses on the group of individuals most impacted by the Covid-19 epidemic, that is, persons living in urban regions of Vietnam. To evaluate the independent impact of the Covid 19 pandemic on this target group, a group of persons in urban regions of Vietnam who are directly impacted by the Covid pandemic (measured directly by data on Covid 19 infections and getting government help for those afflicted by the Covid 19 pandemic) was chosen as research participants.

Furthermore, the digital revolution in Vietnam is presently being implemented and taking place at a rapid pace and is very strong; the application of information technology systems in the development of new livelihood strategies is critical to maintaining people's lives, thus, people's lives are stabilized as the pandemic is progressively driven back and the "new normal" is implemented in nations such as Vietnam.

2. Literature review

The Covid- 19 pandemic influences many elements of socioeconomic life across the world, and scientists have taken diverse approaches to analyze the impact of Covid 19 on the economy, livelihoods, income, and social security (Pattiruhu&Paais, 2020; Obrenovic et al, 2020; Shen et al, 2020). The economic vulnerabilities that people have had to endure throughout the Covid-19 pandemic epidemic have become a source of concern and analysis in several aspects and analysis from different viewpoints and approaches.

The Covid-19 epidemic has affected people's incomes; the reduction in income is examined using various computation and quantification approaches, such as dividing income into sources and estimating the decline in people's revenue-producing sources.People's income sources may be divided into salary income, monthly stable income, and other revenues (included is income from investment, from working part-time in addition to a stable monthly job). The change in people's income provides a comparison between the era before the Covid 19 pandemic and after the Covid-19 pandemic to show the income vulnerabilities caused by the Covid-19 pandemic (Qian & Fan, 2020; Dao, Le & Pham, 2022; Le, Dao & Doan, 2021; Le at al, 2021). The data utilized in the research when approached from the standpoint of assessing people's livelihood vulnerability during the outbreak of the Covid-19 pandemic are acquired from families impacted by the Covid-19 pandemic.

The damage caused by the Covid 19 epidemic has affected jobs, reducing people's working hours (Buheji et al, 2020; Paul et al, 2021; Huynh et al, 2021; Dao et al, 2022). When jobs are lost, people's lives suffer, when people's earnings are lowered as a result of job loss, they suffer from a diminished quality of life, people's physical and mental health will be affected, and pressures will emerge, lowering people's quality of life.

From the research overview, the author proposes the following research hypothesis:

Applying information technology has had a positive impact on building new livelihood strategies for people in urban areas after the Covid-19 epidemic broke out.

3. Researh Methodology

3.1. Data Collection

The study's data were gathered from a survey of families in urban regions of Vietnam impacted by the Covid-19 pandemic, house hold saffected by the Covid-19 pandemic must fully meet two requirements:

Firstly, there is a family member infected with Covid-19.

Secondly, households chosen for the survey must receive government subsidies under the government's program.

The urban statistics bureaus will collect data on these households. Choosing the correct families impacted by the Covid-19 pandemic will aid research in analyzing the most comprehensiveand accurate level of the Covid-19 pandemic's influence on people's lives.

Cities where the survey was carried out: The survey was carried out in three main cities in Vietnam, which also represent the three regions of Vietnam and are the cities worst afflicted by the waves of the Covid-19 epidemic.

The first urban area: Hanoi Capital of Vietnam - This is there presentative urban area in the North of Vietnam.

The second urban area: Da Nang City - This is there presentative urban area in the Central region of Vietnam.

The third urban area: Ho Chi Minh City - This is the urban representative of the Southern region of Vietnam.

All three cities have endured the longest durations of lockdown and social distancing in Vietnam, and the people's physical, mental, and live lihood damages are clearly and typical characteristics of Vietnam during the onset of the Covid-19 epidemic. At the same time, because they are Vietnam's major cities and the regions with the quickest economic recovery, the calculation and analysis of vulnerability and adaptation capability of people in these urban areas will be clearer than in other parts of Vietnam.

The sample sizeforthe survey: According to Nguyen (2014), the minimum number of observations required to conduct statistical procedures is 100. To get that minimal number of observations, the study distributed 300 questionnaires throughout three cities, with each city surveying 100 families of the examined individuals. The research team collected 273 questionnaires out of a total of 300 disseminated, the research team completed data entry with 67 questionnaires that did not match the standard sowing to a lack of survey information, and the research team excluded these questionnaires from the data. The remaining number of survey questions is 206, with these 206 questionnaires satisfying the information criteria and the minimal number of observed samples; hence, utilize these 206 observation stoexecute statistical operations in order toachieve the study objectives.

Survey time: The study was performed between March 15, 2022, and April 25, 2022. This is also a moment of adjustment in policy in Vietnam in response to the Covid-19 epidemic.

The income of people was compared during the Covid-19 pandemic's break out and after thee pidemic was progressively restricted according to new government regulations toad just to the new situation.

The income included in this study is the entire amount of money earned by surveyed families in one month. The monthly income is measured in millions of VND. This scale is inherited from the study of Bezerra et al (2020); Dao et al (2022); Qianand Fan (2020); Tranand Vu (2014).

3.2. Data analysis methods

With the collected data, descriptive statistics and test for differences (t-test) methods are used to analyze the data to achieve the set goals.

4. Results

TheDuring the pandemic's breakout, people in urban areas are disproportionately affected by reduced working hours, temporary layoffs (temporary unemployment), and the

Table 1. Change in employment of people in surveyed cities

Criteria	Quantity	Rate
1. Reduced working hours	12	5.83
2. Losing a job completely	72	34.95
3. Leave for work with minimum wage	53	25.73
4. Leave without pay	69	33.50

Source: Author's survey data

Table 2. Comparison of income and expenditure differences of people in urban areas between before and after the Covid-19 pandemic is under control Source: Author's calculation from survey data

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	TN_A - TN_B	-7.6189	7.5771	.5279	-8.6598	-6.5781	-14.432	205	.000
Pair 2	CP_A - CP_B	-2.8898	1.7059	.1189	-3.1241	-2.6555	-24.314	205	.000

incapacity of businesses and manufacturing organizations to operate during the period of social distancing. According to the survey results, the number of family members in the studied families is influenced by job loss or employment to varying degrees (table 1).

Vietnam's economic sectors and fields have all been badly impacted during the time of social distancing, particularly the service industry in urban regions. Enterprises, manufacturing, and commercial facilities must close; businesses must endeavor to retain operations; and these units will take various methods to assure their operational expenses. The employees of the enterprises that are the subject of this study will be directly affected by the decisions of the employers.

The study's survey results revealed that, in the context of the Covid-19 epidemic that broke out in urban areas, the persons examined were relatively affected, specifically, people impacted by reduced working hours account for around 5.83% of those surveyed, although this is also the least severe impact that the survey participants encounter. A portion of the poll respondents lost their employment completely; these individuals will need to find new occupations once the epidemic is under control; this group accounts for around 34.95% of all respondents. These subjects often come within the category of working for the service sector or private firms; nonetheless, enterprises and employers frequently proclaim shutdowns, resulting in workers will lose their jobs completely.

In terms of employment, those who are temporarily away from work due to social distancing are entitled to the minimum pay set by the employer; this group amounts to around 25.73% of those polled. In Vietnam, the minimum monthly pay is 1.4 million VND per person. When people earn this minimal salary, their lives are incredibly tough since it is insufficient to cover the family's living expenditures. Additionally, general unseen life stresses will have a bad mental influence on people's lives.

A part of people will lose their employment temporarily, but when employers return to work, employees will continue to work. Employees in this category are not entitled to pay while on leave; this is a mutual arrangement between the employee and the company. This group comprises around 33.5% of the survey's target group.

Employment damages have had a significant influence on people's lives, and some individuals have chosen urgent remedies in this tough moment, such as self-employment, switching to online business, and financial investment, to address the issues for their life in this new environment. These are also new livelihood methods that people employ in a variety of ways.

When people's jobs are vulnerable, people's incomes will also be affected, specifically:

When the Covid 19 pandemic broke out, people's incomes decreased significantly; the difference between the period of the Covid 19 pandemic, when people were vulnerable in terms of jobs, and the period after the disease's outbreak is controlled, when people return to their "new normal" lives, is relatively large. According to research, the income disparity is approximately 7,6189 million VND each month.

Income loss has a negative impact on family spending because when income is not assured, unnecessary expenses are reduced and people tend to spend exclusively on necessities. People's income categories improved as the pandemic was controlled, and household spending was also "loosened" more; the difference in expenditure between the outbreak and post-pandemic era is fairly substantial, around 2,8898 million VND/month.

5. Discussion

The "new normal" is being established and applied in nations; while the number of Covid-19 cases remains high, people are progressively acclimating to living with the pandemic and securely adjusting to the new circumstances. Countries' economies are also being revived in order for them to recover from the pre-Covid-19 epidemic. In Vietnam, as production and economic activity progressively revive, people's employment and income losses increasingly diminish. However, in order to adapt safely and guarantee livelihoods for themselves and their families, individuals require new livelihood plans. Some of the recommendations made by the study are as follows:

First, using an information technology system to construct a contemporary and adaptable logistics system would improve the circulation and exchange of commodities, establish economic ties between economic players, and contribute to the stability of people's lives.

Second, applying the information technology system to find jobs as well as find workers comes from the needs of both the labor supplier and the employer. Following the Covid-19 pandemic, some workers were unemployed due to job loss, but some businesses also faced difficulties due to being unable to recruit workers; thus, the use of the job transaction system, which employs information technology, plays an important and meaningful role in connecting the needs of the parties.

Third, one of the choices that people can make to meet job requirements in the context of deeper and deeper integration in Vietnam today is to use information technology systems in learning to improve professional qualifications and prepare skills to perform public works.

Fourth, for those whose work has not been returned to 100% of working time and whose income from traditional occupations is still uncertain, it is vital to use information technology to develop online sales or business channels, which will generate more revenue for them in new circumstances./.

References

1. *Bach Xuan Tran, Hien Thi Nguyen, Hai Quang Pham, Huong Thi Le, Giang Thu Vu, Carl A.Latkin, Cyrus S.H.Ho, Roger C.M.Ho, (2020), Capacity of local authority and community on epidemic response in Vietnam: Implication for COVID-19 preparedness, Safety Science, 130, 104867, https://doi.org/10.1016/j.ssci.2020.104867*
2. *Bezerra, A., Silva, C., Soares, F., & Silva, J. (2020). Factors associated with people's behavior in social isolation during the Covid-19 pandemic. Ciencia&SaudeColetiva, 25(suppl1), 2411-2421. https://doi.org/10.1590/1413-81232020256.1.10792020*
3. *Bhagat, R., Reshmi, R., Sahoo, H., Roy, A., &Govil, D. (2020). The COVID-19, migration and livelihood in India: challenges and policy issues. Migration Letters, 17(5), 705-718. https://doi.org/10.33182/ml.v17i5.1048*
4. *Buheji, M., da Costa Cunha, K., &Beka, G., BartolaMavrić, Yuri Leandro do Carmo de Souza, Simone Souza da Costa Silva, Mohammed Hanafi, &TulikaChetiaYein. (2020). The extent of Covid-19 pandemic socio-economic impact on global poverty. a global integrative multidisciplinary review. American Journal of Economics, 10(4), 213-224. https://doi.org/10.5923/j.economics.20201004.02*
5. *Dao, Q., Le, T., & Pham, V. (2022). Changes in Income Distribution During the COVID-19 Pandemic: Empirical Evidence from Vietnam. The Journal of Asian Finance, Economics and Business, 9(1), 241-248. https://doi.org/10.13106/jafeb.2022.vol9.no1.0241*
6. *DFID. (1999). Sustainable livelihood guidance sheets. London: DFID. Retrieved from https://www.livelihoodscentre.org/-/sustainable-livelihoods-guidance-sheets*
7. *GSO. (2021). Report the influence of Covid-19 on economic. Retrieved from https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2021/12/thong-cao-bao-chi-ve-tinh-hinh-kinh-te-xa-hoi-quy-iv-va-nam-2021*
8. *GSO. (2021a). Survey on the impact of Covid-19 on enterprises and labors. Hanoi, Vietnam: General Statistics Office. Retrieved from https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2021/09/bao-cao-lao-dong-viec-lam-quy-1-nam-2021/*
9. *GSO. (2022). Report the influence of Covid-19 on laborers' income and employment. Retrieved from https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2022/01/thong-cao-bao-chi-tinh-hinh-lao-dong-viec-lam-quy-iv-nam-2021-va-chi-so-phat-trien-con-nguoi-viet-nam-2016-2020/*
10. *GSO. (2022). Report on the impact of the Covid-19 epidemic on labor and employment situation in the first quarter of 2022. Retrieved from https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2022/04/bao-cao-tac-dong-cua-dich-covid-19-den-tinh-hinh-lao-dong-viec-lam-quy-i-nam-2022/*
11. *Guo, J., Feng, X., Wang, X., & van IJzendoorn, M. (2020). Coping with COVID-19: exposure to COVID-19 and negative impact on livelihood predict elevated mental health problems in Chinese adults. International Journal of Environmental Research and Public Health, 17(11), 3857. https://doi.org/10.3390/ijerph17113857*
12. *Huynh, D., Truong, T., & Duong, L., NhanTrong Nguyen, Giang Vu Huong Dao, &Canh Ngoc Dao. (2021). The COVID-19 Pandemic and Its Impacts on Tourism Business in a Developing City: Insight from Vietnam. Economies, 9(4), 172. https://doi.org/10.3390/economies9040172*
13. *Huynh, T., & Mai, V. (2011). Phan tichcacyeu to anhhuong den thunhapcua ho channuoigia cam o dong bang song cuu long [Analysis of factors affecting the income of poultry farmers in the Mekong Delta]. Vietnam Journals OnLine, 17(b), 87-96. (In Vietnamese).*
14. *Ivan Bamweyana, Daniel A. Okell, Ronald Ssengend, Allan Mazimwe, Patrick Ojirot,Fahad Mubiru, Laban Ndungo, Consolate N. Kiyingi, Alex Ndyabakira, Sheila Bamweyana, Flavia Zabali. (2020). Socio-Economic Vulnerability to COVID-19: The Spatial Case of Greater Kampala Metropolitan Area (GKMA), Journal of Geographic Information System, 2020, 12, 302-318, DOI: 10.4236/jgis.2020.124019*
15. *Le, L., & Le, T. (2020). Determinants of Income Diversification among Rural Households in the Mekong River Delta: The Economic Transition Period. The Journal of Asian Finance, Economics and Business, 7(5), 291-304. https://doi.org/10.13106/jafeb.2020.vol7.no5.291*
16. *Le, T., Dao, Q., & Doan, V. (2021). Effects of the Covid-19 pandemic on employee income: A case study of the Vietnamese aviation industry. Problems and Perspectives in Management, 19(4), 186-197. http://dx.doi.org/10.21511/ppm.19(4).2021.16*
17. *Le, T., Pham, V., Cu, T., Pham, M., & Dao, Q. (2020). The effect of industrial park development on people's lives. Management Science Letters, 10(7), 1487-1496. https://doi.org/10.5267/j.msl.2019.12.018*
18. *Nguyen, V. (2014). Giao trinhthuchanhnghien cu trongkinhtevaquan tri kinhdoanh [Curriculum of research practice in economics and business administration]. Vietnam: National Economics University Publishing House. (In Vietnamese). Retrieved from https://vietbooks.info/threads/giao-trinh-thuc-hanh-nghien-cuu-trong-kinh-te-va-quan-tri-kinh-doanh-nguyen-van-thang-283-trang.96134*
19. *Obrenovic, B., Du, J., &Godinic, D. etc (2020). Sustaining enterprise operations and productivity during the Covid-19 pandemic: "Enterprise Effectiveness and Sustainability Model". Sustainability, 12(15), 5981. https://doi.org/10.3390/su12155981*
20. *Pattiruhu, J., &Paais, M. (2020). Effect of Liquidity, Profitability, Leverage, and Firm Size on Dividend Policy. The Journal of Asian Finance, Economics, and Business, 7(10), 35-42. https://doi.org/10.13106/JAFEB.2020.VOL7.NO10.035*
21. *Paul, A., Nath, T., & Mahanta, J. etc (2021). Psychological and livelihood impacts of COVID-19 on Bangladeshi lower income people. Asia Pacific Journal of Public Health, 33(1), 100-108. https://doi.org/10.1177%2F1010539520977304*
22. *Qian, Y., & Fan, W. (2020). Who loses income during the Covid-19 outbreak? Evidence from China. Research in Social Stratification and Mobility, 68, 100522. https://doi.org/10.1016/j.rssm.2020.100522*
23. *Shen, H., Fu, M., Pan, H., Yu, Z., & Chen, Y. (2020). The impact of the Covid-19 pandemic on firm performance. Emerging Markets Finance and Trade, 56(10), 2213-2230. https://doi.org/10.1080/1540496X.2020.1785863*
24. *SotyaTresnaAnggita, Irham& Lestari RahayuWaluyati. (2021). The impact of the COVID-19 pandemic on urban farming household income in Yogyakarta City, E3S Web of Conferences 306, 1st ICADAI 2021 https://doi.org/10.1051/e3sconf/202130602034*
25. *Tran, T., & Vu, H. (2014). The impact of land loss on household income: The case of Hanoi's sub-urban areas, Vietnam. International Journal of Business and Society, 15(2), 339-358. Retrieved from http://www.ijbs.unimas.my/repository/pdf/Vol15-no2-paper9.pdf*

Building Smart Cities and Developing Public Transport - Oriented Development (TOD) - Key Strategies for Hanoi Capital

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Abstract

Sustainable smart cities are innovative urban areas that utilize information technology, communication, and other means to enhance the quality of life, optimize urban activities, services, and increase competitiveness. In the context of the Fourth Industrial Revolution, the development of smart cities, along with adopting the Transit-Oriented Development (TOD) model with a focus on extensive public transportation, is a suitable and effective direction for Hanoi's urban development. Smart cities are built on three pillars: intelligent social infrastructure, intelligent urban technical infrastructure, and digital infrastructure. The development of cities following the TOD model is closely related to smart cities and these three pillars. Research and evaluations have shown that TOD development is an intelligent solution for urban areas, effectively addressing various economic, social, and environmental challenges while preserving resources.

Key words: *Smart cities, Transit-Oriented Development (TOD), Digital Transformation, TOD model*

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1. Introduction

Resolution 15-NQ/TW dated May 5, 2022, by the Politburo on the orientation and tasks of developing Hanoi Capital, has set the goal of building Hanoi into a city that is "Civilized, Modern, and Sophisticated," becoming a center and driving force for the development of the Red River Delta region, the northern key economic zone, and the whole country. To achieve this desired goal, one of the requirements is to have appropriate solutions and directions from the planning stage. Hanoi is the capital of the country and, especially after the period of renovation, particularly since the administrative boundary expansion, the scale and pace of urban development have been rapid, resulting in significant achievements. The urban landscape has become more modern and splendid, gradually resembling major cities in the region. However, alongside these achievements, the city has also faced various challenges concerning the environment, socio-economic issues, such as traffic congestion, environmental pollution, and inadequate social infrastructure. Despite substantial investments in infrastructure development, particularly in the road traffic system, drainage systems, and other technical infrastructure, the speed has not kept up with the increasing demands, and significant breakthroughs have yet to be made.

Entering the 21st century, with the Fourth Industrial Revolution and the wave of digital transformation, many cities worldwide have transitioned to building smart cities, along with adopting the Transit-Oriented Development (TOD) model, using extensive public transportation as the main backbone for the transport network and urban development orientation. These solutions represent intelligent and effective ways to conserve resources and address the enormous challenges faced by cities, including those applicable to Hanoi.

2. Development of Smart Cities

2.1. The Concept of Digital Transformation, Smart Cities, and Characteristics of Smart Cities

*What is Digital Transformation?

Definition: Digital transformation is the process of self-changing to adapt to the digital future.

- Digital transformation of enterprises - Smart enterprises.
- Digital transformation of cities - Smart cities.
- Digital transformation of governments - Smart governments.
- Digital transformation of nations - Smart nations.
- Digital transformation of humanity - Smart world.

*The Concept of Smart Cities (SC)

Until now, there are still various interpretations of smart cities, and this concept is continually evolving.

ITU-T provides the definition: "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, and environmental aspects."

IEC believes: "A smart city is an effective, sustainable, and livable system of systems, designed for people and shaped by citizens, businesses, organizations, and technology developers with the purpose of creating added value."

In a relatively open interpretation, a smart city converges three elements: efficient infrastructure, sustainable development, and a friendly living environment. This is reflected through six categories: (1) Smart Economy, (2)

Smart Mobility, (3) Smart Citizens, (4) Smart Environment, (5) Smart Governance, and (6) Smart Living.

In Vietnam, the definition states: "Smart Sustainable City" is an innovative city that uses information and communication technology and other means to improve the quality of life, enhance the efficiency of urban activities and services, and increase competitiveness while still ensuring meeting the current and future needs in terms of economic, social, and environmental aspects.

*Characteristics of Smart Cities.

The attributes of smart cities are divided into three groups and are closely related to each other: (1) Environment and sustainable development; (2) Urban services; (3) Quality of life. Smart cities are not just a "product" to be built; they represent a method of development. It is crucial to understand that a city does not need to be wealthy to embark on smart city development. On the contrary, even in challenging economic conditions, there should be more efforts to construct smart cities. Essentially, a smart city represents the integration of digital technology into the urban development process, efficiently utilizing limited resources to best meet the needs of city residents.

According to the Decision No. 950/QD-TTg dated August 1, 2018, by the Prime Minister, and the Official Letter No. 4211/VPCP-QHQT dated May 8, 2018, by the Government Office, Hanoi is striving to become a leading city in the ASEAN Smart Cities Network and a pioneer in smart city development methods. This leadership should be prominently demonstrated in the city's plans. Incorporating general plans, sectoral plans, and detailed plans with a system of standards and criteria for smart urban space infrastructure will provide the foundation for Hanoi's smart city development in the upcoming phase.

Recently, Hanoi has made significant efforts to pilot some Smart City applications, yielding some initial achievements. However, complex issues concerning technical infrastructure, social infrastructure, and the environment still persist, demanding the city to further strengthen the construction of Smart City projects. Building Smart City projects should be seen as a method of comprehensive and modern urban planning and management, not just a collection of scattered and isolated smart applications.

2.2. Structure of Smart Urban Infrastructure

- Smart urban infrastructure is based on three foundational platforms:

+ Smart Social Infrastructure

+ Smart Technical Urban Infrastructure

+ Information (Digital) Infrastructure

Building upon these three foundational platforms, a smart city is characterized by pillars that encompass smart governance, smart citizens, smart environment, smart living, smart economy, and smart information.

* Smartification should start with urban planning: (1) It requires a combination of construction solutions + technological solutions + management solutions. (2) New technical infrastructure projects must be smart from the outset (starting from planning and investment stages). (3) Existing infrastructure projects need to be smartified simultaneously with upgrading and renovation efforts. (4) It is necessary to establish management regulations for smart technical infrastructure projects and issue standards and guidelines to ensure that smart components can interconnect.

a. Smart Social Infrastructure: A society where digital technology improves human happiness, economic power, and organizational efficiency is considered a smart society. The areas covered by smart social infrastructure include smart individuals, smart government, smart economy, and smart lifestyle.

b. Smart Technical Urban Infrastructure: Smart technical infrastructure plays a crucial role in creating smart cities. The areas covered by smart technical infrastructure include: (1) Smart environment (smart energy, smart waste and wastewater management, pollution control); (2) Smart mobility (public transportation, transportation, smart logistics); (3) Smart utilities (internet technology, Building Information Modeling (BIM) technology, and urban utilities services); (4) Smart living (electronic connectivity, housing, cultural platforms, safety, and security).

c. Information (Digital) Infrastructure

A smart city optimizes all parameters by creating intelligent connections among all relevant parties of the city and simultaneously controlling them, utilizing powerful tools for big data processing. Smart information infrastructure includes: smart network, smart data, smart sensors, smart communication.

2.3. Requirements and Steps to Build a Smart City

The implementation of sustainable smart urban development involves a combination of top-down and bottom-up approaches. The central government focuses on establishing a legal framework and supportive policies, while local authorities take an active role. Encouraging investment and promoting the socialization of smart urban development is crucial. The process should be organized and carried out gradually, ensuring both short-term and long-term investment efficiency, avoiding spontaneous and widespread development trends. Prioritize building fundamental contents, including Smart Urban Planning; Constructing and managing smart cities; Providing smart urban utilities for organizations and individuals with the fundamental basis being the Urban Technical Infrastructure System and the ICT infrastructure system, including the connected smart urban spatial database and the integrated system of both [5].

a. The tasks and requirements are as follows

In Decision No. 950/QD-TTg dated August 1, 2018, the Prime Minister outlined the key solutions and tasks for sustainable smart urban development as follows [1]:

Group 1: Review and complete the system of legal documents, policies, economic and technical norms, and issue guidelines for sustainable smart urban development.

Group 2: Gradually form and improve the system of national standards and standards for smart urban areas, promote basic scientific research and application research for sustainable smart urban development.

Group 3: Establish, connect, maintain, and operate the digital urban spatial data system and the national urban database.

Group 4: Strengthen the application of smart technologies in urban planning and management.

Group 5: Develop smart urban infrastructure.

Group 6: Develop smart utilities for urban residents.

Group 7: Build the capacity for sustainable smart urban development.

Group 8: Mobilize investment sources and provide

Table 1. Steps for Implementing Smart City Construction

TT	Content	Description
1	Assessment of the current situation	• Implementation of surveys to assess the current situation, challenges, difficulties, and needs of the city, residents, and businesses
2	Establishing a Vision	• Building a Comprehensive Vision and Concretizing the TOD Vision for the City in Each Area • Ensuring Consensus on the Vision among Government, Citizens, and Businesses.
3	Identifying the overall objectives; establishing guiding principles; specific objectives and measurement criteria for each area.	• Identifying the overall objectives and guiding principles to ensure that activities, solutions, and TOD construction projects always align with the established vision and general goals; • Determining specific objectives for each area and the role of ICT (Information &Communication Technologies) in realizing these objectives. Establishing milestones for each phase and evaluation criteria for each area.
4	Developing a Roadmap	• Developing a Comprehensive Reference Roadmap towards Public Transport-Oriented Development (TOD), which includes urban-level focused projects (related to multiple areas), key projects, hot areas, and fast-track projects that can be implemented quickly and deliver immediate results.
5	Flexible Implementation	• Prioritize the implementation of projects that can be quickly deployed and deliver immediate results, as well as key projects and hot areas. Subsequently, the remaining programs and projects will be defined in terms of scale and evaluation criteria in each implementation phase, ensuring adherence to guiding principles. • Additionally, corresponding to each phase, the city will research and implement supplementary solutions concerning organizational structures, policy mechanisms, financing, communication, etc., to support the implementation of ICT solutions.
6	Measurement, Evaluation, and Improvement	• Involving citizens throughout the implementation of programs/projects will help in measuring, evaluating, and determining the level of responsiveness to their needs, enabling continuous improvement of the solutions. • Annual reviews and updates will be conducted to adjust any outdated content, and multiple evaluation methods will be used, including internal assessments, feedback from citizens, or the possibility of hiring independent evaluation entities.

Source: Research Report by the Ministry [3]

technical support from both domestic and foreign resources.

b. Implementation steps for building a Smart City

It may not be necessary to wait for the completion of the entire smart urban development plan, but rather, general projects and small projects that have immediate impacts can be implemented first (followed by continuous upgrades and improvements). Depending on the level of priority, the city can gradually develop programs for each sector, allowing for flexibility in timing as long as the guiding principles are ensured.

There are 6 steps for Implementing Smart City Construction as following [3]:

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Developing a Roadmap: Developing a Comprehensive Reference Roadmap towards Public Transport-Oriented Development (TOD), which includes urban-level focused projects (related to multiple areas), key projects, hot areas, and fast-track projects that can be implemented quickly and deliver immediate results;

Flexible Implementation: Prioritize the implementation of projects that can be quickly deployed and deliver immediate results, as well as key projects and hot areas. Subsequently, the remaining programs and projects will be defined in terms of scale and evaluation criteria in each implementation phase, ensuring adherence to guiding principles; Additionally, corresponding to each phase, the city will research and implement supplementary solutions concerning organizational structures, policy mechanisms, financing, communication, etc., to support the implementation of ICT solutions;

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2.4. Standards and Criteria for Smart City Development

a. Standards

Standards are essential in connecting stakeholders,

components, and operations of a Smart City. Some groups like IEEE (Institute of Electrical and Electronics Engineers) focus on detailed technological aspects related to connectivity and transportation in Smart Cities, while others like ISO (International Organization for Standardization) concentrate on higher-level activities such as management strategies and authority in Smart Cities. These standardization activities can be categorized into three levels: strategic, procedural, and technical.

- Level 1: Strategic Standards. These standards provide guidance to city leadership and agencies. They include guidelines for identifying priorities, building implementation roadmaps, and monitoring and evaluating progress along the roadmap.

- Level 2: Procedural Standards. This level focuses on managing Smart City projects and provides best practices and integration guidance.

- Level 3: Technical Standards. This level includes technical specifications required to implement Smart City products to meet all objectives.

The Ministry of Science and Technology has issued 14 Vietnamese Standards on Smart Cities.

b. Criteria for Smart Urban Technical Infrastructure

According to a research project on smart urban technical infrastructure conducted by the Hanoi Institute of Planning and Architecture (HUPI), it has proposed 7 groups of criteria as follows [2]:

Smart Transport Infrastructure: Density of highways and interconnectivity between urban areas; Traffic information system; Traffic monitoring system; Smart public transportation system (buses, trains, etc.); Smart parking management system; Electronic payment system for public transport.

Smart Power Supply Infrastructure: Assessment factors include: Density and distribution of smart power stations; Smart power distribution system; Smart power management system; Renewable energy power system; Smart maintenance, repair, and inspection system; Smart electricity consumption measurement and monitoring system.

Smart Lighting Infrastructure: Assessment factors include: Smart urban lighting system with automatic brightness adjustment capability; Aesthetic design; Lighting system linked to security monitoring system; Integration with smart power grid.

Smart ICT (Information and Communication Technology) Infrastructure: Assessment factors include: Network coverage density; Network speed and bandwidth; Smart public access points; Sensor system; Urban information management system; Interconnected database system; Smart monitoring and control system; Smart applications; Information security and safety system.

Smart Water Supply System: Assessment factors include: Smart water distribution system; Centralized water supply system; Smart water monitoring and control system.

Smart Drainage System: (1) Rainwater drainage: Adaptability to natural disasters and climate change; Flood monitoring and warning system; Information system on drainage, data collection devices, geographic information system; (2) Wastewater drainage: Smart wastewater drainage system; Wastewater treatment system; Environmental technology system; Interconnected drainage system with other systems such as transportation, electricity, clean water, and ICT to support each other.

Smart Waste Management System: assessment factors include: Waste treatment technology; Convenience and meeting demands; Smart interaction capability; Space optimization; Ensuring safety and environmental protection.

3. Developing Smart Cities Using TOD Model in Hanoi

3.1. The Relationship Between Smart City Development and TOD

Smart city development is based on three platforms:

+ Smart social infrastructure

+ Smart urban technical infrastructure

+ Information infrastructure

Developing cities according to the Transit-Oriented Development (TOD) model is closely related to these three platforms. Regarding the smart social infrastructure aspect: TOD creates an efficient and convenient living, working, and recreational environment. Land use planning is linked to public transportation hubs, effectively meeting the needs of residential, working, entertainment, and commuting purposes. Residents enjoy a good living environment with well-developed public social infrastructure and ample green spaces in parks. Urban services, office spaces, and workplaces are arranged in integrated or interconnected settings. The development of public transportation is also closely linked to urban economic growth and the effectiveness of urban rail and public transportation systems.

Regarding the smart urban technical infrastructure aspect: A high-quality public transportation network, with urban rail as its backbone, ensures the highest efficiency in transportation, guaranteeing fast and convenient access to destinations. It adheres to the "From door to door" principle, making it easy and convenient for people to travel to their destinations through transit hubs, including bus stops, taxis, bicycles, pedestrian-friendly paths, etc. Smoke-free public transportation provides a good environmental quality, energy efficiency, and time savings.

Regarding the information infrastructure aspect: Developing TOD requires an efficient information network to connect public transportation systems effectively. This includes information and operation coordination between urban rail lines and other public transportation systems such as buses, taxis, parking lots, and ticketing systems, all interconnected seamlessly. For example, within an urban rail station and its surrounding TOD area, the information infrastructure must support guidance, ticket purchasing, operation monitoring, safety, and security. Predictions for TOD development trends in the 21st century emphasize the importance of network connectivity and the application of information technology, including the Internet of Things (IoT) in the industrial 4.0 era.

3.2. Developing TOD in the Context of Hanoi

3.2.1. Opportunities and Challenges in Implementing TOD Development in Hanoi

- Land, space, and infrastructure conditions: There are limited opportunities for new development in the inner city, requiring a focus on exploiting redevelopment and revitalization. New development areas, such as the Eastern Beltway 4 and the northern bank of the Red River, offer favorable conditions for TOD implementation. The urban technical infrastructure and social infrastructure, in general, are insufficiently developed. Public transportation, especially urban rail, has not been fully developed. The establishment

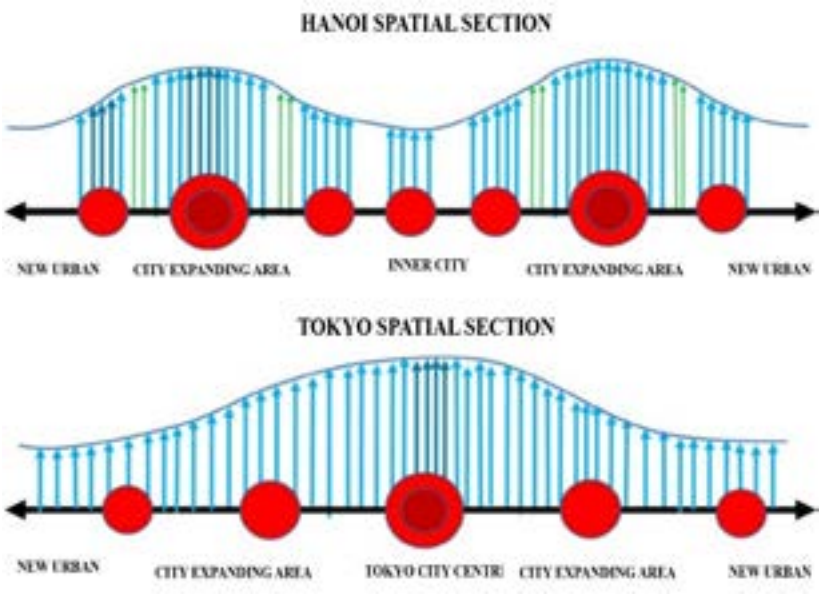

Fig.1. Cross-section diagram of the central urban space in Hanoi[9]

of transportation connections, land use connections, and transportation connections has not been fully achieved. The unique characteristics of Hanoi's natural conditions include numerous rivers and lakes, a hot and humid climate with heavy rainfall, and cultural and lifestyle habits related to transportation.

- Preservation and development: Preserving historical and cultural values will contribute to creating a modern, refined, and distinctive urban Hanoi. When researching TOD, solutions should be closely tailored to the specific conditions of each region in Hanoi, especially within the historic inner city.

- Challenges to be addressed:

+ Increasing the ratio of public transportation usage: Solutions for funding mechanisms are needed to prioritize the development of the public transportation system. TOD projects should be linked to the development of land around transit hubs to offset construction costs. The government needs to have a comprehensive plan for investing in the underground public transportation system, while other investors should invest in station facilities, train equipment, and operations.

+ Institutional arrangements: Specific mechanisms for project implementation and coordination among relevant parties, including the government, residents, and investors, need to be established to ensure consensus and a balance of interests under the governance of the authorities.

+ Investment capital: The city's resources are limited, so there should be mechanisms to attract cooperation and investment. The availability of land funds to correspond with TOD projects should be preserved.

+ Urban restructuring: Urban restructuring will gradually transition as the TOD and public transportation systems are established along the roadmap. The implementation of the TOD model must be strategically planned and integrated with urban planning.

+ Establishing the urban image: TOD development should aim to create a distinct character for Hanoi, suitable for the cultural and lifestyle habits, without disrupting the landscape and preserving heritage and historical values.

+ Addressing the current land fund issue, especially in the restricted inner city: Appropriate evaluations should be made to determine the suitability of the TOD model for different regions in Hanoi. Solutions for completely new development areas, redevelopment, and revitalization should be provided based on the TOD development level.

3.2.2. Some Specificities and Development Potential for TOD Adaptation in Hanoi

- Developing TOD harmoniously with the conservation of historical and cultural spaces, monuments, and controlling high-rise development in the historic inner city. TOD characteristics are divided into three different regions: the historic inner city, the expanded inner city, and new development areas. Regarding space utilization: exploit the potential of lakes, water surfaces, connected open spaces, green spaces, and community spaces.

- Strengthening parking spaces for motorcycles, providing ride-hailing spaces, and expanding the TOD radius. To reduce access distance, implement crosswalk green spaces. Plant shade trees, rooftop trees, deploy shade structures, bridges, and pedestrian tunnels to create a comfortable environment for pedestrians.

- Developing housing in the form of shop-houses, utilizing "sidewalk economies" for services, tourism, etc., associated with walking. Organize spaces according to the urban form of each area.

- Applying high-density, compressed ratios, and increasing the proportion of residential areas in TOD (for new development areas) to create community spaces.

- Ensuring the allocation of public technical infrastructure: schools, kindergartens, cultural facilities according to the standards. Place local markets near the TOD area.

- For existing areas, some parts of the historic inner city without new development opportunities will improve accessibility and public transportation transfer to the urban rail station, utilizing underground space, and possibly forming incomplete TOD points.

- Applying information technology, the Internet of Things (IoT), and industry 4.0 in managing and operating the functions of the urban rail station area and the TOD area.

When the TOD model has not been implemented, many cities, including Hanoi, have been planned and constructed according to traditional models, including existing urban areas and new development areas. The thesis proposes a solution to transform from the traditional urban model and traditional unit model to the TOD unit model, aiming for sustainable and effective urban development.

Implementing the TOD model needs to be associated with the Urban development program, setting out plans for developing the urban rail system and TOD areas in the medium and long term to create a synchronized and mutually supportive operation.

Develop unified management principles for underground and surface spaces in areas with a transportation orientation. Establish urban design guidelines for TOD areas.

Propose policies to successfully develop the TOD model suitable for Hanoi's conditions. Address the spatial connection between existing areas and new development areas using the TOD model, developing TOD in the inner city through redevelopment and revitalization. Propose guidelines for the planning process for Hanoi, serving as the basis for the Urban development orientation.

3.2.4. The advantages of applying TOD in Hanoi

- TOD helps solve the traffic congestion problem in Hanoi, especially in the central urban areas. According to the Hanoi Capital Construction Master Plan, the population of the central urban areas will reach about 4.6-5.4 million people. According to the forecast of the Hanoi Master Plan Adjustment, the population size will be even higher. If relying only on expanding road infrastructure and continuing to increase private vehicles, the congestion problem cannot be solved. Currently, the bus system has developed quite well with improved service quality. However, it cannot continue to significantly increase the public transport proportion because it uses the road system, suffers from traffic congestion and takes time, which is less attractive to passengers. Urban railways with large transportation volume and high speed are the optimal means of public transportation. The development of urban railways and promoting walking and cycling will eliminate the need to invest more in road construction and urban expansion. This is also suitable for the current situation in Hanoi which lacks road area. By developing the TOD model, economic efficiency can be exploited from the land fund around metro stations to invest in building and maintaining the metro system. The problem of lack of capital and resources for metro construction will be solved. Developing the TOD model will also increase walking, cycling, limit private cars, and does not require too many additional roads, so the problem of lack of transportation area will also be solved. In summary, the development of TODs, metros, and public transportation will increase transportation capacity, fight congestion, while reducing costs for road construction, urban expansion, and can make up for resource imbalances from land funds, commercial services at TOD points. Hanoi is a developing and expanding city, with a lot of new development areas outside still having a lot of undeveloped land funds, with many favorable conditions for implementing the TOD model.

- The implementation of the TOD model will contribute to building sustainable, green, civilized, smart and modern urban development, as stated by Hanoi's goals. TOD brings economic, social and environmental efficiency. TOD optimizes the organization of land use functions, including mixed-use functions that help reduce distance and travel time for 3 needs: Living - Working - Services & Entertainment; increasing land use efficiency with height to save land, allocating space for green spaces, without having to invest too much in urban expansion infrastructure. The application of information technology, IoT, the operation of the metro system, multimodal interchange hubs, information and data connectivity, combined with underground transportation infrastructure and other technical infrastructure are favorable conditions for developing smart cities.

- Economic efficiency: the development of commercial services, offices at TOD hubs associated with transportation needs will increase efficiency, customer utility and business efficiency, creating connections in the urban commercial and financial system. With the habit of trading and sidewalk economy of people, developing shops, commercial streets within TOD areas, within walking distance of stations suits the lifestyle of Hanoi people as well as Vietnamese.

- Public spaces, open spaces, street services will help create highlights and preserve cultural values and identities of the city.

- TOD development will guide urban development. TOD is the driving force for developing different areas of the city according to the urban development program. Hanoi's goal is to reduce the population in the inner city, expanding urban development outward. The metro network and TOD system in new urban areas will attract people concentrated in the old inner city as well as promote the development of satellite towns as desired.

- The development of TOD brings economic, social and environmental benefits, creates modern and civilized cities, reduces investment costs for technical and social infrastructure, suitable to the ability of resources. Balancing

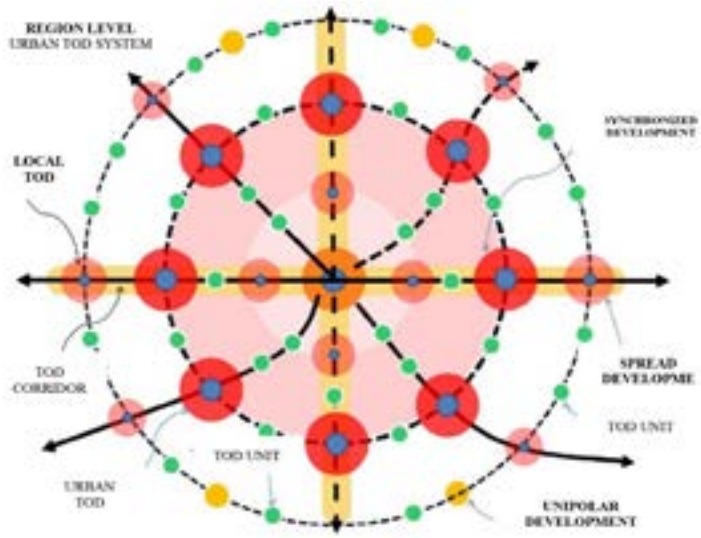

Fig. 2. The TOD System Organization Model for the entire central urban area of Hanoi[9]

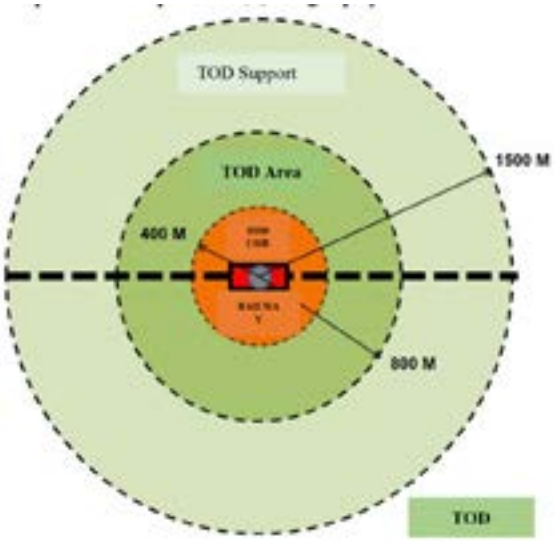

Fig.3. The TOD Point Organization Model[9]

the exploitation of land value towards "using the city to feed the city" will be a necessary solution for large and crowded cities like Hanoi.

3.2.4. Orientations for TOD Development in Central Hanoi

a. TOD in Restricted Development Areas and Historic Inner City

These areas are already developed with high population density, representing the central part of the city (Fig 1).

- Develop TOD with a focus on commercial and service functions to serve the dense population, improve transportation infrastructure, and develop commercial and tourism services. Avoid developing TOD areas primarily for residential purposes.

- Limit high-rise development to preserve the characteristic landscape, prioritize the development and utilization of underground space.

- Develop TOD with office functions in a limited capacity to reduce commuting pressure and focus on commercial TOD.

- Organize small TOD points based on redevelopment criteria, aiming to improve landscape conditions, spaces, the environment, enhance pedestrian access, and connect the transportation network.

- Develop TOD in areas with available land funds, such as some redeveloped residential areas, industrial areas, and hospitals.

b. TOD in Expanded Inner City

- These areas have already been developed to a relatively high density, but there is uneven development among different regions. The public transportation network and rail stations are well-established [4].

- The planned urban rail lines (MRT lines 1, 2, 3, 4, 5, 6, 8) will facilitate the development of TOD in these areas. Some central and beltway-oriented lines will form chains of TOD points.

- Develop large-scale urban TOD areas with varying density and height depending on the location and characteristics. Maximize the utilization of public transportation capacity. The characteristics of TOD will be based on the area's functions, population distribution, and the capacity to meet social needs.

- Organize modern TOD spaces that are associated with sustainable development, address transit transfer methods, and promote compressed development.

c. TOD in New Development Areas Eastern Beltway 4 and Northern Bank of the Red River

- These are newly developing areas with relatively low population and building density. Developing TOD in these areas will stimulate the creation of centers and urban development areas.

- These areas have the potential for large-scale TOD development with a goal of modern and synchronized development, reducing population pressure on the inner city [4].

- Develop TOD systems at different levels, including urban-level, area-level, and unit-level TOD. They have the potential to form large TOD centers with strategic significance and drive new developments. These areas have the potential for residential development, accompanied by synchronized technical and social infrastructure due to the availability of large land funds.

- Strongly develop TOD at the unit-level, associated with the development of new urban areas.

- Develop based on the MRT network: lines 1, 2, 3, 4, 5, 6, 7, 8, and connections to national railway lines, LRT lines, and BRT lines.

3.2.6. TOD Spatial Organization.

a. General Principles (fig.3)

TOD is developed following the 8D principles, which can be specified through the following elements: (1) Transport capacity; (2) Intermodal transportation conversion; (3) Mixed-use function; (4) Economic development; (5) Land reserves, development potential; (6) Compact development; (7) High population density, labor; (8) Pedestrian and bicycle accessibility. TOD points are developed around a "transit hub" such as urban railway stations for MRT, LRT, etc. To ensure an appropriate walking distance within 10 minutes, the TOD radius is 800 - 1000 meters. TOD consists of two zones: a core zone with a radius of 400 meters and an outer zone with a radius of 800 meters. The core TOD zone concentrates on commercial, office, and partially residential functions. [6], [7], [8]

*Commercial Core: Each TOD must have a mixed-use commercial area adjacent to the transit hub. This core area includes convenience stores, professional offices, restaurants, commercial and entertainment services.

*Surrounding Area: Within a radius of 400-800 meters, walking distances are ensured. This area serves mixed functions: commercial, office, residential, and public services such as social housing, green spaces.

*TOD Support Area: The surrounding area with a radius of 1500 meters is influenced by TOD and is automatically oriented. It includes residential functions (with lower density), green spaces, and other services such as schools. The support area is connected to the transit hub via a convenient transportation network, suitable for bicycles or bus services.

b. Some specific models for TOD spatial organization

*TOD spatial organization for new development areas (fig.4)

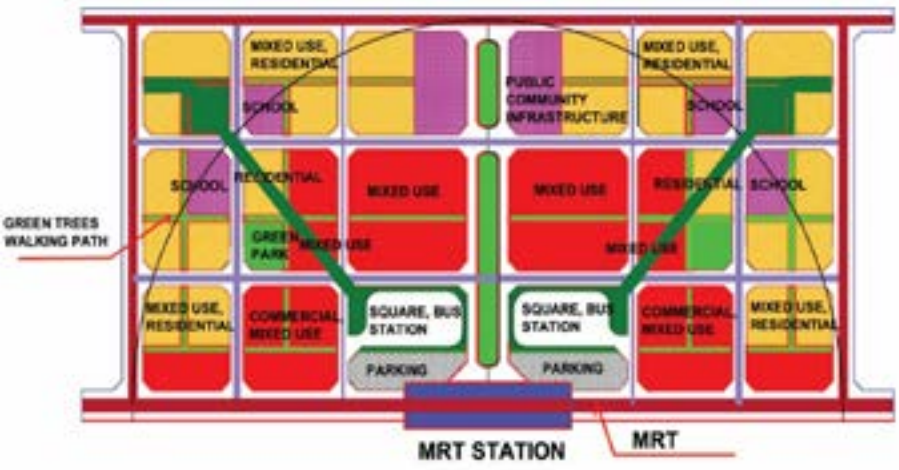

Fig. 4. TOD Point Spatial Organization following the Grid Road Network with Green Spaces and Central Pedestrian Walkways[9]

Fig.5. Addressing the Development of Connectivity Space between Old and New Areas through the TOD Model[9]

For inner-city expansion and new development areas with available construction land, planning can adhere to theoretical models. In this model, the transportation network is organized in a grid pattern with smaller road distances to enhance land accessibility. The TOD transit station is located at the center, adjacent to the station square, bus terminal, taxi stand, transfer point, green spaces, and public spaces. Highlighted space axes are created. From the core zone around the transit station, there will be functions like commercial, office, mixed-use, residential, social housing, with decreasing land utilization ratios and density. In the case of underground transit stations, underground space is maximally utilized for parking and commercial purposes, while the surface is dedicated to green spaces, squares, and bus transfer terminals. Pedestrian walkways and central pedestrian routes are organized to reduce travel distances and times.

*TOD spatial organization for renovation, integration, and transition between existing and new areas (fig.5)

For renovation and reconstruction areas based on the current reality of Hanoi, the TOD model is organized to integrate new and existing areas. Existing residential areas and villages will retain their characteristic structures, undergo expansion and improved transportation connections to the transit hub, including enhancements to pedestrian and bicycle traffic. Unused land areas will be used to build public facilities, social housing, and green spaces. Unused land areas will be prioritized for mixed-use functions, commercial services, public spaces, open spaces, and public transit transfer points around the transit hub, while also organizing transportation and pedestrian pathways connecting to existing areas.

*TOD spatial organization for underground areas

For historical, restricted development areas in the inner city where main urban railway lines will primarily run underground, due to the lack of surface land and to avoid affecting the urban landscape, the TOD development approach for these areas focuses on exploiting underground spaces. In this approach, the underground station will be arranged to include commercial floors, parking spaces, and underground intermodal transport centers around the station, combined with underground levels of high-rise buildings. The entire underground space will be interconnected through pedestrian tunnels, while also linking the open green spaces on the surface.

4. Conclusion

In the context of Industry 4.0 and the current digital transformation trends, building smart cities has become an essential requirement for urban areas. It also presents an opportunity for outstanding development, allowing cities to catch up with developed countries in the region in terms of economic, social, and environmental aspects.

For major and mega cities like Hanoi, adopting the TOD model is a comprehensive approach towards constructing a smart city. Developing TOD brings numerous benefits in terms of economic and social efficiency, resource conservation, land utilization, and protection of the natural environment. It is a necessary solution for densely populated urban areas.

Research and development of TOD will be integrated into urban development programs, wherein priority projects will be identified, and a roadmap for developing public transportation systems and TOD will be established based on short-term, medium-term, and long-term plans. This will create mutual supportive linkages within the system, enhancing operational efficiency.

Building a smart city while implementing the Public transport - TOD development model will contribute to the development of our Hanoi city, making it green, civilized, intelligent, and modern, in line with the set objectives./.

References

1. *Project on sustainable smart city development in Vietnam in the period of 2018 - 2025 with a vision to 2030.*
2. *Proposing a system of basic criteria for smart urban technical infrastructure to support the assessment of urban planning in Hanoi until 2030- HUPI City-level scientific research project.*
3. *Pham Duc Long, Research and propose suitable smart city deployment models in Vietnam*
4. *General planning on construction of Hanoi capital to 2030 with a vision to 2050.*
5. *Document No. 58/BTTT-KHCN dated 11/01/2018 Guiding principles of information and communication technology in smart city construction in Vietnam.*
6. *California Department of Transportation (2002) Statewide Transit-Oriented Development (TOD) Study Factors for Success in California*
7. *ITDP Institute for Transportation & Development Policy TOD Standard*
8. *Statewide Transit- OrientedDevelopment Study Factors for Success in California - California Department of transportation*
9. *Le Chinh Truc, 2023, Spatial Planning of TOD (Transit – Oriented Development) in Hanoi's Central Urban area, Doctoral Thesis, Hanoi Architectural University*

The propagation of the SH wave in layered concentric cylindrical structure

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Abstract

The present work deal with the propagation of a horizontally polarised shear (SH) wave in an infinitely long cylindrical structure comprised of three concentric isotropic layered media. The model has been formulated in cylindrical co-ordinates and an analytical approach is employed to achieve the closed form of the dispersion equation. The present analysis highlights the influence of the wave number on the phase velocity of the shear wave propagating in the embraced structure. Numerical computations have been carried out to accomplish the graphical demonstration unravelling some important peculiarities associated with the propagation characteristics of the shear wave in the considered cylindrical structure.

Key words: *propagation, cylindrical structural, SH wave, isotropic*

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1. Introduction

The dynamical problems on the propagation of horizontally polarized shear waves (SH waves) in anisotropic media have great geophysical importance because they help to investigate the structure of the earth. The horizontally polarised shear (SH) wave, a type of seismic surface wave is a useful indicator for possible fluid pathways because with the increase in permeability of the medium, velocity of shear wave propagation through it decreases. The study of propagation of the shear wave is useful in assessing hydrological properties of the medium, in particular the oceanic basement rocks. Also, the shear wave can detect and characterize the permeable zones which is very useful in geophysical exploration [1],[2].

Nowadays, the study of wave propagation in cylindrical structured media for its dynamic behaviour became a subject of great interest in many fields such as seismology, geophysics, and some engineering streams including mechanical, aerospace and geotechnical engineering, etc. Such a cylindrical structure occurs practically in various engineered form like pipes, aircrafts, submarines, missiles, rockets; boreholes and power transmission shafts are typical cylindrical structures [3],[4],[5].

Therefore, the main purpose of this paper is to consider the propagation of the SH-wave in a triple layered concentric finite long cylindrical structure.

2. Basic equations

In the present work, we have considered the propagation of the SH-wave in an infinitely long horizontal cylindrical structure which is constituted by three concentric isotropic media with different width. In many respects, surface wave propagation in elastic solid layered cylindrical structure is analogous to that in a rectangular elastic layered structure. Let a, b, c be the radii of innermost, intermediate and outermost media with $0 < a < b < c$, respectively, whereas $h_1(=b-a), h_2(=c-b)$ be the width of intermediate and outermost layered media. Introducing the cylindrical coordinate (r,θ,z) of a point inside the model with the z-axis being along the axis of the cylinder as shown in Fig.1. The direction of wave propagation over the cylindrical surface is symmetric about the axis of the cylinder, consequently along the rotating angle θ. The propagation of the shear wave over the cylindrical surface is symmetric about the axis of the cylinder, so that the displacement may be assumed to be independent of z and characterized as

$$u_z = u_z(r,\theta) \tag{1}$$

The stress σ_{ij} are related to the displacement component u_z by the following relations

$$\sigma_{rz} = \mu u_{z,r}; \sigma_{\theta z} = \frac{1}{r}\mu u_{z,\theta} \tag{2}$$

The equations of motion have the form [6], [7]

$$\sigma_{rz,r} + \frac{1}{r}\sigma_{\theta z,\theta} + \frac{\sigma_{rz}}{r} = \rho \ddot{u}_z \tag{3}$$

The equation of motion for the shear wave propagation about the cylindrical surface can be obtained from eq. (1), (2), (3) as

$$\frac{1}{r^2}\mu u_{z,\theta\theta} + \mu u_{z,rr} + \frac{1}{r}\mu u_{z,r} = \rho \ddot{u}_z \tag{4}$$

3. Formulation of the problem

We consider a model which is constituted by three concentric isotropic media with elastic constant of the cylindrically isotropic material and they are defined as

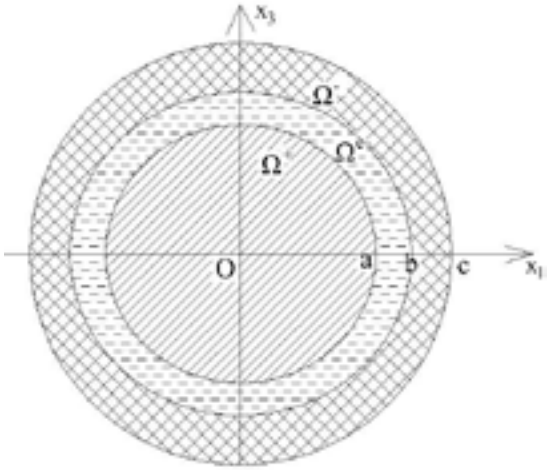

Figure 1. Geometry of the problem

$$\mu,\rho=\begin{cases}\mu^{+},\rho^{+} & in \quad \Omega^{+}\\ \mu^{e},\rho^{e} & in \quad \Omega^{e}\\ \mu^{-},\rho^{-} & in \quad \Omega^{-}\end{cases} \tag{5}$$

Therefore, the motion of SH-wave in three concentric isotropic homogeneous media is given

$$\begin{cases} r^2u_{z,rr}+u_{z,\theta\theta}+ru_{z,r}=\dfrac{r^2}{\beta_{+}^2}\ddot{u}_z, 0<r<a\\ r^2u_{z,rr}+u_{z,\theta\theta}+ru_{z,r}=\dfrac{r^2}{\beta_{e}^2}\ddot{u}_z, a<r<b\\ r^2u_{z,rr}+u_{z,\theta\theta}+ru_{z,r}=\dfrac{r^2}{\beta_{-}^2}\ddot{u}_z, b<r<c\end{cases} \tag{6}$$

where $\beta_{+}^2=\dfrac{\mu^{+}}{\rho^{+}};\beta_{-}^2=\dfrac{\mu^{-}}{\rho^{-}};\beta_{e}^2=\dfrac{\mu^{e}}{\rho^{e}}$.

Using the transformation $u_z=U_z(r)e^{i\omega t}\cos(n\theta)$ [4], [5], [9], the system equations (6) take the form

$$\begin{cases} r^2U_{z,rr}+rU_{z,r}+(\dfrac{r^2\omega^2}{\beta_{+}^2}-n^2)U_z=0, 0<r<a\\ r^2U_{z,rr}+rU_{z,r}+(\dfrac{r^2\omega^2}{\beta_{e}^2}-n^2)U_z=0, a<r<b\\ r^2U_{z,rr}+rU_{z,r}+(\dfrac{r^2\omega^2}{\beta_{-}^2}-n^2)U_z=0, b<r<c\end{cases} \tag{7}$$

where n is positive integer.

The solutions of (7) for innermost layer medium $0<r<a$ (the shear wave dies out with increase in depth as we approach towards the origin $r\to 0$) may be written as [1], [2]

$$U_z=A_1J_n\left(\frac{\omega r}{\beta_{+}}\right) \tag{8}$$

The solutions of $(7)_2$ and $(7)_3$ for intermediate layer $a<r<b$ and outermost layer medium $b<r<c$ can be obtained as [8], [9]

$$U_z=A_2H_e^{(1)}\left(\frac{\omega r}{\beta_e}\right)+A_3H_e^{(2)}\left(\frac{\omega r}{\beta_e}\right), a<r<b$$
$$U_z=A_4H_n^{(1)}\left(\frac{\omega r}{\beta_{-}}\right)+A_5H_n^{(2)}\left(\frac{\omega r}{\beta_{-}}\right), b<r<c \tag{9}$$

where $A_i,(i=\overline{1,5})$ arbitrary constants, $J_n;H_n^{(1)};H_n^{(2)}$ are Bessel's function, Hankel's functions of first and second kind of order n, respectively.

Recalling the inversion formula of the finite transformation, the displacement components for three respective layer media may further be written as [8],[9]

$$\begin{cases} u_z=A_1J_n\left(\dfrac{\omega r}{\beta_{+}}\right)e^{i\omega t}\cos(n\theta), 0<r<a\\ u_z=\left(A_2H_e^{(1)}\left(\dfrac{\omega r}{\beta_e}\right)+A_3H_e^{(2)}\left(\dfrac{\omega r}{\beta_e}\right)\right)e^{i\omega t}cos(n\theta), a<r<b\\ u_z=\left(A_4H_n^{(1)}\left(\dfrac{\omega r}{\beta_{-}}\right)+A_5H_n^{(2)}\left(\dfrac{\omega r}{\beta_{-}}\right)\right)e^{i\omega t}cos(n\theta), b<r<c\end{cases} \tag{10}$$

4. The dispersion equation of SH wave

The following conditions concerned with the continuity of stresses u_z and displacement u_z at the interfaces r = a and r = b as well as the free stress $\sigma_{rz}=0$ at the outermost surface r = c. Using the relation stress σ_{rz} to the displacement component u_z in (2) and taking into account (10), we have five equations for five constants $A_1...A_5$, namely

$$\begin{aligned}
&A_1J_n\left(\frac{\omega r}{\beta_{+}}\right)=A_2H_e^{(1)}\left(\frac{\omega r}{\beta_e}\right)+A_3H_e^{(2)}\left(\frac{\omega r}{\beta_e}\right), at \quad r=a\\
&A_2H_e^{(1)}\left(\frac{\omega r}{\beta_e}\right)+A_3H_e^{(2)}\left(\frac{\omega r}{\beta_e}\right)=\\
&=A_4H_n^{(1)}\left(\frac{\omega r}{\beta_{-}}\right)+A_5H_n^{(2)}\left(\frac{\omega r}{\beta_{-}}\right), at \quad r=b\\
&A_1\frac{\mu^{+}}{\beta_{+}}J_n'\left(\frac{\omega r}{\beta_{+}}\right)=\\
&=\frac{\mu_e}{\beta_e}\left[A_2H_e^{(1)'}\left(\frac{\omega r}{\beta_e}\right)+A_3H_e^{(2)'}\left(\frac{\omega r}{\beta_e}\right)\right], at \quad r=a\\
&\frac{\mu_e}{\beta_e}\left[A_2H_e^{(1)'}\left(\frac{\omega r}{\beta_e}\right)+A_3H_e^{(2)'}\left(\frac{\omega r}{\beta_e}\right)\right]=\\
&=\frac{\mu^{-}}{\beta_{-}}\left[A_4H_n^{(1)'}\left(\frac{\omega r}{\beta_{-}}\right)+A_5H_n^{(2)'}\left(\frac{\omega r}{\beta_{-}}\right)\right], at \quad r=b\\
&\frac{\mu^{-}}{\beta_{-}}\left[A_4H_n^{(1)'}\left(\frac{\omega r}{\beta_{-}}\right)+A_5H_n^{(2)'}\left(\frac{\omega r}{\beta_{-}}\right)\right]=0, at \quad r=c
\end{aligned} \tag{11}$$

where prime (') appearing in the superscript denotes the derivative of the quantity with respect to r. Eliminating arbitrary constants $A_1...A_5$ from system (11), we get the dispersion relation of SH wave propagating in a cylindrical structure constituted by three concentric isotopic layered media with different width, which includes Bessel's functions of first and second kind along with their derivatives.

The numerical calculation has been carried out for illustrating the theoretical results obtained in the preceding sections. The following data [2] have been taken into account

+) For the innermost layer medium Ω^+:

$$\mu^+ = 18.32\times10^{10}\, N/m^2; \rho^+ = 4700 kg/m^3$$

+) For the innermost layer medium Ω^-:

$$\mu^- = 3.23\times10^{10}\, N/m^2; \rho^- = 2802 kg/m^3$$

+) For the intermediate layer medium Ω^e:

$$\mu^e = 6.248\times10^{10}\, N/m^2; \rho^e = 3155 kg/m^3$$

The dispersion curve describes the variation of dimensionless phase velocity $x=c/\beta_+$ against dimensionless wave number $ep = k.h$ (h=c-a) for the SH wave propagating in three concentric cylinders have been plotted in Fig.2. It can be observed that the dimensionless phase velocityx decreases rapidly as the value of the dimensionless wave number ep increases from 0.6 to 0.9. In comparison with the model of Kumar [2], the domain of ep in which the dimensionless phase velocity exists is smaller.

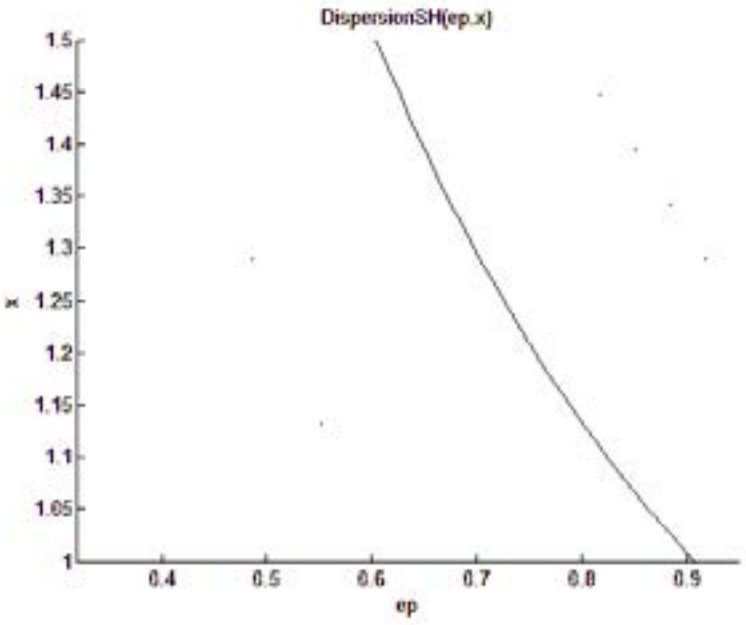

Figure 2. Variation of the dimensionless phase velocity with dimensionless wave number

5. Conclusions

This paper deals with the propagation of the shear wave in an infinitely long horizontal cylindrical structure which is comprised of three isotropic elastic concentric media with distinct radii. The dispersion equation has been obtained based on Bessel's and Hankel's functions. The effects of dimensionless wave number on the propagation of the shear wave have been accomplished by numerical simulation and depicted graphically./.

References

1. *Mahantya. M, Chattopadhyay.A, Singh.A.K, "Shear wave propagation in a cylindrical Earth model", Procedia Engineering, 173, 2017, pp. 1959-1966.*
2. *Kumar.P, Chattopadhyay.A, Mahantya. M, Singh.A.K, " Analysis on propagation characteristics of the shear wave in a triple layered concentric infinite long cylindrical structure: An analytical approach", Eur. Phys. J. Plus,134, 2019, pp. 134:35.*
3. *Watanabe.K, Payton.R.G, "Source of a time-harmonic SH wave in a cylindrically orthotropic elastic solid",Geophys.J.Int, 145, 2001, pp.709-713.*
4. *Tsukrov.I, Drach.B, "Elastic deformation of composite cylinders with cylindrically orthotropic layers", International Journal of Solids and Structures, Vol. 47, 2010, pp. 25–33.*
5. *Tarn.J.Q, Chang.H.H, "Torsion of cylindrically orthotropic elastic circular bars with radial inhomogeneity: some exact solutions and end effects", International Journal of Solids and structures, Vol. 45, 2008, pp. 303-319.*
6. *Achenbach.J.D, Wave propagation in Elastic Solids, North-Holland Publishing Company, Amsterdam-New York-Oxford, 1973.*
7. *Nayfeh.A.H, Wave Propagation in Layered Anisotropic Media, North-Holland, Amsterdam, 1995.*
8. *Chattopadhyay.A, Chaudhury.S"Magnetoelastic shear waves in an infinite self-reinforced plate", Int. J Number. Anan. Methods Geomechanics,19, 1995, pp. 289-304.*
9. *Chattopadhyay.A, Mahata.N.P,"Propagation of Love waves on a cylindrical earth model", J Acoutics. Soc. Am, Vol 74, 1983, pp.286-293.*

Design of castellated and cellular beam according to TCVN 5575

Nguyễn Hồng Sơn

Abstract

This article introduces the structural and calculation requirements for steel beams with openings in the web, including: irregular hexagonal or oval openings, special cases are castellated (regular hexagonal) and cellular (round) openings. Calculation requirements, including verified the strength and deflection of the beam. Performing a numerical example for a beam with a opening in the web by zigzag cutting the web of the I-shaped steel beam, then butt-welding the cut part to form a regular hexagonal opening. The calculation steps show the implementation sequence, from material selection, load calculation, bending verified strength, verified buckling and deflection. Through numerical examples, to clarify the steps of designing steel web beams according to Vietnam's standard Design of steel structure TCVN 5575 (draft version 2023).

Key words: *castellated beam, cellular beam, I section, design, TCVN 5575 ((draft version 2023)*

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1. Introduction

Steel structures in general and steel beams in particular are widely used in civil and industrial engineering projects, including steel beams with openings in web beam. The openings in the beam's web have a very diverse shape, they can be square, rectangular, regular (castellated) or irregular hexagonal, circular (cellular) or oval. Square or rectangular openings are often created locally at several locations along the beam length, with hexagonal (castellated) or circular (cellular) or oval openings are often created continuously along the beam length. It can be seen that the main advantage of perforated steel beams is that they allow technical pipes of electrical, water or air conditioning and ventilation systems to pass through the beam's web, so it does not require much height space house for the technical system below the floor, to improve the efficiency of the building's usable space. At the same time, the web of the perforated web beam is made from a solid steel plate that is cut zigzag and then welded head-on at the cut part to create a steel plate with openings in the desired shape. This steel plate with openings has a height greater than the height original solid steel plate height, which means more efficient use of section height.

The problem of designing castellated and cellular steel beam structures to meet the requirements for resistance, stability as well as deflection requirements is a matter of concern. Recently, Vietnam's new standard design of steel structure TCVN 5575 (draft version 2023) [1] replaced the current standard TCVN 5575:2012 [2]. Standard TCVN 5575 is compiled based on the Russian Federation Standard of the same name SP 16.13330.2017 [5], updated with revisions 1 to 5 from 2018 to 2022, in addition to adding many contents of SP 294.1325800.2017 [7]. In addition, the standards of some advanced countries also mention the type of castellated and cellular beam members, such as the American Standard (AISC) [4], and recently the draft European standard (FprEN 1993-1-13) [5].

Accordingly, this article will introduce in detail the structural requirements and calculation of castellated and cellular steel beam components according to the conditions of resistance, stability and deflection, and design regulations mentioned in TCVN 5575. Limited to irregular hexagonal and oval opening shapes (regular hexagonal (castellated) or round (cellular) opening shapes are special cases of the two shapes mentioned above).

2. Design of castellated and cellular beam

2.1. Definition

Beams with opening in web are also known as castellated or cellular beams, they are designed with rolled I-shaped steel (with a cross-sectional height not less than 200 mm) made of steel with a yield limit of up to 440 MPa.

The expansion level of rolled steel (the ratio of the height of the expanded beam to the original I-shaped height) is taken to be no greater than 1.5.

The weld connection of the web should be made with a butt weld through the thickness.

2.2. Calculate

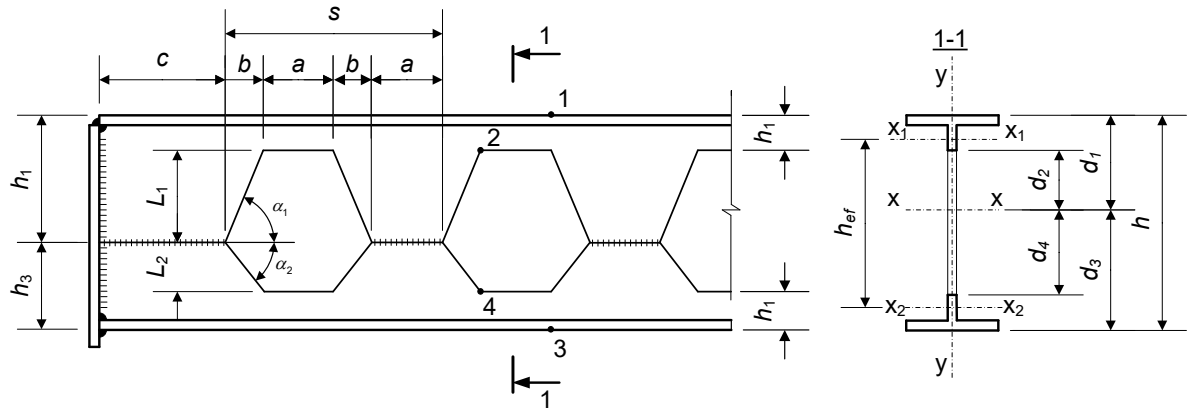
a) Calculation of resistance

Calculation of Flexural Strength in plane of beam (Fig 1) is carried out according to the formulas:

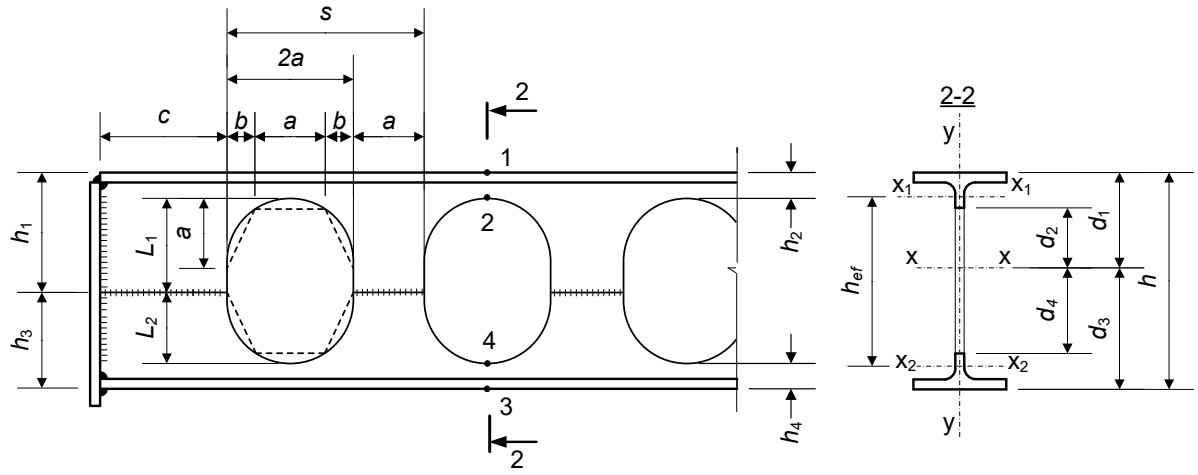
- For points at the corners of the openings, nearest to the flanges of the T:

$$\frac{1}{f_{ud}\gamma_c}\cdot\left(\frac{M}{W_x}+\frac{Va}{4W_{min}}\right)\le 1 \qquad (1)$$

- For the nearest points located on the upper side of the T flanges above the openings:



a) castellated (regular hexagonal) openings



b) cellular (round) openings

Figure 1. Diagram of the openings in beam's web [1]

$$\frac{1}{f_{yd}\gamma_c}\cdot\left(\frac{M}{W_x}+\frac{V_1 a}{4W_{max}}\right)\le 1 \quad (2)$$

$$\frac{V_s s}{t_w a h_{ef} f_v \gamma_c}\le 1 \quad (3)$$

where:

M is the bending moment in the beam;

t_w is the web thickness;

V is the shear force in the beam;

V_s is the shear force in the beam section at distance (c + s – 0.5a) from the support (see Fig 1);

W_x is the section modulus of the I-beam developed at the opening section (actual cross-section) with respect to the x–x axis (when calculating the cross-section according to point 2: $W_x = I_x/d_2$; when calculating the cross-section according to point 4: $W_x = I_x/d_4$ where d_2, d_4 are the distances from the center of the section to points 2 and 4 respectively);

W_{max}, W_{min} are the largest and smallest section modulus of the T-section.

When determining the bearing capacity of the opening web beam at points 2 and 4:

$$\frac{\gamma_u}{f_{ud}\gamma_c}\cdot\left(\frac{Md_2}{I_x}+\frac{V_1 a}{2W_{1,min}}+\frac{N}{A_n}\right)\le 1 \quad (4a)$$

$$\frac{\gamma_u}{f_{ud}\gamma_c}\cdot\left(\frac{Md_4}{I_x}+\frac{V_2 a}{2W_{2,min}}+\frac{N}{A_n}\right)\le 1 \quad (4b)$$

where:

M is the bending moment in the beam;

V_1, V_2 are the shear forces under by the upper and lower T sections;

N is the longitudinal force in the beam;

I_x is the moment of inertia of the I section developed at the opening beam section (gross section) with respect to the x–x axis;

A_n is the area of the I section developed at the beam section with openings (gross section);

$W_{1,min}$, $W_{2,min}$ are the smallest section moduli of the upper and lower T-sections, respectively;

a is the lintel width of the web beam;

d_2, d_4 are the distances from the centroid of the section to points 2 and 4 respectively.

When determining the bearing capacity of the castellated and cellular beam at points 1 and 3:

$$\frac{1}{f_{yd}\gamma_c}\cdot\left(\frac{Md_1}{I_x}+\frac{V_1 a}{2W_{1,min}}+\frac{N}{A_n}\right)\le 1 \quad (5c)$$

$$\frac{1}{f_{yd}\gamma_c}\cdot\left(\frac{Md_3}{I_x}+\frac{V_2a}{2W_{2,min}}+\frac{N}{A_n}\right)\le 1 \quad (5d)$$

where:

M is the bending moment in the beam;

V_1, V_2 are the shear forces under by the upper and lower T sections;

N is the longitudinal force in the beam;

I_x is the moment of inertia of the I beam developed at the opening beam section (gross section) with respect to the x–x axis;

An is the area of the I section developed at the beam section with openings (gross section);

$W_{1,min}$, $W_{2,min}$ are the smallest section moduli of the upper and lower T-sections, respectively;

a is the lintel width of the web beam;

d_1, d_3 are the distances from the centroid of the section to points 1 and 3 respectively.

b) Calculation of buckling

Calculations of beam buckling are performed according to 8.4.1 in TCVN 5575:2023; then the geometric characteristics of the beam are calculated for the opening section. The stability of the beam is considered guaranteed if it meets the requirements in 8.4.4 and 8.4.5 in TCVN 5575:2023.

At the support sections, if the abdomen has $h_{ef}/t_w>40$, it needs to be stiffened with rigid ribs and is calculated according to 8.5.17 in TCVN 5575:2023; Then the bearing cross section needs to be c ≥ 250 mm (see Fig 1).

The web beam in the upper area must be checked for stability according to the formula:

$$\tau \le \tau_{cr} \quad (5e)$$

The shear stress at the lintel of the web beam is calculated according to the formula:

$$\tau=\frac{Vs}{t_w a h_{ef}} \quad (5f)$$

where:

V is the shear force at the cross-section of the lintel under consideration;

t_w is the web thickness;

a is the lintel width of the beam web;

s is the opening pitch of the beam web;

h_{ef} is the distance between the centroids of the T section.

The critical shear stress is calculated according to the formula:

$$\tau_{cr}=\frac{4\left(\alpha-\frac{\pi}{2}\right)^2\sigma_{cr}}{3tg\left(\alpha-\frac{\pi}{2}\right)}\le f_v\gamma_c \quad (4g)$$

where:

α is the opening angle of the beam web (see Fig 1);

σ_{cr} is the critical normal stress, calculated according to the formula:

$$\sigma_{cr}=\varphi f_{yd}\gamma_c \quad (4h)$$

where:

is the stability coefficient, determined according to 7.1.3 when slenderness, where $L = L_1 + L_2$ is the opening height of the beam web (see Fig. 1).

When calculating the castellated beam or cellular beam, in the lintel area, use the geometric dimensions of a regular hexagon inscribed in a circle with diameter 2a (see Fig 1b).

Concentrated loads should only be placed on beam sections that are not placed openings.

The web height of the compression T-section needs to satisfy the requirements in 7.3.2 in TCVN 5575:2023, in which in formula (28) take $\bar{\lambda}=1,4$.

c) Caculation of deflection

Determining the deflection of a hexagonal opening web beam with opening height d = 0.667h and ratio L/h_{ef} ≥ 12 (where L is the beam span) should be carried out according to the formula:

$$f_{perf}=f\cdot\left(1+\frac{1,3\pi^2 dA_f\alpha(\eta)\left(1+\frac{2}{\eta}\right)}{t_w L^2}\right) \quad (5)$$

where:

$$f=\frac{5qL^4}{384EI_m}$$

is the beam deflection calculated according to bending theory (including I_m);

Af is the area of the T-shaped flang above the opening, calculated by the formula:

$$A_f=t_f b_f+t_w\left(0,5(h-d)-t_f\right) \quad (6)$$

$\eta=2/(s/a-1)$ relative clearance distance between openings, where a is the clearance distance between adjacent openings at the neutral axis level and s is the opening pitch (see Fig 1);

$\alpha(\eta)$ is a function of η :

$$\alpha(\eta)=-2,43\eta^2+4,54\eta+0,586 \quad (7)$$

The moment of inertia of section Im is calculated according to the formula:

$$I_m=\frac{b_f t_f(h-t_f)^2}{2}+\frac{t_w(h-2t_f)^3}{12}-\frac{t_w d^3}{24} \quad (8)$$

3. Design example

3.1. Calculated data

Given: Castellated roof beam with I section constructed from shaped H section. Simple beam with span L = 18.0

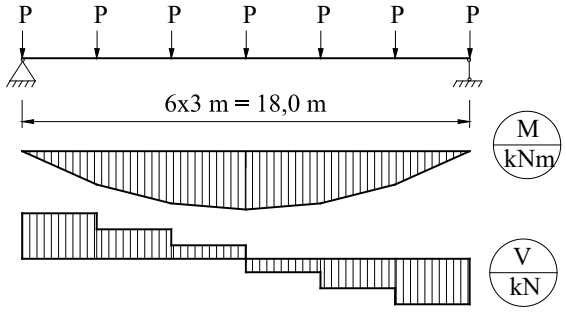


Fig 2. Load arrangement and diagram of internal forces M and V

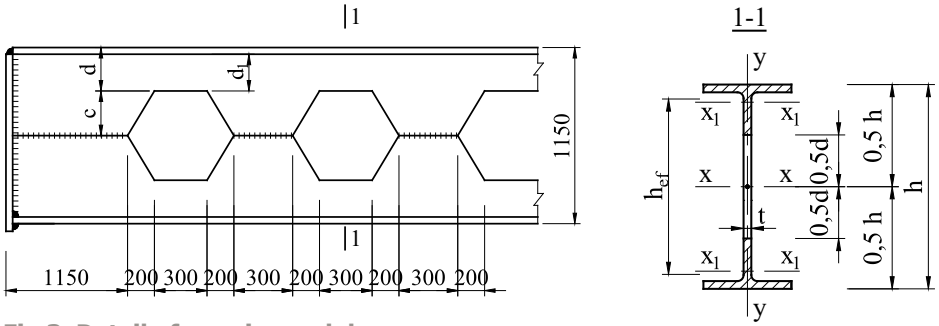


Fig 3. Detail of opening web beam

m, subjected to concentrated load from secondary beams placed 3.0 m spacing. The concentrated load distributed uniformly on the beam is 39 kN/m (q0 = 31.2 kN/m). The bending moment M and shear force V diagrams are shown in Fig 2 [3].

3.2. Solution:

Step 1. Determine beam cross-section and zigzag cutting diagram of web I section

Use H section. Steel material – HSGS 490 (according to Table B.9 in TCVN 5575:2023); For thickness up to 16mm, f_{yd} = 27.14 kN/cm^2; f_v = 15.74 kN/cm^2; f_{ud} = 46.67 kN/cm^2; For thickness up to 40mm, f_{yd} = 26.19 kN/cm^2. For beam head stiffeners, S235 steel is used.

Maximum bending moment caused by design load:

$$M_{max} = \frac{qL^2}{8} = \frac{39 \times 18^2}{8} = 1579,5 kN.m$$

Required section modulus:

$$W_{req} = \frac{M_{max}}{f_{yd}\gamma_c} = \frac{1579,5 \times 100}{26,19 \times 1} = 6031 cm^3$$

Choose the initial H section H800×300×14×22 according to TCVN 7571-16:2017. Dimensions section h_0 = 792mm; b = 300mm; t_f = 22mm; t_w = 14mm; R = 18mm. Cross-sectional area A = 239.5cm^2; I_x = 248000cm^4; W_x = 6270cm^3. The mass of 1 m is 188 kg long.

Check deflection due to standard load qc = 31,2 kN/m:

$$\frac{f}{L} = \frac{5q^cL^3}{384EI_x} = \frac{5 \times 31,2 \times 18^3 \times 10^6}{384 \times 2,06 \times 10^6 \times 248000} = \frac{1}{216} > \left[\frac{f}{L}\right] = \frac{1}{250}$$

Seeing that using a section beam H800×300×14×22 does not satisfy the allowable deflection, measures to increase stiffness are needed (increasing the beam height by using a openings web beam). The level of rolled steel development is required to be no greater than 1.5. Take height h = 115cm.

Choose the initial H section zigzag cutting method so that the secondary beam placed on the beam section is not weakened by the opening (3 m beam spacing requires even cutting steps s). Choose a opening pitch of 1 m (there are three openings within the beam spacing limit), i.e. 3×2×(b+e) = 3000mm or (b+e) = 500mm.

Suppose e = 300mm, b = 200mm. At the end of each 3m interval, arrange only two openings (Fig 3). Arrange welds of beam sections at mid-height. Take the beam end plate and weld it to the beam end.

Step 2. Determine the parameters of the opening beam section

Area of T flange:

$$A_T = \frac{A - ct_w}{2} = \frac{239,5 - 35,8 \times 1,4}{2} = 94,69 cm^2;$$

c = 115 – 79,2 = 35,8cm.

Wing equivelence thickness:

$$t_f = \frac{A - h_0 t_w}{2(b - t_w)} = \frac{239,5 - 79,2 \times 1,4}{2 \times (30 - 1,4)} = 2,25 \text{ cm.}$$

T section height:

$$d = \frac{79,2 - 35,8}{2} = 21,7 \text{ cm; } d_1 = 19,45 \text{ cm.}$$

Step 3. Check the local buckling of the T section web

Check by condition:

$$\bar{\lambda}_w = (h_{ef} / t_w)\sqrt{f_{yd} / E} \le \bar{\lambda}_{uw}$$

The limited equivelence slenderness $\bar{\lambda}_{uw}$ is determined according to formula (28) in Table 9 in TCVN 5575:2023:

$$\bar{\lambda}_{uw} = (0,40 + 0,07\bar{\lambda})(1 + 0,25\sqrt{2 - b_f / h_{ef}}) =$$

$$(0,40 + 0,07 \times 1,4) \times (1 + 0,25\sqrt{2 - 30 / 19,45}) = 0,58,$$

trong đó $\bar{\lambda}$ = 1,4 according to 15.13.5 in TCVN 5575:2023.

Equivelence slenderness of the web:

$$\bar{\lambda}_w = (19,45 / 1,4) \times \sqrt{271,4 / (2,06 \times 10^5)} = 0,504 < 0,58.$$

Thus, the T section web ensures local buckling.

Step 4. Check beam section resistance

Flange cross-sectional area:

$$A_f = bt_f = 30 \times 2,25 = 67,5 \text{ cm}^2.$$

Modulus of section of the upper T flange with respect to the lower edge:

$$S_T = A_f\left(d_1 + \frac{t_f}{2}\right) + \frac{t_w d_1^2}{2}$$

$$= 67,5 \times \left(19,45 + \frac{2,25}{2}\right) + \frac{1,4 \times 19,45^2}{2} = 1654 cm^3$$

Moment of inertia of the T section about the bottom edge:

$$I_{T,1} = A_f\left(d_1^2 + d_1 t_f + \frac{t_f^2}{3}\right) + \frac{t_w d_1^3}{3} =$$

$$= 67,5 \times \left(19,45^2 + 19,45 \times 2,25 + \frac{2,25^2}{3} \right) + \frac{1,4 \times 19,45^3}{3}$$

= 32037 cm^4.

The centroid section on the distance:

z = ST/AT = 1654/94,69 = 17,5 cm.

Moment of inertia of the T section about the central axis:

$I_T = \left| I_{T,1} - zS_T \right| = \left| 32037 - 17,5 \times 1654 \right| = 3092$ cm^4.

Section modulus of T section flange:

$$W_{T,max} = \frac{I_T}{d-z} = \frac{3092}{21,7-17,5} = 736,2 \text{ cm}^3;$$

$$W_{T,min} = \frac{I_T}{z} = \frac{3092}{17,5} = 176,7 \text{ cm}^3.$$

The lever arm of the force pair acting in the flange:

f = 2(c+z) = 2×(35,8+17,5) = 106,6cm.

Moment of inertia of beam cross-section according to opening:

$$I_{x,0} = 2I_T + \frac{A_T f^2}{2}$$

$$I_{x,0} = 2 \times 3092 + \frac{94,69 \times 106,6^2}{2} = 544192 \text{ cm}^4.$$

The section modulus of the I section expands with respect to the x-x axis:

$$W_x = \frac{2I_{x,0}}{h_{ef}} = \frac{2 \times 544192}{107} = 10172 \text{ cm}^3.$$

Check the bending moment resistance of the T flange at mid-span:

M_{max} = 1579,5 kN.m; V = 117,1 kN; N = 0 (see Fig 1).

Point located above the opening corners at a distance of 0.5h from the x-x axis:

$$\frac{1}{26,2 \times 1,0} \times \left(\frac{1579,5 \times 100}{10172} + \frac{117,1 \times 30}{4 \times 736,1} \right) = 0,64 < 1.$$

The point is located at the opening corners at a distance of 0.5d from the x-x axis:

$$\frac{1}{46,7 \times 1,0} \times \left(\frac{1579,5 \times 100}{10172} + \frac{117,1 \times 30}{4 \times 176,7} \right) = 0,44 < 1.$$

Check the bending strength of the T section at a quarter span (under the second force from the support):

$M_1/4$ = 1361,6 kN.m; $V_1/4$ = 234,2 kN.

Point located above the opening corners at a distance of 0.5h from the x-x axis:

$$\frac{1}{46,7 \times 1,0} \times \left(\frac{1361,6 \times 100}{10172} + \frac{234,2 \times 30}{4 \times 176,7} \right) = 0,50 < 1;$$

The point is located at the opening corners at a distance of 0.5d from the x-x axis:

$$\frac{1}{46,7 \times 1,0} \times \left(\frac{1361,6 \times 100}{10172} + \frac{234,2 \times 30}{4 \times 176,7} \right) = 0,50 < 1.$$

Check the bending strength of the T section flange at the beam support (on the first opening):

M_1,65 = (351,4-29,3)×1,65 = 531,46 kN.m;

V_1,65 = 322,08 kN.

The point is located at the opening corners at a distance of 0.5d from the x-x axis:

$$\frac{1}{46,7 \times 1,0} \times \left(\frac{531,46 \times 100}{10172} + \frac{322,08 \times 30}{4 \times 176,7} \right) = 0,40 < 1.$$

Thus, the bearing capacity of the bending moment T section is guaranteed.

Step 5. Check the local buckling of the beam web

Check beam web thickness according to standard requirements (Article 15.13.5 in TCVN 5575:2023).

$$\frac{h_{ef}}{t_w} = \frac{115 - 2 \times (2,2 + 1,8)}{1,4} = 76,4$$

(h_{ef} according to Figure 3);

$$2,5\sqrt{\frac{E}{f_{yd}}} = 2,5 \times \sqrt{\frac{2,06 \times 10^4}{27,14}} = 68,9 \quad (76,4 > 68,9).$$

Check the installation of horizontal stiffeners in the web section:

$$\bar{\lambda}_w = 76,4 \times \sqrt{\frac{271,4}{2,06 \times 10^5}} = 2,8 < 3,2$$

,

horizontal stiffeners are only installed under concentrated loads (at the secondary beam position, i.e. 3 m away). Stiffeners sizes are taken according to standards:

Stiffeners width:

$$b_r \geq h_w / 30 + 25 \text{ mm} = 1250 / 30 + 25 = 66,7 \text{ mm}$$

.

Take b_r = 70 mm.

Stiffeners thickness:

$$t_r \geq 2 \times 70 \times \sqrt{223,8 / \left(2,06 \times 10^5 \right)} = 4,6 \text{ mm}.$$

Take t_r = 6 mm.

Beam head stiffener size:

Width of beam head stiffener (support stiffener):

$b_{ro} = b_f$ = 300mm (b_f is the beam flange width).

Thickness according to strength:

$$t_{ro} \geq \frac{V_{max}}{b_{ro} f_c \gamma_c} = \frac{351,4}{300 \times 34,3 \times 10^{-2}} = 3,4 \text{ mm}.$$

In addition, article 8.5.17 in TCVN 5575:2023 requires:

$$t_{ro} \geq 3 \times 150 \times \sqrt{223,8 / \left(2,06 \times 10^5 \right)} = 14,8 \text{ mm}.$$

Take t_{ro} = 16mm.

Check the buckling of the first zone from the bearing (with the highest load) according to the formula:

$t_{2\varphi} = 35,8 / 20 = 1,79$; φ = 60,8°; θ = 29,2°.

Units in radians θ = 29,2×π/180 = 0,5096; tgθ = 0,5589;

$$\tau_{cr} = \frac{4\theta^2}{3tg\theta} \sigma_{cr} = \frac{4}{3} \times \frac{0,5096^2}{0,5589} \sigma_{cr} = 0,6195 \sigma_{cr};$$

$$\sigma_{cr} = \varphi f_{yd} \gamma_c;$$

$$L_0 = \frac{c}{\sin\varphi} = \frac{35,8}{0,873} = 41,0;$$

$$i = 0,289 t_w = 0,289 \times 1,35 = 0,39 \text{cm};$$

$\lambda = 105$, $\bar{\lambda} = 105 \times \sqrt{\frac{271,4}{2,06 \times 10^5}} = 3,81$;

according to Table D.1 in TCVN 5575:2023, there is $\varphi = 0,485$;

$\tau_{cr} = 0,6195 \times 13,2 = 8,18$ kN/cm^2;

$\tau_{cr} = 0,6195 \times 13,2 = 8,18$ kN/cm^2.

Gross shear stress in the first zone:

$$\tau = \frac{322,08}{1,35 \times 30} = 7,95 \text{ kN/cm}^2 < \tau_{cr}.$$

Step 6. Check overall buckling

Overall buckling is ensured by braces (auxiliary beams). In any case, this inspection is no different from that of conventional beams. Geometric characteristics need to be obtained for sections with openings.

Step 7. Check beam deflection

Check deflection according to formula (204) in TCVN 5575:2023:

$$f_{perf} = f\left(1 + \pi^2 1,3 d A_f \alpha(\eta)\left(1 + \frac{2}{\eta}\right)\frac{1}{t_w L^2}\right);$$

$$f = \frac{5 q_n L^4}{384 E I_m} = \frac{5 \times 31,2 \times 18^4 \times 10^8}{384 \times 2,06 \times 10^6 \times 560138} = 3,70 \text{ cm};$$

$A_f = t_f b_f + t_w(0,5(h - d) - t_f)$

$= 2,25 \times 30 + 1,4 \times [0,5 \times (115 - 76,7) - 2,25] = 91,2$ cm^2;

$d = 0,667h = 0,667 \times 115 = 76,7$ cm;

$$I_m = b_f t_f \frac{(h - t_f)^2}{2} + \frac{t_w (h - 2t_f)^3}{12} - \frac{t_w d^3}{24} =;$$

According to formula (206) in TCVN 5575:2023:

$\alpha(\eta) = -2,432 + 4,54\eta + 0,586$

$= 2,43 \times 0,862 + 4,54 \times 0,86 + 0,586 = 2,69$;

According to formula (208) in TCVN 5575:2023:

$$I_m = b_f t_f \frac{(h - t_f)^2}{2} + \frac{t_w (h - 2t_f)^3}{12} - \frac{t_w d^3}{24} =$$

$$= 30 \times 2,25 \times \frac{(115 - 2,25)^2}{2} + \frac{1,4 \times (115 - 2 \times 2,25)^3}{12} - \frac{1,4 \times 76,7^3}{24} = 560138 \text{cm}^4$$

$$f_{perf} = 3,70 \times \left(\begin{array}{c} 1 + \pi^2 \times 1,3 \times 76,7 \times 91,2 \times 2,69 \times \\ \times \left(1 + \frac{2}{0,86}\right) \times \frac{1}{1,4 \times 1800^2} \end{array}\right)$$

$= 3,70 \times (1 + 0,177) = 4,35$ cm.

$$\frac{f_{perf}}{L} = \frac{4,35}{1800} = \frac{1}{414} < \left[\frac{f}{L}\right] = \frac{1}{250}.$$

Beams ensure deflection conditions.

Conclusion: The deployed I-beam cross section ensures the load bearing requirements.

Conclusions

- Calculation of steel beam members with opening in web mentioned in TCVN 5575 (draft version 2023) for the general case of irregular hexagonal openings, oval openings and special cases of beams with (castellated) regular hexagonal openings or (cellular) round openings. Accordingly, other advanced steel structure design standards have also been accessed, for example European standards (prEN 1993-1-13) [5] or US standards (AISC) [4].

- Vietnam's Steel Structure Design Standard TCVN 5575 (draft version 2023) has many new points compared to TCVN 5575:2012, and their content is quite extensive. Therefore, there needs to be further research into this standard in the future to properly understand and exploit all the contents mentioned in this standard./.

References

1. *Tiêu chuẩn Việt Nam (2023), TCVN 5575 (phiên bản dự thảo năm 2023) - Thiết kế kết cấu thép.*
2. *Tiêu chuẩn Việt Nam (2012), TCVN 5575:2012 - Kết cấu thép – Tiêu chuẩn thiết kế.*
3. *Bộ Xây dựng (2022), Hướng dẫn thiết kế kết cấu thép theo TCVN 5575:2023 (dự thảo), đề tài nghiên cứu hoa học cấp Bộ Xây dựng năm 2021, mã số RD 21-21.*
4. *Steel Design Guide – 31 (2016), Castellated and Cellular Beam Design.*
5. *FprEN 1993-1-13, Design of steel structures - Part 1-13: Beams with large web openings.*
6. *SP 16.13330.2017, Стальные конструкции. Актуализированная редакция СНиП II-23-81*" (с Поправкой, с Изменениями N 1, 2) (Kết cấu thép – Phiên bản cập nhật của SniP II-23-81 (với đính chính, sửa đổi 1, 2).*
7. *SP 43.13330.2012, Сооружения промышленных предприятий. Актуализированная редакция СНиП 2.09.03-85 (с Изменениями N 1, 2) (Các công trình xí nghiệp công nghiệp – Phiên bản cập nhật của SNiP 2.09.03-85 (với các sửa đổi 1, 2).*
8. *SP 294.1325800.2017, Конструкции стальные. Правила проектирования (с Изменением N 1, N 2) (Kết cấu thép – Quy tắc thiết kế (với các sửa đổi 1, 2).*

Applying forecasting demand for traffic model at Hai Phong, Vietnam

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Abstract

Traffic demand forecasting is a crucial step in the process of urban transportation planning, management, and operation. In developed countries around the world, the application of forecasting models is almost mandatory and brings significant benefits. However, in Vietnam, there have been relatively few studies on the application of traffic demand forecasting models. This research introduces the application of such a model in Hai Phong City and identifies the challenges and solutions to improve the implementation of traffic demand forecasting models in Vietnam. We believe that these results will support policymakers and researchers with a basis for enhancing the effectiveness of urban transportation planning, management, and operation. By applying forecasting models, decision-makers can make more informed choices, leading to better traffic management and more efficient transportation systems in Vietnamese cities. The study's insights are expected to contribute to the overall improvement of transportation policies and practices in the country.

Key words: *public transport; modelling transport; Hai Phong*

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1. Introduction

The forecasting of transportation demand plays a crucial role in urban transportation system planning. Currently, there are several methods for forecasting transportation demand, including extrapolation method, Fratar method (USA), Detroit method used in the city of Detroit, USA, and the gravity model, also known as the 4-step model [1]. In Vietnam, some projects have used a four-step transportation model, such as:

1. The Urban Transport Support Project in Vietnam in 1993, supported by the Swedish International Development Cooperation Agency (SIDA).

2. The Comprehensive Transportation Master Plan Study for Hanoi in 1996, supported by the Japan International Cooperation Agency (JICA).

3. The National Strategy for Transport Development in the Socialist Republic of Vietnam (VITRANSS).

4. The Comprehensive Urban Development Program for Hanoi, Socialist Republic of Vietnam (HAIDEP).

5. The Transportation Master Plan for Hanoi until 2030 with a vision until 2050, conducted by the Transport and Transportation Design Consultancy Corporation.

Transportation demand forecasting is a critical step in the process of urban transportation planning, management, and operation. Across the world, the use of various forecasting models has led to better planning, construction, and management of transportation systems. In Vietnam, there has been some initial progress in applying transportation demand forecasting models. However, on the whole, these models are not yet widely used, resulting in transportation systems' development not meeting expectations, reduced service levels, and various adverse effects such as traffic congestion and environmental pollution. As of 2020, the transportation sector accounted for approximately 27% of global greenhouse gas emissions [2], leading to increased transportation costs and significant pressure on the economy, society, and the environment.

In the Vietnamese Construction Standards 01: 2008/BXD, it is stipulated that urban planning must forecast the demand for passenger and cargo transportation as well as various types of transportation within the city to determine the land allocation for future transportation development [3]. On May 19, 2021, the Ministry of Construction issued the standard 01: 2021/BXD, which also requires urban transportation planning in general planning projects to forecast the demand for passenger and cargo transportation and the composition of transportation means [4]. Over the past 10 years of applying these standards, the forecasting of transportation demand has not been implemented uniformly nationwide. One of the main reasons is the lack of sufficient databases and human resources for conducting transportation demand forecasting. Additionally, the costs of forecasting software and surveys are relatively high.

Hai Phong is one of the five centrally-governed cities in Vietnam. It holds the following characteristics: It is a type I urban area directly governed by the central government, a significant economic hub for the country's coastal region in the North, and a center for education, healthcare, and scientific and technological research in the North Coastal area. Hai Phong is a green, modern, and civilized port city that serves as a transportation and communication hub for both domestic and international exchanges. It also holds a strategically important position in terms of national defense and security [5]. Given its role as a transportation hub, forecasting transportation demand becomes crucial for providing guidance in planning and formulating policies.

Based on these characteristics, the research team has initially applied a transportation demand forecasting model in Hai Phong City, Vietnam. The model utilized is the 4-step model. (These are: trip generation, trip distribution, modal split and traffic assignments).

Fig. 1. Illustration of the Four-step transportation model, [7]

The four-step transportation model is a ubiquitous framework for determining transportation forecasts that goes back to the 1950s. It was one of the first transportation demand models that sought to link land use and behavior to inform transportation planning [6]. Originally applied in the highway planning context, the model was expanded in the 1970s and 1980s to include multimodal trips and improved modelling techniques [6].

We believe that the results of this study will contribute to a better understanding of the application of the transportation demand forecasting model in Hai Phong City, as well as the challenges faced during its implementation. The study also proposes some solutions to overcome these difficulties, ultimately improving the effectiveness of urban transportation planning, management, and operation.

The remaining parts of the study consist of four sections. Section 2 presents the steps involved in constructing the forecasting model. Section 3 presents the main results. We will discuss these findings in Section 4 and provide our conclusions in Section 5.

2. 4-step transportation model

There are many methods of forecasting transportation demand such as: Extrapolation method, Fratar method (USA), Detroit method (Detroit city of USA), Gravity method, also known as 4-step modeling method which are applied in the results this study:

2.1. Step 1: Generate and attract trip

Regression analysis is a statistical method in which the mean value (mean) of one or more random variables is predicted based on the conditions of other (calculated) random variables.

The general regression model involves:

$$Y_i = a_i + p_1X_1 + P_2X_2 + \ldots + P_nX_n + S_i \quad (1)$$

Of which:

Y_i = the number of itineraries arising in i;

a_i = real number;

$p_1 \ldots p_n$: = regression coefficient; $X_1 \ldots X_n$ = random variable (variables representing a factor affecting the number of trips such as population, household...;

S_i = correction coefficient (balance); a_i, p_I, $p_2 \ldots P_n$, S_i are determined by regression method.

2.2. Step 2: Trip Distribution Model

$$T_{ij} = P_i \left[\frac{A_j F_{ij} K_{ij}}{\sum_j A_j F_{ij} K_{ij}} \right]$$

The most common method to determine the journey distribution is to use Gravity mode, which specifies the number of journeys between the origin and the destination as a function of inbound and outbound calculation (OD attribute) and transportation cost between them.

$$T_{ij} = P_i \left[\frac{A_j F_{ij} K_{ij}}{\sum_j A_j F_{ij} K_{ij}} \right] \quad (2)$$

Of which:

T_{ij}: Itinerary from region i to region j;

P_i: Total journeys arising from region I;

A_j: Number of journeys absorbed into region j;

F_{ij}: Impedance coefficient, usually a function inversely proportional to the transportation time between i and j;

K_{ij}: The socioeconomic adjustment coefficient for journeys originating from i and to region j, usually is 1.

2.3. Step 3: Modal Split Model

The most popular method is the Logit model.

The general formula is:

$$P_i = \frac{e^{U_i}}{\sum_j e^{U_j}} \quad (3)$$

Of which:

P_i: Ability to choose method i;

U_i: The utility function of the method i, the function has the form;

$U_i = \alpha + \beta_1 . X_1 + \beta_2 . X_2 + \ldots + \beta_n . X_n$

Of which:

$X_1 \ldots X_n$, are the attribute variables depending on model I;

α is a constant;

β_1, $\beta_2, \ldots$, β_n are the coefficients representing the components it incorporates in utility functions. This constant, coefficients can be determined by regression method.

2.4. Step 4: Trafic Assignment

To assign traffic on traffic networks use the function BPR (Bureau of Public Roads) which is a function of traffic delay used commonly. The variables used in this function are traffic volume, traffic capacity α, β. The formula for the traffic delay function is as follows:

$$T = T_0 \left[1 + \alpha \left(\frac{V}{C} \right)^{\beta} \right] \quad (4)$$

Of which:

T_o = Free Flow Trip Time;

V = Link Trip Flow;

C = Link Capacity;

α, β = Parameter.

3. Results

To forecast the transport demand, it is necessary to follow 3 phases: input data preparation stage, 4-step forecasting model application stage, output completion stage (see figure 2).

- Zoning, building and simulating transportation network:

Hai Phong is divided into 158 regions. Of which, 113 regions are based on administrative boundaries, land use planning; 12 regions are neighboring localities; 25 are industrial zones, 8 are towns.

The need to generate and attract from 158 regions is shown through the origin-destination (O-D) matrix. From this O-D matrix the traffic will be concentrated to the center of the region (centroid) and then will form virtual links. Road network is built based on the current status and general planning orientation of Hai Phong city until 2025.

- Cruise distribution: A common method to determine the trip distribution is to use an attractive distribution model.
- Method devision

According to the development orientation of the public transport use rate in 2025, Hai Phong city is expected to be 10%. The most common method used is the Logarithmic model.

Result: Determine the number of itineraries from each region to another which are organized by different traffic patterns.

- Transportation assignment

To assign traffic on traffic networks, people often use BPR (Bureau of Public Roads) which is a function of traffic delay commonly. The two parameters α and β used to be taken into account by the results this study are 3.59 and 0.4. After being put into the model, the results of traffic distribution on the road network are shown (see Figure 6).

4. Discussions

The urban transportation model of Hai Phong City is built on a 4-step model. In this model, the city is divided into 158 zones: including 113 zones within the city, 12 zones in neighboring localities, 25 zones in industrial areas, and 8 zones representing towns. The Transcad software, which was previously used in the Urban Transport Development Project in Hanoi, was employed for the analysis [9]. After running the 4-step model, the study generated traffic flow results distributed across the city's road network.

The results of traffic flow analysis using the 4-step model have revealed that many future planned road networks exceed the traffic capacity. If the research results are highly accurate, it will be valuable for policymakers to consider and implement solutions to alleviate future traffic congestion.

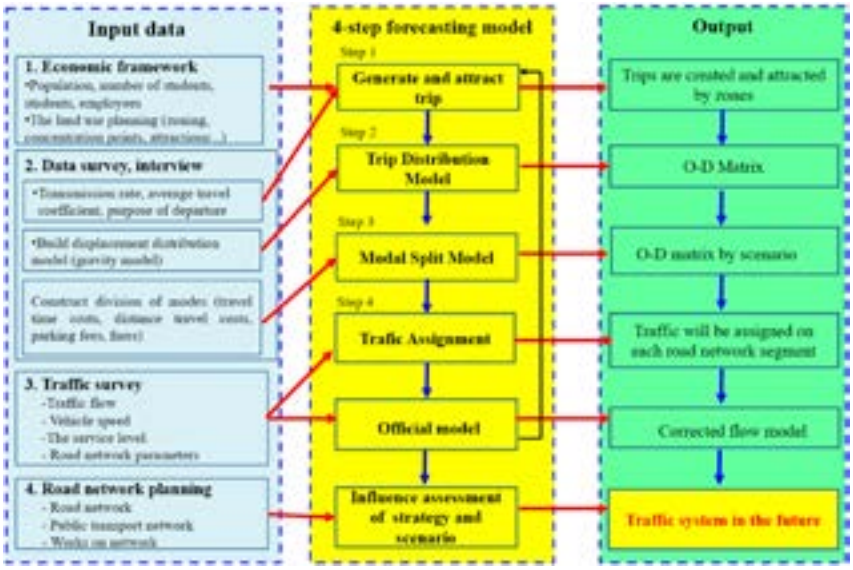

Fig. 2. Transport demand forecasting diagram

Fig. 3. Traffic Zoning in Hai Phong City

Fig. 4. Length of some roads in Hai Phong City

Collecting the necessary data for transportation demand forecasting indeed requires a relatively long period of time and significant financial resources. In this study, some of the traffic demand survey data were obtained through surveys conducted by the Department of Transport of Hai Phong City [8]. Some data used include household interview data, vehicle count data at traffic hubs, average travel

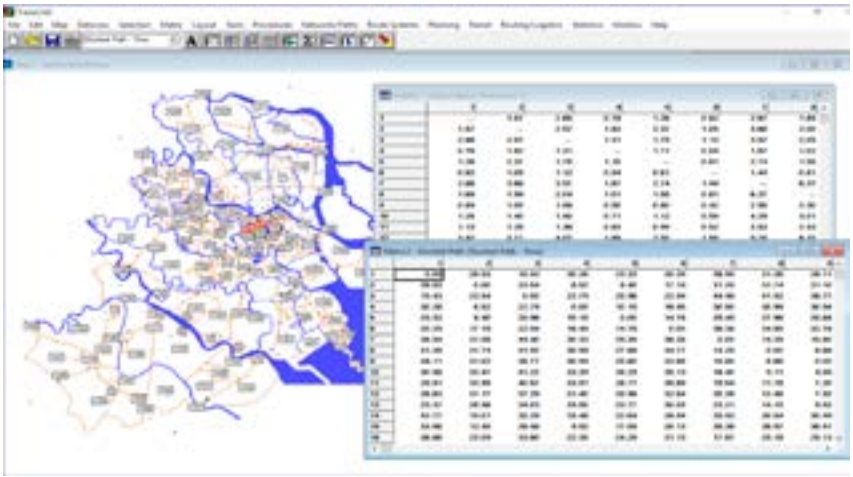

Fig. 5. Itinerary matrix among regions

Fig. 6. Itinerary matrix among regions

coefficient...The lack of a comprehensive database is a critical issue faced not only by Hai Phong City but also by other municipalities in Vietnam. To achieve higher accuracy in applying the traffic demand forecasting model in Vietnam, it is essential to collect and survey the following key data:

1. Economic Framework Data: This includes population data, the number of students, workers, etc. Economic data provides insights into the transportation patterns related to work, education, and other activities.

2. Transportation Survey Data: Conducting transportation surveys and interviews to gather information about the percentage of trips completed, average trip rates, trip purposes, etc., are essential for developing trip distribution models on the current transportation network.

3. Traffic Survey Data: Gathering data on traffic flow, vehicle speed, road capacity, level of service, network characteristics, and traffic resistance is necessary for trip assignment and evaluating transportation network performance.

To achieve good results in applying the traffic demand forecasting model in Hai Phong specifically and Vietnam in general. We need to tackle the following problems:

Firstly: Complete the mechanism of policies and laws, which make it mandatory to apply the traffic demand forecasting model in the planning, management, and operation of the transportation system.

Secondly: Train a highly specialized workforce in the fields of planning, management, and operation of the transportation system. Prepare them to utilize and operate the forecasting models for controlling the traffic system effectively.

Thirdly: Establish a digital traffic data survey database with regular annual updates in various areas, such as population, household age structure, occupation, average income per capita, traffic participation habits, traffic flow, and transportation volume on urban and suburban roads, and so on. These data will serve as the foundation for urban planners to determine crucial parameters for land use planning and transportation planning. Vietnam currently lacks mandatory laws and regulations requiring the collection of annual statistical data in these areas, making it challenging to apply the forecasting model effectively.

Fourthly: Establish a roadmap for constructing the network data: To incorporate the network into the calculation and application of the Geographic Information System (GIS) for the urban transportation network, it must be represented in an appropriate format. In Vietnam's planning law of 2017 [10], it was mandated to establish a provincial planning database. However, in the urban planning law of 2009, which has not been amended, there is no compulsory requirement for establishing a database to serve future planning, management, and operation [11].

Fifthly: It is necessary to conduct regular socioeconomic surveys at the commune and ward levels, including information on the socioeconomic status, population, income, ownership, and vehicles in these areas.

5. Limitations and conclusions

The application of the traffic demand forecasting model in Hai Phong City, Vietnam, using Transcad software, involves a large dataset with 158 zones. The results of applying the model indicate that many city road networks in the future will exceed their traffic capacity. Additionally, the issue of data collection for running the model poses challenges specific to Hai Phong and Vietnam in general. Furthermore, the study highlights the necessity of surveying and gathering essential databases.

The research also provides recommendations for the improved application of the forecasting model in urban transportation planning, management, and operation in Vietnam. The findings of the current study contribute to both practical and academic aspects. Firstly, they serve as a valuable reference for policymakers and researchers in the transportation field to enhance the quality of urban transportation planning, management, and operation. Secondly, the study opens up avenues for further research related to the application of traffic demand forecasting models in Hai Phong and other Vietnamese cities.

(*continue reading page 93)*

Technical process of operation of bubbling and circulating fluidized bed technology incinerator to domestic solid waste treatment for energy

Nghiem Van Khanh

Abstract

In order to meet the development trend of incinerator technology with high efficiency and suitability to Vietnam's conditions in the future, the research focuses on developing technical instructions for the operation process of fluidized bed incinerator technology (BFB, CFB) in domestic solid waste treatment. The content of the article presents the procedures for starting the incinerator, the operation of the incinerator and the process of stopping the incinerator. The research results are aimed at providing materials for use in training engineers specializing in urban environmental engineering. It is also a reference for engineers who directly perform operational management at waste power plants or scientists and managers interested in research in the field of domestic solid waste management.

Key words: *domestic solid waste, fluidized bed technology incinerator, Bubbling Fluidized Bed (BFB), Circulating Fluidized Bed (CFB), technical process of operation*

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Heading

Burning solid waste to generate electricity has become a new trend in Vietnam. Finding technology to turn solid waste into a valuable resource has also become an important component of Vietnam's environmental industry, in accordance with Decision 491/QD-TTg dated May 7/ 2018 "on adjusting the national strategy on integrated solid waste management to 2025, vision to 2050" [1] and the Law on Environmental Protection 2020 (promulgated and amended by the Government according to consolidated document No. 21/VBHN-VPQH dated December 29, 2022) [2]. Currently, the technology of burning waste to generate electricity is of interest to Vietnamese cities. Among them, there are three waste incinerator technologies that are used and implemented in most localities: Stocker Incinerator, Rotary Kiln Incinerators and (Fluidized Bed Incinerators. Evaluation of these technologies shows that: fluidized bed combustion technology is the most advanced combustion technology used for many types of fuel [3]. Fluidized bed burners burn fuel in and on the fluidized bed with the boiling material usually being natural sand. The high heat capacity of the fluidized bed keeps combustion in the incinerator even when the input fuel has a low calorific value. Low temperatures and high combustion efficiency create lower emissions into the environment than other combustion technologies. Simple incinerators with no internal moving parts ensure reliable operation with low maintenance costs. The incinerator was designed with consideration so that mechanical components were manufactured by reputable manufacturers in Vietnam as much as possible [4].To be able to apply fluidized bed technology to operate effectively when disposing and burning domestic solid waste to recover energy in Vietnam's urban areas, below the research team will present in detail the characteristics of technology and technical process of operation for CFB and BFB fluidized bed technology incinerators.

1. Introduction about CFB and BFB fluid bed technology incinerator

There are two types of fluidized bed incinerator technology commonly designed in waste-to-energy plants (waste power plants): bubbling fluidized bed incinerator technology (BFB) or circulating fluidized bed incinerator technology. (CFB). The operating principles of these two technologies are basically the same and are described as follows: After preliminary processing, fuel is brought into the combustion chamber, level 1 air is supplied from below the combustion chamber to create a fluid layer. Level 2 air is supplied to the combustion chamber at a certain height. Fuel particles move up and down in the combustion chamber and burn. The cycle is repeated until the fuel particles are completely burned. To desulfurize, limestone is added to the fire chamber. The amount of heat emitted during the fuel combustion process is supplied to the steam generating tubes arranged around the fire chamber. High-temperature smoke (800-900°C) coming out of the combustion chamber will transfer heat to the superheaters and heaters. water heater, air dryer, etc. Smoke discharged from the incinerator at low temperature (below 200°C) is passed through a dust removal system to filter ash and slag flying with the smoke before going through the chimney into the environment. The only difference between the two technologies is:

BFB is a fluidized bed boiler with low boiling point. In BFB, the coefficient "intake of air into the incinerator" is less. The fluidized bed temperature is controlled by providing a suitable amount of primary boiling gas and circulating the gas in the incinerator. Normally, the boiling speed in a bubbling fluidized bed incineratoris only 1.5-2.5 m/s and the fluidized bed height when operating is about 0.8m. The base material and fuel mainly burn in the bottom part of the

combustion chamber, a clear boundary can be seen between the fluidized layer and the upper combustion chamber[5].

CFB circulating fluidized bed incinerator has a high boiling rate, with smoke velocity in the combustion chamber up to 4 - 6 m/s, solid particles in the smoke (including substrate and fuel) will be retained by the Cyclone separator. (hot or cold type) and circulated back to the combustion chamber [5]. The lowest calorific value of waste for the incinerator to operate is 4 MJ/kg. The factory has a reserve area for fuel (waste) with high calorific value for use at times when the fuel loaded does not reach the minimum calorific value. The difference when choosing a BFB or CFB incinerator depends on many issues. But basically, CFB works more effectively with waste with higher calorific value.

CFB and BFB fluidized bed incinerators have some common characteristics as follows:

Flexible fuel:

+ Capable of handling all types of classified and crushed domestic solid waste, TDF, RDF, a variety of biomass fuels, peat, wood chips and sludge and coal at a controlled level wide, different humidity.

+ Fluidized bed allows effective removal of raw materials on the incinerator surface.

+ Easy to use additives;

High availability:

+ Careful design ensures good operational features and high availability.

+ Low maintenance because of simple and reliable structure.

Improved technological structure:

+ There are no moving parts in the heating chamber;

+ Homogeneous burning conditions; Very high fuel burning efficiency (High heat transfer ability)

+ Very low residual oxygen for best combustion efficiency and low exhaust gas flow;

+ Automation can reach 100%, minimizing impact on workers at the factory.

Low emissions:

+ Effective waste incineration technology ensures the amount of hard-to-burn carbon in fly ash along with low CO emissions. Reduces greenhouse gases 17-23 times compared to landfills.

+ Optimize air and combustion temperature with reasonable residual residue, ensuring low NOx emissions. If it is necessary to reduce emissions, it can be solved by installing an SNCR system (non-catalytic filtration system) to measure the amount of Urea or ammonium entering the flue gas stream in the incinerator and vortex cage.

+ SO2 capture is done by lime as an additive to the incinerator and the remaining SO2 is retained by the flue gas cleaning system [7].

+ The remaining ash and slag ratio is 8%; Therefore, the required area of landfill after burning exhaust outletis relatively suitable;

+ Wastewater from the factory is treated to meet environmental protection standards.

Reduce dependence on coal by generating non-fossil fuel electricity

Defects:

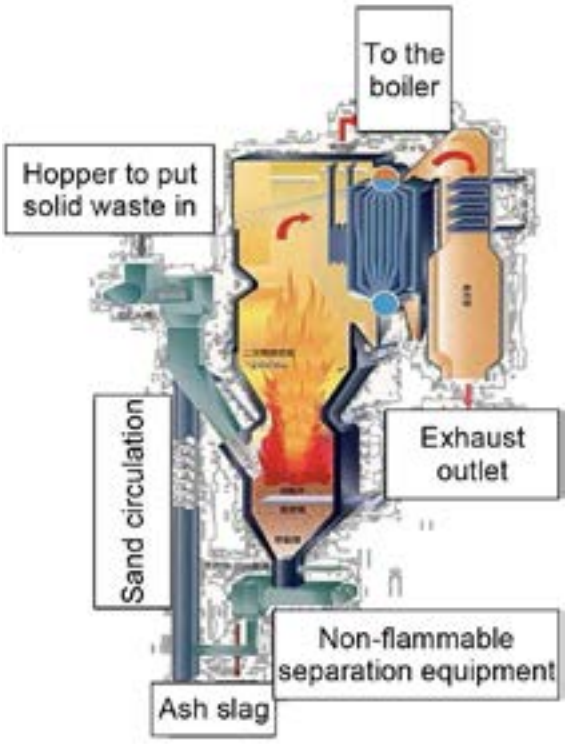

Figure 1. Diagram of fluidized bed incinerator
Source: Engineering Co., Ltd. et al., 2013 [6]

+ High initial investment price and operating costs;

+ Must pre-treat waste (crushing and drying);

+ Need to add fluidized bed material (sand);

+ Partial load operation requires a second combustion stage;

+ High precision regarding ash slag;

+ Moderate corrosion in the heat exchanger.

2. Research methods

Method of collecting information, surveying and investigating the current status: collecting and understanding the current status of management and operation of current household solid waste incineration technologies in Vietnam

Theoretical research method: learn about the theoretical foundations related to the technical process of incinerator operation

Inheritance method: inheriting relevant content from existing research.

Methods of synthesis, analysis, comparison: synthesize and analyze technologies for treating household solid waste using incineration technology, compare and evaluate with actual requirements and trends in choosing incinerator technology fluidized bed combustion.

Expert method: listen and absorb opinions of experienced experts in the field of training and research in fields related to environmental engineering.

3. Technical process of operating CFB, BFB

3.1. Incinerator start-up procedure

Requirements when starting a waste incinerator:

Check the specifications of the waste feeding equipment into the incinerator.

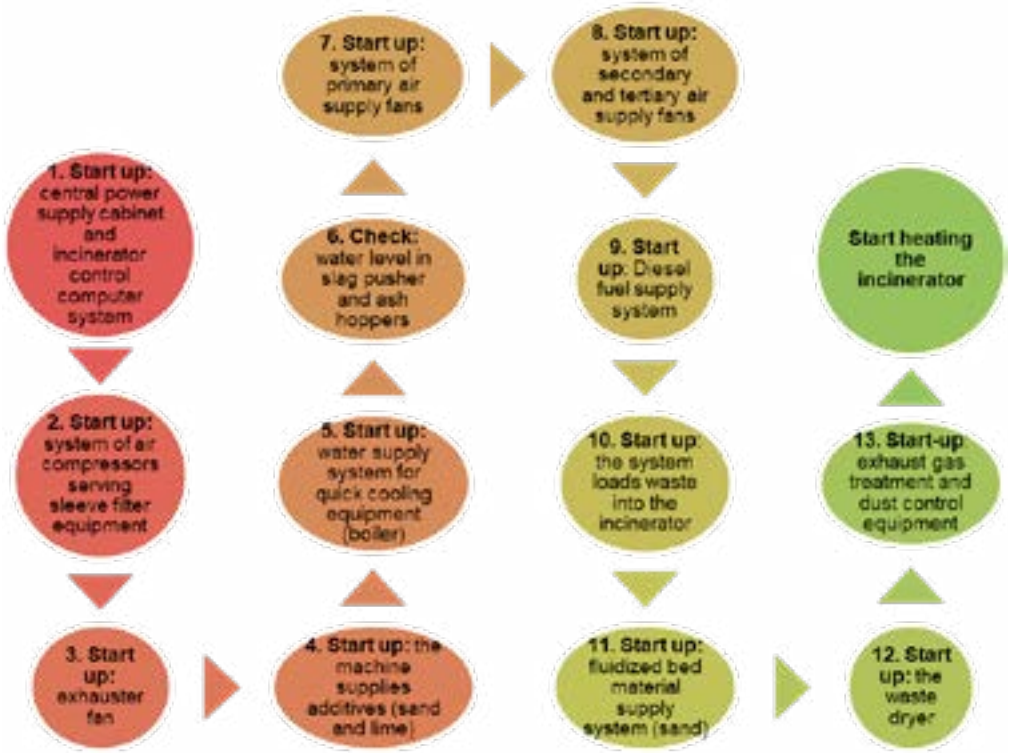

Figure 2. Diagram of the incinerator start-up process [8]

Operating status of the pressure control unit.

Based on waste characteristics and combustion conditions, adjust the combustion chamber temperature, air pressure inside and outside the incinerator, solid waste loading dosage, combustion gas flow and other ratios accordingly.

Monitor the fire in the incinerator and make adjustments to the waste burning conditions when you see the fire has black smoke, the fire is not spreading horizontally, the back is extinguished, etc.

When waste burning conditions are unstable, the waste burning temperature in the incinerator cannot be maintained at a temperature of 850°C or more, so auxiliary fuel is added to the incinerator.

Avoid placing the slag collection hopper in a high position near the incinerator so that the hot slag can gradually reduce its temperature when it reaches the collection hopper without melting the hopper.

Adjust the amount of clean air supplied to the incinerator while optimizing the system's waste heat usage conditions.

Check steam, water, oil, wind and other systems related to equipment operating conditions.

Waste water and waste heat from the boiler must be discharged continuously every day.

Regularly blow and clean coke stuck outside the incinerator.

Check the steam and waste heat parameters of the boiler to meet technical equipment requirements when designing.

Check steam quality according to domestic water quality standards.

Check the igniter and other parts of the incinerator to ensure that after ignition, the incinerator operates normally and stably. Specifically: Check and remove coke and slag on the door and walls of the incinerator; Clean dust from the air collection funnels of chimneys, air pipes, insulation pipes, heat exhaust pipes...; Check thermal relay; Check clean water supply equipment to ensure there are no leaks; Close the locks on the water supply pipes; Check remote control devices; Check heating components and compressed air supply system; Check the auxiliary combustion unit according to flexible and precise combustion programs; Watch for signs of water supply lines during combustion (normal water flow is 100mm); In case of using oil as auxiliary fuel: Check the stability of oil pressure, the normal fluctuation range is not more than 98kPa, then the safety of the ignition device is good; Check the air heating system

The process of starting the incinerator must strictly comply with water regulations stated in the National Technical Regulation on domestic solid waste incinerators QCVN 61:MT/BTNMT and follow the basic steps presented. Details on picture 2:

3.2. Incinerator operating procedures

Waste is loaded into the incinerator for burning according to standards and ensures that the volume of waste fed into the incinerator does not exceed the design capacity; Monitor the temperature of the combustion chamber gradually increasing to the required value: when the combustion chamber temperature is ≥600- 6500C, turn off the combustion equipment.

Bottom ash catchers and slag pushers: there must always be enough water inside, the water level must cover the ash and slag discharge mouth from the incinerator to avoid drawing air from outdoors into the incinerator. Therefore, you must pay attention to regularly adding water to these devices. When the amount of slag in the bottom ash collecting bins is full, a rotating forklift must be used to carry these collecting

bins to the designated place of the factory.

At rapid cooling equipment or heat recovery boilers: At the beginning of the shift, operators use compressed air to clean the cooling tube system and check the equipment's safety monitoring devices. cool down quickly (level indicator, glass, observation device); Boilers are equipment that require great attention to operational safety. Therefore, there must be specialized workers in charge of monitoring the situation of the boiler and promptly taking action when detecting the risk of an unsafe situation.

Operators must regularly check the amount of primary, secondary and tertiary gas entering the incinerator to ensure the fluidized bed keeps the fluidized bed material particles suspended.

Other tasks: Check the operation of the burner system for the combustion chamber; Check the operation of the bypass system and explosion prevention valve to ensure the system is operating.

Work contents that need to be checked during operation include:

(1) Steam drum: Check to see if there is a steam or water leak at the connection flanges of the steam drum.

Before stopping the incinerator: Check the steam pressure gauges, safety valves, and water level gauges to see if they work accurately and reliably.

(2) Superheater

Monitor the steam temperature leaving the superheater and compare it with design values.

Monitor steam line and smoke line pressure loss.

Monitor inlet and outlet smoke temperature.

Pressure loss and smoke temperature tell us the level of fouling by ash and allow us to plan the cleaning of the superheater.

Listen for unusual sounds and check for steam leaks at the superheater installation. This will help identify the problem of the superheater's tube bursting.

(3) Water heater

Check the outside of the pipes to see if there are any signs listed below: Warping; Do not follow rows; Erosion; Dirty

If pitting is detected on the inner surface of the steam drum, examine the water sample of the heater and check to see if the inner surface of the heater tubes is pitted.

If it is discovered that the inner surface of the pipes is covered with scale, the pipe sections should be removed for inspection purposes. Before putting the superheater into operation, the cause must be found and corrected.

Check the support system.

Check the positioning steel bars and mounting brackets for wear.

Check whether the welds used to connect pipes are worn or cracked.

(4) Combustion chamber

Check at high temperature locations to see if there is a smoke leak or layer material leak.

Check for cracks or blisters on the outside wall of the combustion chamber.

Check whether the combustion chamber wall temperature shows any signs of abnormality.

Check whether the thermocouples used to measure combustion chamber temperature and fuel layer temperature are working well.

(5) Air box

Check if there are air leaks or layer material leaks around the air box.

Check for signs of overheating of the air box, a fire inside the air box, or the reverse passage of hot smoke into the air box.

Regularly check the air pressure difference between the air box and the combustion chamber. For a specific load value, the phenomenon of air box pressure changes indicates that the boiling air flow is hindered because of improper operation of the inlet flow regulator, clogged air mushroom or layer density. high material.

(6) Smoke, ductwork, and shield-type flow regulators

Check around all pipes and smoke lines for signs of leaks.

Check the position of fans and shield-type flow regulators.

Check locations with high temperatures.

(7) Ash hoppers

Make sure there are no air leaks in the ash hopper flanges of the entire system. Air intrusion can lead to solidification of the ash and impede the flow of ash out of the ash hoppers.

Check to see if the ash hoppers have unusual colors, the hopper temperature is higher than normal and if there are protrusions on the hopper surface.

Make sure all ash hoppers are emptying properly.

Periodic cleaning: Make sure all ash hoppers are empty; Replace all manhole insert rings; Make sure the condition of the barriers does not have a flow-directing effect.

(8) Wear-resistant material layer / insulation layer

Check around all smoke ducts and air ducts for leaks.

Check the wear-resistant material layer at the ash return ports to see if it is damaged or not. If damaged, repair it.

Check the wear-resistant material layer at the fuel supply ports/layer material for damage and repair.

(9) Canopy

Visually check for air leaks

Before stopping every year: Check the outside of the roof area to see if there is any smoke leak. If so, mark the location of the smoke leak for handling when stopping the incinerator.

(10) RAV

Check all bearings for signs of overheating or friction.

Check whether the bearing seal and shaft seal are intact. This seal prevents air, dust and foreign substances from entering the bearing housing.

(11) Fans

Check to see if the bearings are lubricated, check the oil level.

Check the temperature of the bearings. If the bearings are abnormally hot, find the cause and handle it.

Make sure all seals are intact and working properly.

Check vibration; Listen for unusual sounds from the motor and fan.

Visually inspect bearing seals.

Before stopping the fan: Record the temperature and vibration parameters of the fan; Review the fan parameters

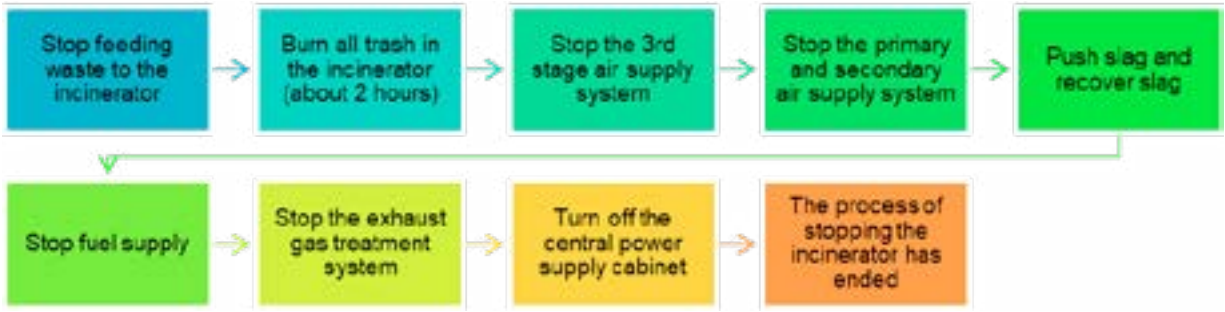

Figure 3. Procedure for stopping solid waste incinerators [8]

record kept in the control room: Fan vibration a few months ago; Bearing temperature at a few months ago; Oil used; Check the operation of the flow regulator and the display of fan parameters.

(12) Fuel supply system

Check for unusual sounds coming from the rotary feeders and bearings.

Check to see if the drive chain is loose.

Lubricate the bearings: periodically lubricate because the equipment works in a dusty environment and close to the combustion chamber.

(13) Degassing tank

Visually check for leaks in the valves before checking for sound at normal working pressure.

Check the working of the level meter and level signal transmitter.

(14) Incinerator water pump

Check the bearing lubrication status and check whether the oil level meets the requirements.

Check bearing temperature. If the bearing temperature is high, find the cause and correct the situation.

Make sure all inserts are intact and working properly.

Check vibration

Listen for any unusual sounds coming from the pump or motor.

Check for signs of water leakage at the seals and connections.

Check the differential pressure at the filter and clean the filter if necessary.

(15) Safety valves

Check for leaks in the valves before checking audibly and visually, at normal working pressure.

Check drain lines and condensate sections for signs of blockage.

When the safety valves go into operation, pay attention to the operating pressure and setting pressure of the valve. After the normal working pressure is restored, check whether the valve is leaking or not. Prices Wrong setting value needs to be adjusted.

Assess the level of valve leakage through the inspection book if the valve leakage level is increasing. Plan to stop the incinerator early for repair. Stopping the incinerator early can reduce the level of damage to the valve.

(16) Incinerator valves

Mark valves with high leaks and prepare a report.

Refer to the deaerator operating manual for more information.

(17) Water level display elements

Check the gauges or evaporator water level display elements. With level gauges, the check can be done by slowly opening the discharge line, then quickly closing the discharge line. to avoid damaging MICA. Observe whether the water level returns to its normal position.

Check to see if there is a water or steam leak at the connection points to the steam drum.

A leak in the water column or connection of the discharge line will lead to an incorrect display value of the device in the meter.

Replace the lights used for the damaged level display element.

Check the water tube to see if it is discolored or dirty. If the water tube is dirty, flush it to clean it, or remove it and replace it. Install a new water tube if it is discolored., stained or broken. If for any reason, the water tube and packing become loose, replace them.

Clean the watch. Perform a dirty flush for the level display element to remove suspended substances from the pipeline. Remove only two or three cuffs. Before that, it is necessary to close the valves used for measuring purposes.

(18) Electrostatic precipitator

Check and ensure the protective interlocks are working properly.

Check and ensure the cleaning air supply fan operates properly and ensure the cleanliness of the filter installed at the fan suction end.

Make sure the ceramic heater works well, the presence of moisture particles can cause the ceramic to crack.

Closely monitor working parameters related to electricity, if any unusual signs are detected, handle them immediately.

Ensure continuous circulation of ash out of each ash hopper of each electric field.

Monitor the temperature of the smoke entering and leaving the electrostatic precipitator.

Make sure there are no air leaks in the connecting flanges of the ash hopper of the entire electrostatic precipitator system. Outside air entering the interior can create ash clumps, thereby hindering the circulation of ash. out of the ash hopper.

(19) Chemical supply system

Check the lubrication status of the drive system

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Technical preparation solutions of construction land to prevent landslides and flooding in Da Lat urban planning

Vu Hoang Diep[(1)*], Dinh Thi Thu Hoai[(2)]

Abstract

In recent years, under the impact of the increasing rate of urbanization and prolonged heavy rain due to the effects of climate change, urban areas in the highlands of Vietnam in general, and Da Lat City, in particular, have faced a lot of significant consequences due to landslides and local flooding. Fromthe perspective of urban planning and with the view that urban planning solutions are considered a source solution in preventing landslides and flooding, the following article presents a general understanding of the technical preparation of urban construction land, the current situation of landslides and local flooding in Da Lat city and based on that, propose planning solutions to preventing landslides and flooding.

Key words: *planning, technical preparation solutions, landslides, flooding, Da Lat*

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I. Question

Located in the south of the Central Highlands region, Da Lat is rarely affected by destructive natural disasters such as storms, super storms, and earthquakes, but typical types of regional ones likes drought, heavy rain, local flooding, floods, flash floods, landslides, natural forest fires, etc. Mountain terrain distributed in Da Lat City has a slope of over 15 degrees, which is strongly divided, most rivers and streams have quite small basins with many rapids and at the same time, waterfalls are upstream, which is often affected by flash floods and landslides. The residential area is concentrated mostly on high-altitude areas, mostly following topography with relatively gentle and flat slopes. The biggest impact of this area is the massive amount of water running on slopes within a short time in heavy rain. It reduces flooding and landslides. Due to the short water concentration time, flooding and landslides were created from the mountains and hills. Faced with the above situation, researching and proposing technical infrastructure solutions in general and technical preparation solutions in particular for adapting to climate change and suit the natural situations of Da Lat as well asforpreventing landslides and local flooding in the city is very urgent.

II. Content

1. Technical preparation work for construction land in urban planning

Technical preparation for urban construction land is based on natural situations to synthesize, analyze, and determine the favorable level of land for construction and propose technical improvement measures, which will improve unfavorable situations to satisfy the requirements of urban construction planning [1].The main measures of technical preparation for urban construction land include:

- Ground elevation planning: reorganize the surface of natural terrain to create a design surface for works and urban land.

- Surface water drainage: organize the drainage of water running on the surface of the construction land including rainwater, water for watering plants, watering roads, and water from melting snow (of which rainwater is the main one).

- Lowering the underground water level: increase the depth of the underground water level to minimize the impact on construction and the project.

- Protect construction land from flooding: ensuring urban safety against the threat of natural phenomena such as floods, rising water...

- Other special technical preparation measures include preventing and combating landslides, ditch erosion, underground cavities, mud and rock flows, as well as earthquakes.

Thus, it can be seen that technical preparation for urban construction land is a broad field related to many different specialties used in the preparation of urban planning projects. It can also be called technical preparation planning.

Technical preparation planning is understood as the study, assessment of land funds, and proposal of technical preparation measures for the construction of land in a planning project. In particular, researching and proposing measures for ground elevation planning and drainage planning are mandatory with a large proportion of work.

The purpose of technical preparation is to improve natural conditions and create the best living environment. To use the land area for effective urban construction planning purposes, it is necessary to evaluate its potential. The results of natural condition assessment are one of the important bases for selecting construction land, determining the functional structure of the urban

Figure 1. Slope collapse at alley 36 Hoang HoaTham, Da Lat City on June 29, 2023 [2]

Figure 2. A typical flooded location in Da Lat City during the rain on September 1, 2022 [2]

area, and orienting construction technical solutions. Orienting the development of urban space in accordance with natural situations will minimize the impact on nature, preserve the value of the natural landscape, ensure environmental ecological requirements, and be an opportunity as a basis for sustainable development. In addition, technical preparation measures also play a role in ensuring safety for urban operations, contributing to increasing aesthetic value in architectural space, together with creating favorable technical situations. for the construction of infrastructure as well as works in urban areas, bringing high economic efficiency in the exploitation and use of construction land funds.

2. Current situation,the causes of landslides, local flooding in Da Lat City,and lessons learned

The planning situation of Vietnam's hilly urban areas, especially in Dalat City, shows that the favorable characteristics of terrain factors have also been exploited through reasonable solutions in choosing construction land, model orientation and spatial development direction, and urban technical infrastructure development orientation. The disadvantages of the terrain are also oriented to be improved to create a future surface to meet urban development requirements. However, there are still many inadequacies related to the selection of urban planning solutions that are not suitable for the terrain or construction management that has not been strictly followed according to planning orientations, leading to issues like waterlogging, inundation, landslides, landscape disruption, ecological imbalance, reduced long-term economic efficiency, failure to create local identity...

a. The current situation of local landslides and flooding

As a city in the Central Highlands region, landslides most often occur on pass roads and in Dran town (Don Duong district), Da Lat City. In the first months of 2023, due to heavy rainfall and prolonged periods of rain, the ground is weak, causing several very serious landslides, specifically:

June 17, 2023: 02 landslides occurred in Da Lat City, killing 02 people; June 29, 2023: 13 landslides occurred in Da Lat City, killing 2 people and injuring 3 people; 02 solid houses collapsed, 01 solid house was seriously damaged, 09 houses were partially damaged, 01 electric pole was broken; 13 pine trees fell. The damage was huge after the rain from the night of June 28 to the early morning of June 29, 2023, with up to 200mm of rain causing landslides, flooding in many places, and serious slope collapse in alley 36 Hoang HoaTham, Ward 10, killing 02 people, injuring 05 people, affecting many people's houses.

Through the review, 163 current locations with landslides and at risk of landslides throughout Lam Dong area, Da Lat City accounts for more than 1/3 of the above number with 60 locations. (Source: Department of Agriculture and Rural Development of Lam Dong province).

In recent years, extreme weather, the number of concentrated heavy rains, and urban flooding are showing signs of increasing. In Da Lat City, flooding mainly occurs along the Cam Ly stream basin intersecting with Phan Dinh Phung Street to Mac Dinh Chi residential area and around the Xuan Huong settling lakes.

At the beginning of the rainy season in 2023, many heavy rains caused serious damage. On June 23, 2023, after a rain of over 60mm during 1 hour and 30 minutes, many roads (Phan Dinh Phung, To Ngoc Van, Tran Quoc Toan Street,...) were deeply floodedand trees were uprooted. The damage was actuallyenormous aftera long rain of 200mm fromthe night of June 28 to the morning of June 29, 2023, causinglandslides and flooding in the whole city. On the afternoon of July 17, 2023,all areas where flooding often occurs were flooded all over after the 90mm of rain.

Through the review, Lam Dong currently has 73 locations at risk of flooding and Da Lat City has 12 places that appeared in heavy rains. (Source: Department of Agriculture and Rural Development of Lam Dong province).

b. Cause of landslides and local flooding

The causes of the above situations have been notcarefully analyzed in evaluating the actual situation. In addition, construction activities according to the enacted planning are not well implemented. The quality of urban planning projects is not high and the solution is still subjective without inter-sectoral coordination. Moreover, design solutions, especially in terms of technical preparation, are still quite general.

Landslides and flooding in recent times come from objective and subjective causes, including:

Objective reasons:

Effects of climate change:the rainy season in Da Lat lasts from May to November, mainly in June and July (June 2023 alone will reach 349mm with an increase of 54% and July will reach 442mm with an increase of 36% over the same period in 2022); At some times, the rainfall in Da Lat City is very high, from 100mm-190mm/day, which will weaken the ground, cause landslides, and the amount of water suddenly rushes into drainage basins, making the existing system of canals, ditches, and streams overloaded and unable to

Figure 3. Streams and regulating lakes in Da Lat have been encroached on and sedimented, reducing the water storage space of Da Lat [3]

ensure the drainage function.

Terrain characteristics: the terrain is mainly mountainous, with altitudes from 200m-1500m above sea level. Soil groups are mainly composed of red basalt soil, alluvial soil, etc land with high slopes (above 25 degrees, accounting for 50%), the soil structure is weak, causing a very high risk of landslides in prolonged heavy rain.

Geological characteristics: the geological foundation is poorly connected, with mainly unconsolidated basalt, soin prolonged heavy rain, water in the soil is saturated, leading to landslides, slides, and cracks. In addition, due to geological architecture and stratigraphy creating heterogeneous geological structures, sliding arcs have a large scale and degree of influence.

Subjective reasons:

Construction activities: leveling and excavating activities to create ground for construction works in locations, which have steep slopes, high negative/positive slopes, and are at risk of landslides. The quality management (design, construction, supervision) of the entities involved in construction (investors, construction units, consultants, etc.) is not fully guaranteed according to regulations.

State management: localities have not promptly reviewed all areas at risk of landslides, especially steep hills and areas with high negative/positive slopes to strengthen quality management, survey, design, and appraisal before and after granting construction permits; Planning and changing land use purposes in steep, rugged mountainous areas was proceeded. Organizing and implementing the planning is still slow and ineffective. Most urban planning projects identified basins and oriented drainage routes, but the implementation of drainage systems according to planning is still slow. The basic system of canals, ditches, and streams, has just been reinforced according to the current status but does not meet and match the requirements and speed of urban development. The maintenance and repair of the drainage system are not effective; Dredging sludge from rivers, canals, and the network still has many limitations; Flood discharge operations at small regulation lakes have not been paid attention to; Funding for these activities is still quite modest. The capital source for new construction, renovation, and upgrading of urban drainage systems is huge and needs to be invested synchronously; However, reality shows that capital resources are very limited and mainly rely on the state budget. Poor coordination between investment in the construction of technical infrastructure and drainage works is also the reasonfor greater complexity in solving drainage problems.

Drainage capacity of the drainage system:

Drainage systems are mostly built on old urban foundations (which are incomplete and have many limitations). Most of the sewer network was built a long time ago and has only concentrated in old residential areas. The size of the holes is small, the distance is large and they are still blocked by garbage, therefore, if itrains heavily, water cannot be drained promptly and, cause flooding. Many road and alley systems are hardened but lack a drainage ditch system, preventing water from flowing along the road surface, draining freely and uncontrolled. Besides, the repair and improvement of roads and sewers in some places do not meet the requirements, such as the sewer system on Hoang Dieu Street, and Hai Ba TrungStreet near the Hoang Dieu Hai Thuong intersection, etc are all quite small and narrow. In many new urban areas, the construction of drainage systems is not synchronous and the connection between the new drainage system and the old one still has many shortcomings; On the other hand, connecting the urban drainage system with the irrigation system has still many limitations. When heavy rain happens, some low-lying areas often become stagnant and flooded for long periods, making it difficult for residents to daily activities.

In addition, the state of sedimentation and encroachment on the corridors of regulating lakes, canals, and streams by encroaching housing construction and greenhouses changes the flow, and the lakes gradually lose their regulating ability to reduce water flow. Water flow is concentrated during heavy rain while the drainage system is narrowed,which is unableto ensure itsdrainage capacity. Da Lat City is divided into 3 basins, most of which do not have their rainwater drainage system, therefore, rainwater flows only drain into rivers, streams, and lakes through the natural terrain. However, due to sedimentation and encroachment, the lakes gradually lose their regulatory ability.

Status of concrete and development of net houses and greenhouses:

Currently, the pace of urbanization is increasing rapidly, accompanied by increased construction density. Areas where construction is allowed are covered with concrete by construction projects; Agricultural land areas, even forest land, are covered with net houses and greenhouses (according to statistics, in Lam Dong province there are currently 4,500 hectares of greenhouses, of which the largest number is in Da Lat, with about 2,800 hectares, accounting for more than 62%). It narrows the water space and land, reduces the ability of absorbingwater into the soil, and makesmany new great-intensity flows without control. Not only does stagnant water cause flooding, but it can also easily induce landslides, threatening people's lives and property.

Planning and urban development management:

In practice, the vision of urban development planning and management is still limited, which are also direct or indirect causes of urban flooding such as:

Drainage system planning according to regulations is not prepared separately from provincial planning, regional planning, and urban planning projects. Therefore, it lacks specificity, and regional connection and there are still some subjective factors; Forecasting has not fully anticipated

Figure 4. A greenhouse agricultural area in Da Lat City [2]

climate change and the development of net houses and greenhouses, so the planning design parameters are no longer consistent with the actual situation, making some drainage routes to become unsuitable and overloaded, etc.

Lack of synchronization in land use planning and construction planning leads to the separation of plots, forming residential areas lacking infrastructure, and the drainage system requirements are not guaranteed, not by the planning orientation. Changing land use purposes and building structures in low-lying areas with regulating functions or locations that obstruct flow are also causes of local flooding.

Awareness of the community:

Residents have not got enough awareness to keep their living environment. They still construct houses and works without complying with construction regulations, leveling and encroaching on water areas such as rivers, canals, ponds, and lakes; exploitingexcessively groundwater; and Indiscriminately dumpingwaste into manholes, canals, sewers, and onto roads leading to blockage of drainage pipes and making drainage even more difficult.

c. Lessons learned on preventing and controlling landslides and local flooding

Canberra City (Australia)

Canberra City is a completely new city built to become the capital of Australia in the early 20th century. This area is a highland terrain that is not only convenient for construction but also has beautiful scenery. The city center has a similar topography to Da Lat City. The city's architectural space is formed on the basis ofconnecting urban space with topographic and water surface elements, in which Burley Griffin artificial lake plays a particularly important role.In addition to blocking the flow to form lakes and wetlands, topographic components are fully utilized in urban planning. The hills are planned for residential units with an internal road network curving according to the terrain; valleys are for green areas. The organization of surface water drainage follows Sullivans Creek and drainage channels. Along the directing routes, there are wetlands holding water, which is to reduce the flow volume pouring downstream. The channel section is reinforced with a sloping roof and there are overflow corridors on both sides.

Typical lessons on landslide prevention from Japan

Currently, many developed countries around the world have researched and applied many effective solutions to cope with flooding and landslides, including Japan. Landslide is a combination of many factors such as terrain, geology, stratigraphic structure, rainfall, and human factors, so soil hazard response measures are also different. In general, these measures can be classified into control solutions and prevention ones.

The Japanese have used control solutions including water collection like well constructions, in which groundwater in the landslide area is collected and drained by digging underground wells with water collection drill pipes or placing horizontal drill pipes, in which groundwater is collected and drained by drill pipes placed horizontally on the surface. Prevention solutions include anchor-reinforced constructions and deep foundation piling ones.

Planning solutions contribute to preventing landslides and flooding

Urban planning practice has shown that the role of topographic factors, as well as urban planning solutions suitable to the terrain and the role of technical preparation of construction land, is vital to create an artificial environment in harmony with the natural environment in urban planning. Therefore, there needs to be directional solutions in Da Lat urban planning from the perspective of reasonable exploitation of topographic factors based on the requirements for urban space development. These will also be effective solutionsin overcoming urban landslides and flooding that have caused significant consequences in recent times in Da Lat. The principle solutions below are proposed for use in urban planning projects in Da Lat to contribute to preventing landslides and flooding.

Assess the natural situations of the land

Assessing natural conditions of the construction land in the corner of technical preparation is understood as evaluating the technically favorable level of technical construction on the land. The natural elements need to be evaluated including climate and terrain, hydrology, engineering geology, and hydrogeology... The aim is to possibly exploit and effectively use land both for the environment and expense.

Assessment of natural situations of the land is conducted at the stage of master planning with the tasksrelated to classifying and determing the areas which are favorable, less favorable, and unfavorable for construction. These are the basis for selecting suitable landfor construction, functional subdivision, and proposing technical preparation measures.

For urban areas characterized by wavy hills alternating with valleys like in Da Lat, analyzing and evaluating natural terrain factors is an important task and needs to be considered in both aspects: construction and landscape engineering.

Technically, it is necessary to evaluate the favorable

Figure 5. The spatial organization closely follows the natural terrain, making the most of drainage condensations in Canberra City [8]

level of natural terrain conditions (mainly slope) for urban construction based on land classification regulations: (1) favorable Land for construction (slope from 0,4 to 10%); (2) less favorable Land for construction (slope from 10 to 20%, mountainous areas up to 30%); unfavorable Land for construction (slope > 20%, mountainous area > 30%).In addition, areas with separate sliding soil terraces that can be simply treated will be assessed as less favorable soil; Areas with many consecutive sliding terraces that require complex treatment will be considered unfavorable land for construction. The construction land assessment map for Da Lat City needs to be integrated with the risk zoning map and landslide risk warning in the study area based on survey, analysis, and forecast results.

Regarding landscape, it is necessary to analyze and evaluate the landscape characteristics and potential of a land area, including Characteristics of the land's appearance (flat terrain, evenly sloping terrain, divided terrain...); Limit the division of terrain by distributaries and reservoirs; High points, low points, views and directions, obstacles of natural terrain; The influence of terrain on the ability to observe and perceive space...

Exploit and use terrain

Reasonable and effective exploitation and use of terrain are one of the leading principles in Da Lat's urban planning and design. It contributes to creating an urban space in harmony with natural features, maximizing the potential and limiting the disadvantages of the land. At the same time, it contributes to protecting the environmental landscape, preserving valuable landscapes, and developing high-quality and sustainable Da Lat urban.

Topographic factors need to be considered in functional zoning; selecting the location of works as architecturalhighlights; determining the spatial axis; organizing the road network; arranging the layout of architectural works; determining construction density and building height; dividing construction phases, etc.

Figure 6. Planning diagram of solutions to prevent rock falls, landslides, and flash floods in Japan [4]

Based on the results of the analysis and assessment of the terrain, the level of exploitation and use of the terrain is also different depending on construction requirements and terrain characteristics. For example: In cases where the terrain has a unique surface structure, it will be retained in the urban landscape, as a nature reserve, green area, or forest park; Utilizethe advantages of low-lying areas to create water landscape elements;

Buildings should gradually reduce their height and construction density when approaching water or valleys; Taking advantage of terrain elevation to arrange landmark buildings; Arrange buildings parallel to the contour line along the length of the structure.

The overall site planning plan is established on the basis of exploiting and using the terrain of the land, which will bring compatibility and harmony with the natural situations and typical ecological environment of Da Lat, thereby minimizing the impact of destroying natural structures which/that has been recently replaced by new construction sites.

Ground elevation planning of construction land (ground elevation planning)

Research and design of ground elevation planning for construction land in Da Lat urban area needs to comply with principles, the most important of which is the principle of thoroughly taking advantage of natural terrain. We must try to maximize the use of the good aspects of natural situations, take advantage of the existing terrain, and retain green areas and fertile soil layers to bring about high efficiency in landscape architecture and economy. Leveling should only be done in areas where construction works, streets, and yards are located, and in other areas. If it is possible, we should keep the terrain intact situations, especially paying attention to ensure all leveling activities do not narrow the flow.

Figure 7. Land assessment according to natural terrain factors in Da Lat urban planning area and surrounding areas

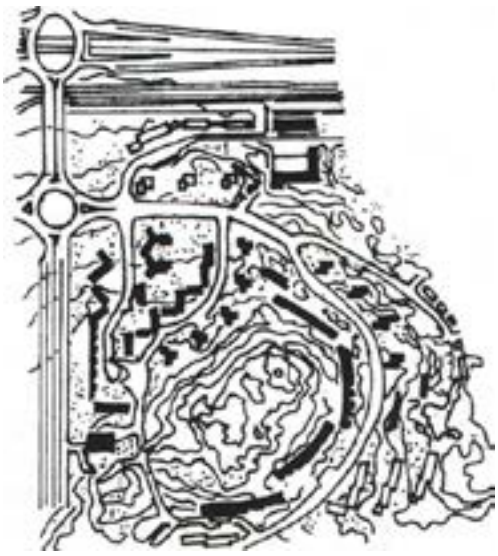

Figure 8. Master plan suitable for natural situations [6]

Organize surface water drainage

The design and planning of surface water drainage systems are closely linked to the planning of the ground elevation of the land. It is necessary to take full advantage of the terrain to design a free-flowing drainage network and make full use of streams, lakes, and low-lying areas. Low water can be drained or used as a regulating lake.

For the highland terrain in general and Da Lat urban area in particular,special attention should be paid to analyzing the characteristics of hill terrain and hydrological conditions of flow concentration to organize surface water drainage runs to, natural flows such as streams, and water reservoirs. In planning the surface drainage network, the drainage flow not only needs to be calculated for the sewer lines along the road but also needs to calculate the concentrated flow according to the drainage joints, thereby determining the

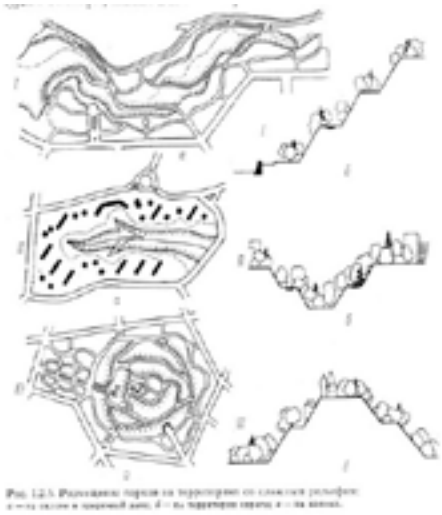

Figure 9. Location of land in complex terrain [7]

a. Located in the riverside area
b. On ravine territory (constructions built on rolling hills using valleys for drainage)
c. On the hill

Figure 10. Analysis of topography and flow in Da Lat City

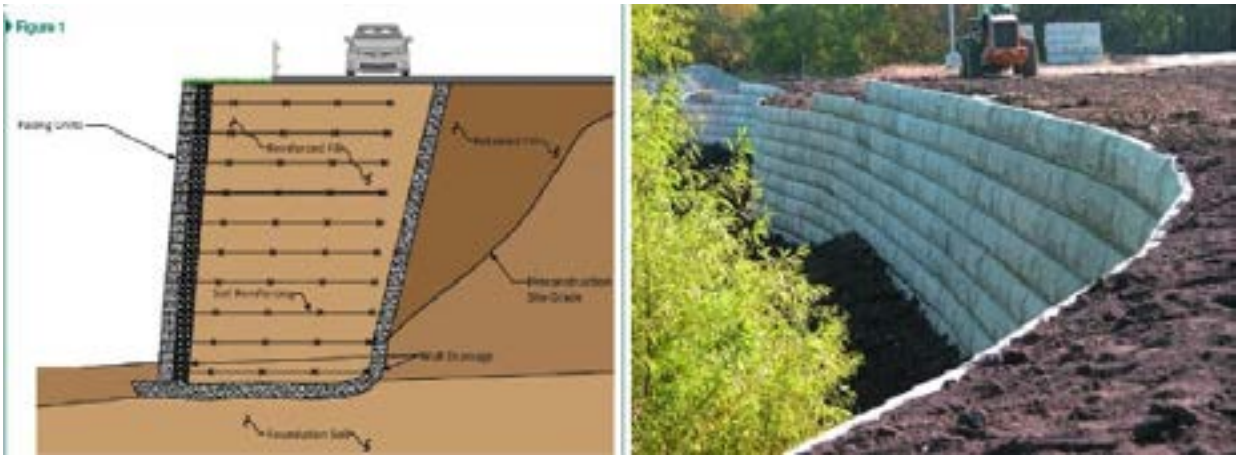

Figure 11. Structure of geotextile retaining wall [2]

required flow cross-section, the necessary size of bridge and culvert across the road and safety corridors along the flows to ensure water drainagein the case of unexpected heavy rain. The hydrological calculation to determine the flow rate must also take into account the impacts of climate change in proposed scenarios, which makes changes in calculating rainfall. Besides, there is also a need for more specific calculations on the flow coefficient, which has changed a lot under the impact of urbanization and greenhouse agriculture.

Technical measures for construction land with landslides

For landslides, natural terrain (topography, slope) and impacts of terrain improvement are factors contributing to landslides. Urban planning solutions in general and technical preparation in particular need to limit impacts that cause imbalance and natural stability of the land.

Measures to prevent and control landslides that can be applied appropriately in construction planning for Da Lat urban area are:

- Ground elevation planning: leveling to create a ground according to appropriate levels and slopes, pre-loading the low part, replacing soil on sliding surfaces; Avoid digging and cutting the foot of the slope and limit construction or loading on the slope on the basis ofplanning the site in accordance with terrain characteristics.

- Organize surface water drainage: regulate surface flow on land areas and slopes to limit water seeping deep into the ground at risk of landslides and at the same time have measures to collect and drain underground water from within the land. hydrate to reduce water pressure and increase soil strength.

- Plant trees to prevent erosion and weathering on slopes, paying special attention to planning for the conservation and development of pine forests not only as a typical landscape element of Da Lat but also contribute to stabilizing sloping land areas.

- Lower the slope to increase slope stability, reduce sliding force, and increase sliding resistance. Changing the shape of the slope must be in harmony with the landscape and typical ecological environment of Da Lat City.

- Reinforce and stabilize the slope using technical measures such as Covering nets, ground spraying, soil anchors, soil nails, retaining piles, gravity walls, and geotechnical retaining walls... priority should be given to solutions applying advanced technology to handle landslides sustainably, limiting construction. Soil retaining walls made of large stones or concrete disrupt the landscape.

III. Conclusions

Analyzing and evaluating topographic and hydrological situations will be the basis for choosing architectural space layout solutions, along with determining construction density appropriate to natural situations, thereby minimizing the impact as well as harmonizingwith nature during the urban construction process. Solutions for planning ground elevation and organizing surface water drainage thoroughly take advantage of terrain shape; Technical measures to prevent slippage, used properly, will contribute to overcoming landslides and flooding in Da Lat City.

To meet the goal of developing Da Lat into a unique urban area in terms of planning, architecture, natural landscape, and sustainable development, technical preparation solutions need to be determined at all stages of urban planning as well as ensure harmony with natural situations, and the stability,together with balance of the natural structure./.

References

1. *Vu Hoang Diep, Technical preparation for urban construction land, Hanoi University of Architecture, 2022.*
2. *Conference proceedings, "Assessing the current situation, causes and proposing solutions to prevent local landslides and flooding in Lam Dong province", People's Committee of Lam Dong province, 2023.*
3. *Pham Linh, Phuoc Tuan, Dang Khoa, "Da Lat - a hot spot for flooding and landslides", vnexpress.net, 2023, https://vnexpress.net/da-lat-diem-nong-mua-ngap-sat- lo-4633247.html, September 30, 2023.*
4. *"Preventing flash floods and landslides - Lessons from Japan", baotainguyenmoitruong.vn, 2022, https://baotainguyenmoitruong.vn/phong-tranh-lu-quet-sat-lo-dat-nhin-tu-nhat-ban-335721.html, November13, 2023.*
5. *National Institute of Urban and Rural Planning, Adjusting the administrative planning of Da Lat city and surrounding areas to 2030 and vision to 2050, 2014.*
6. *Vu Hoang Diep, "Topographic factors in urban planning and design", Construction Magazine, No. 9, 2008.*
7. *Под редакцией канд. техн. наук В. С. Нищука (1983) СТРАИВАЕМЫХ ТЕРРИТОРИИ, Киев Будівельник.*
8. *Australian Capital Territory, Canberra, May 2004.*

Management of drainage network on Southern bank of Huong River in Hue City in the context of climate change

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Abstract

This paper aims at proposing solutions to enhance efficiency ofthe drainage network onthe Southern bank of Huong River in Hue City in the context of climate change. Southern bank of Huong River area has an elevation of 2 to 4 meters, but in severallocations, the elevation is very low, only 0.5m. After heavy rains, some locations are flooded for several days. Under the impacts of climate change,unseasonal rains with high intensity have caused inundation for wards of Vy Da, Xuan Phu, Vinh Ninh, Phu Nhuan, An Cuu, Phuong Duc, etc.,affecting the people's lives and local infrastructures. Currently, the drainage network on the Southern bank of Huong River area has been invested with the new construction of sewers, interceptors, overflow chambers,etc., however, the flooding situation has not been solved. From the analysis results, the paper offers some solutions to improve the drainage network capacity as well as to enhance the City's resilience in the context of climate change, including consideration of additional design parameters, technological management and use of sustainableurban drainage solutions (SUDSs) for the City.

Key words: *drainage network, climate change, Southern bank of Huong River.*

HEPCO: Hue Urban Environment and Public Works Joint Stock Company

ODA:Official Development Assistance

RCP: Representative Concentration Pathways

SUDS: sustainable urban drainage solution

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1. Introduction

Vietnam is one of the countries most heavily affected by the climate change. Increasingly complex and unpredictable weather patterns have caused serious infrastructure damages and human mortality [1]. Climate change has been a major challenge for humanity, especially issues such as flooding, drainage of low ground areas, protection of river and lake ecosystems, clean water supply, exploitation of water resources, water for farming, transportation, and in the management of dams and reservoirs [2]

The urban drainage system is an important city infrastructure to collectand transport stormwater and wastewater away from urban areas. Although it has evolved over the years, designing an efficient drainage system remains a major challenge. In particular, the impacts of climate change and urbanization are widely recognized, which can lead to a significant increase in the frequency and intensity of urban flooding in many regions of the world[3].

Therefore, in recent years, there have been many studies in the world as well as in Vietnam on strengthening the capacity of the drainage network to adapt to climate change. The study on Optimization of the drainage system under climate change scenarios is one such example. The authors argue that the increasing frequency of extreme rainstorms due to climate change calls for cost-effective methods to optimize drainage networks and measures to mitigate flooding risks[4].

Besides, urban drainage systems in general fail to perform their function mainly due to unstable climate and rapid urbanization process. As these systems are becoming less efficient, problems such as overflowing sewers and increasing urban flooding leading to an increase in pollutant loads on receiving waters are becoming extremely common. Yazdanfar and Sharma (2015) pointed out the need for a comprehensive survey to understand the impact of these factors on the performance of urban drainage systems, and how these factors vary in space and time and their complexity when combined. In addition, the study also shows that adaptation measures need to be carefully selected to ensure the sustainability of the drainage system to meet the combined challenges of climate change and urbanization. The study also examined the challenges associated with urban drainage systems and explored the limitations and potential of different adaptation solutions. The research was conducted with the aim of providing drainage engineers, water planners and decision makers with the most advanced information and technology on adaptation options to increase system efficiency in conditions of climate change and urbanization[5].

In fact, many infrastructures have been built in low-lying areas prone to flooding and measures and solutions to reduce flooding mainly focus on construction solutions. Public participation in the development of future flood management principles has benefited both stakeholders and engineers. Suggested methods to improve the problem include increasing the drainage capacity, using the pond system as reservoirs, constructing pumping stations and culverts. To assess the impact on the drainage system under the conditions of projected increased rainfall due to climate change, for each approach, simulations were performed to show the extent and depth of inundation. The results show the importance of assessing the impacts of climate change in implementation of appropriate flood management methods [6].

Hue city is the political, economic, cultural and social center of Thua Thien Hue province, home to a complex of human cultural heritage recognized by UNESCO. Hue is a grade 1 city, an important urban center in the national urban system and one of the key cities in the central region. Hue was formed in the center of the narrow delta of the lower Huong River and is divided into two main areas, consisting of North of Huong River and South of Huong River.

In particular, the area south of the Huong River has a very large difference in elevations, ranging from +2,0m ÷ +4m, and Dong Ba, Ba Trieu, Nguyen Cong Tru areas are the lowest, with elevation of only 0.5m. Therefore, this area is often flooded and threatened by floods, and regularly flooded when there is moderate and heavy rain at the upstream of Huong River (on the Truong Son Mountain Range) [7]. Over the past decades, the most obvious manifestations of climate change in the study area include floods, heat, drought, landslides, and saltwater intrusion, threatening the lives and livelihoods of local people, the ecosystem and local infrastructures. In the current climate change context, dangerous weather phenomena such as storms, thunderstorms, whirlwinds, natural disasters related to temperature and rain are forecasted to increase in number and influence on Hue city in particular and Thua Thien Hue province in general. Besides, like other provinces with hydroelectric projects, the management of drainage in Hue city is more difficult because the operation of the reservoirs leads to floods. Climate change would increase inundation in Hue city by 31.8% by 2050. The risk of flooding also comes from threats of storm surge occurring at the same time with heavy rains, and challenges from the management of upstream reservoirs. Rain is the most variable climate factor in Hue city [8].This makes flooding on the south bank of Huong River increasingly difficult to control and shows the importance of improving the efficiency of the management of the drainage system with aims to protect property and people's lives, enhance resilience to climate change and ensure sustainable development for Hue city.

2. Methodology

2.1. Scope of study

The study scope is the urban drainage network on the southern bank of Huong River (according to the division of administrative boundaries of Hue city by Decree No. 44/2007/ND-CP, dated March 27, 2007) and Resolution No. 14/NQ-CP, dated March 25, 2010 of the Government) with 10 wards of Vinh Ninh, Phu Nhuan, Phu Hoi, Xuan Phu, Ward Duc, Phuoc Vinh, Truong An, An Cuu, Vi Da and part of An Dong ward with a total area of 1010 ha as shown in the Figure 1.

2.2. Methods of study

Collection of secondary data: with information and data about the study area, the current situation of the drainage network, operation capacity, the current inundation, scenarios, etc., from various parties including PMU of Hue City Water Environment Improvement, Project Consultants, HEPCO, etc. and from previous research.

Site survey: Survey and collection of information on the current situation of the drainage network in the Southern bank of Huong River.

Data processing and analyzing: The information is collected, synthesized and analyzed to assess the current situation of the drainage network, climate change situation in Thua Thien Hue province, impacts of climate change on mentioned drainage capacity.

Consultation of experts: The experts are consulted in assessing the current situation of the drainage network, proposing measures for management of the drainage network in the context of climate change.

Map and diagram: The paper are used the surface water drainage planning of Hue City and other drainage networks.

2.3. Data sources

Fig. 1. Southern bank of Huong River [12]

The main documents used by the authors in the study process include 1) various project reports for Improvement of Water Environment in Hue City (Japanese ODA); 2) Project Report for Green Cities in Thua Thien Hue Province (ODA from ADB); 3) Surface water drainage planning of Hue City, Thua Thien Hue Province; 4) Summary report on climate assessment for Thua Thien Hue Province (DoNRE of Thua Thien Hue province, 2021); and 5) Final Report on Development and Update of Action Plans in Response to Climate Change in Thua Thien Hue Province (DoNRE of Thua Thien Hue Province, 2021).

3. Results and discussion

3.1. Climate change in Hue City

Hue city is an urban area in Thua Thien Hue Province - a central coastal province of Vietnam, located in an area highly vulnerable to the impacts of sea level rise, heavy rain, storms and tropical depressions, etc. Climate change affects many regions, localities, sectors of the province, especially water resources, agriculture, industry, energy, construction, urban areas, tourism and people's lives. In recent years, the manifestations of climate change in the study area have become increasingly clear such as increase both in frequency and intensity of average temperature, rainfall, extreme events, and with unpredictable, irregular changes [9].

In the period from 2010 to 2019, due to Elnino influence, the rain situation changed against the rules, such as the heavy rain on November 15-17, 2013 with great intensity of 68.5mm/h at Kim station Long and 78mm/h at Hue station. The rainfall in 3 hours, from 16:00 to 19:00 on November 15, 2013 was 185mm at Hue station, 134 mm at Kim Long station and 172mm at Phu Oc station. This caused the most serious flood due to heavy rainfall intensity since the flood in 1999. In 2015, right from end of March, there was a heavy rain on a large scale, with rainfall from 380-620mm. This is an unseasonal, unusual and unprecedented heavy rain in the period of the winter-spring crop, and the heavy rain upstream led to floods in the rivers and widespread flooding. In 2016, due to the influence of climate change and the transition from El Nino to La Nina, from early September to mid-December,

throughout the province, natural disasters, storms and floods occurred consecutively. In 2017, heavy to extremely heavy rains concentrated in October and November, especially heavy rains in November, causing huge to especially huge floods throughout the province. The flood was especially massive from November 3 to November 9, 2017 with the total rainfall from 7 p.m. on November 3 to 7:00 a.m. on November 9 of 600 to 1200mm, and even higher at Bach Ma (2,751 mm), a flood of III level alarm appeared on the Huong and Bo rivers. The peak flood water level was +4.03m at Kim Long on Huong River at 19:00 on November 5, which was 0.53mover of III level alarm; +5.05m at Phu Oc station on Bo River at 5:00 p.m on November 5, which was 0.55m over of III level alarm, approximately the historical flood peak of 1999 (+5.18m). The huge flood lasted from November 19 to November 24, 2017 was with average rainfall from 360 to 800mm, and even 1,028mm at Bach Ma resulting into massive flood on the river banks. The highest peak flood water level on Huong River was + 2.71 m at Kim Long, which was 0.71 m over of III level alarm; on Bo river, it was +4.17 m at Phu Oc, which was 0.33m under III level alarm. In 2018, due to the increasing influence of cold air combined with high-altitude easterly wind disturbances, from the morning of December 7 to December 17, 2018 in Thua Thien Hue, there was moderate rain, heavy rain, and torrential rain with average rainfall from 200mm to 400mm, in Hue it was 392mm.[9]

The most recent event was the rain on October 14-15, 2022 with an average intensity in 24 hours of 450-500mm. At 3 a.m. on October 15, the water level of Huong River was +3.73m at Kim Long, which was 0.23m over III level alarm; Boriver water level at Phu Oc station was +3.97m, which was0.53m under alarm III is. Heavy rains resulted inmassive flooding, resulting into more than 11,200 houses to be flooded from 0.3-0.8m.

Under the impact of climate change, temperature and rainfall in Hue have changed.

Temperature: Figure 2 shows the annual variation of the average temperature at Hue monitoring station in the period of 1976-2019 and the assessment period of 2010-2019. The data show that the annual variation of the mean temperature over the period is similar. However, there is a clear difference in the number of months.

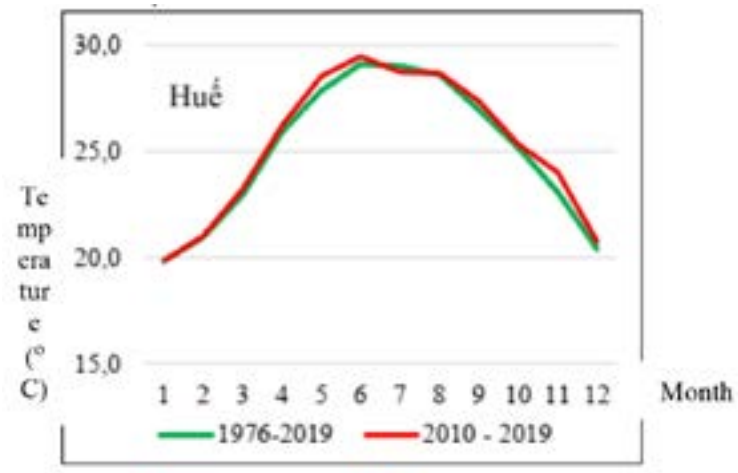

Fig.2. Annual variation of temperature (°C) for the period 1976-2019 and 2010-2019[9]

Rainfall: The annual rainfall pattern at Hue station in the assessment period compared to the period of 1976-2019 not only increased in volume but also diverged in heavy rainfall towards the end of the year. According to Figure 3, the long period with the largest amount of rainfall was in October, while the period of assessing the peak rainfall was skewed to November and the annual December rainfall has an increase of approximately 100 mm. Therefore, the climate change has made the rainy season in the region end later and the rainfall also increases sharply in the last two months of the year. In addition, annual rainfall in Hue in between the two periods indicates that the heavy rainfall was both at the end of the year and the heaviest rainfall was in November as shown in Figure 3.

As such, in comparison of the period of 2010-2019 and the standard climate period of 1981-2010, the rainfall in the study area changes at an average of 2%, i.e., 2.2% in the dry season, and1.9% in the rainy season.

In addition, due to the impact of climate change, the number and frequency of disasters such as large-scale heat, drought, storm and tropical depression, floods, severe cold, fog and hail, etc. show tendency of increase.

3.2. Climate change scenarios of Thua Thien Hue Province

The climate change scenarios have been developed for Thua Thien Hue Province, with the emphasis on RCP4.5 and RCP 8.5 scenarios on basis of Climate Change Scenario of MONRE in 2016 [10].

Average temperature: According to all RCP scenarios, in all three periods of the beginning, middle and end of the 21st century, the annual and seasonal average temperatures in Hue tend to increase compared to the baseline period. By the end of the 21st century, the increase in temperature is greater. In which, the RCP8.5 scenario usually gives the largest increase and the difference is quite clear with other scenarios. According to the scenario RCP4.5, the annual temperature and seasons will increase by 0.7 0C at the beginning of the 21st century, by 1.50C by the middle of the century, and by 1.9oC by the end of the century. Under the RCP8.5 scenario, the annual temperature could increase to 3.50C. In general, the temperature increase is quite uniform in each scenario and period.

Annual rainfall: There is tendency of sharp increase compared to the base period. According to the RCP4.5 and RCP8.5 scenarios, annual rainfall will increase at 20 ÷ 22% at the beginning of the century, 32% in the middle of the century, and 26 ÷ 31% at the end of the century.

3.3. Current situationof drainage network and management

3.3.1. Existing drainage network on Southern bank of Huong River

Key drainage works: rivers including Huong, Nhu Y, An Cuu, Nhat Dong, Phat Lat and drainage channels such as Moc Han, Ba Niem, Nhat Tri, etc and the lakes in the area.

Sewerage network: Most of the semi-separate sewer systems have been renovated and newly constructed in the Hue City Water Environment Improvement Project - Phase 1 (Japanese ODA, 2008-2020) and a small part is a separate drainage system (separate drainage of rainwater and wastewater) recently built in An Van Duong New Urban Area.

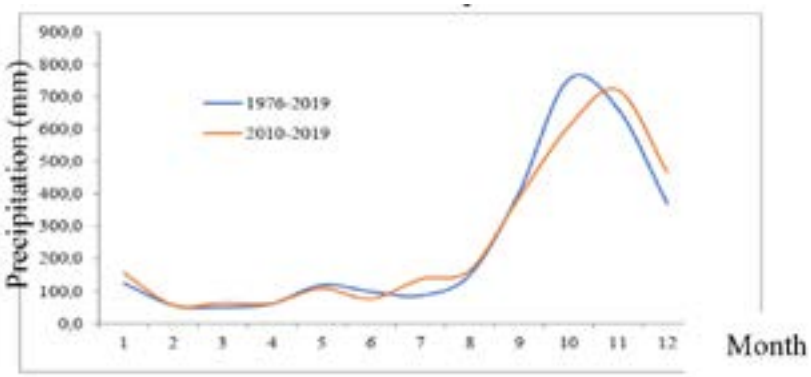

Fig. 3. Annual precipitation (mm) in the period 1976-2019 and 2010-2019 at Hue station[9]

Within the above mentioned project, the drainage network in the densely populated inner city wards on the Southern bank of Huong River have been enhanced and built to collect both rain water and wastewater. At the outlets into the key drainage works (rivers, lakes, canals), the overflow chambers are provided to collect the wastewater and initial stormwater into the interceptors which then transfer the flow to the wastewater treatment plant for treatment to required standards before discharge into the environment. The main measures, which have been constructed within the project scope, consist of the followings.

(1) Dredging and embankment of key drainage works including An Cuu river (0.746km); Nhu Y Bac river (1,456km); Canal No. 7 (0.616km); Moc Han canal (1,396km);

(2) Rehabilitation and construction of the combined sewers, including renovation and replacement of old culverts and new construction of primary and secondary sewers (38,663m); tertiary network for the whole project area (74,700m); and 107 outlets;

(3) Renovation and construction of the wastewater sewers system, including the construction of a new interceptors (32,406m); 94 overflow chambers; 07 pumping stations;

(4) Construction of 1 new waste water treatment plant using activated sludge treatment process, with the capacity of 30,000 m^3/day in An Dong ward with a total area of 9.6 ha.

The project scope is illustrated in Figure 5 below [12]:

In addition, in the period 2018-2024, Component 1 - Flood prevention and environmental sanitation under the Green Cities Project in Thua Thien Hue Province (ADB fund) has been implemented improve the drainage network for the inner city area on the Southern bank of Huong River in Hue city, including enhancement and embankment of two banks of An Cuu river (0.5km); Nhu Y river (0.35km); and drainage, trees, sidewalks, lighting system for the central ecological routes of An Van Duong urban area [11].

Furthermore, in the period of 2021-2024, Hue City Water Environment Improvement Project, Phase I (residual capital) has been extended for enhacement of the drainage system on the Southern bank of Huong River [12]. The proposed measures include the below items.

(1) Separate sewer lines to collect wastewater for Zone A, An Van Duong urban area and for the remaining areas of An Van Duong urban area with total length of 23,502m;

(2) Construction of additional combined sewer lines with a total length of 7,300m;

(3) Embankment of Nhu Y river (13,846m); An Cuu river (365m); Long Tho - Thuy Bieu canal (1,900m);

(4) Additional storm water and wastewater drainage for Bau Va area, total length of 647m;

(5) Drainage for Pham Van Dong roadside, length of drainage system of 3,100 m;

(6) Combined sewers downstream of 245 Phan Boi Chau lane, total length of 1,010m.

Therefore, in recent years, Hue city's drainage network has continuously been invested for new construction and improvement in order to have a comprehensive drainage network.

3.3.2. Drainage network management

According to Decision No: 51/2017/QD-UBND of Thua Thien Hue Provincial People's Committee issued on July 6, 2017 on regulations on management of drainage and wastewater treatment activities in Thua Thien province, the owner of the drainage system in Hue city is the People's Committee of Hue city.

Before the construction of the Hue City Water Environment

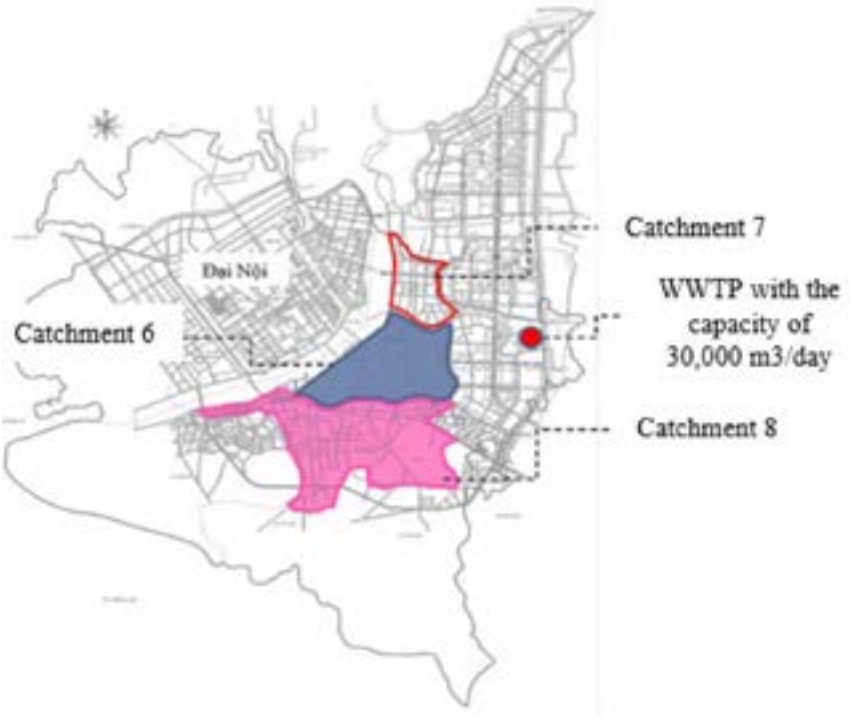

Fig. 4. Scope of Hue City Water Environment Improvement Project[12]

Fig. 5. Outlets of combined sewers into An Cuu River at Ton Quang Phiet Str.

Fig. 6. Flooding in some areas on southern bank of Huong River[13]

Improvement Project, the Hue Urban Environment and Public Works Joint Stock Company (HEPCO) was assigned the task of maintaining the drainage system in Hue city via the contract signed with the People's Committee of Hue City. Since the project construction in 2015, the project construction site has been handed over to the Project.

The project has been basically completed in 2020, the project owner is conducting the bidding process for selection of an operator for the drainage and wastewater treatment system in the city according to the above Decision.

3.3.3. Dewatering capacity of drainage network under climate change context

Although the environmental improvement projects have contributed to the increased drainage capacity of the drainage network on the Southern bank of Huong River, currently, the drainage network has only been built in the inner city, showing certain limits in dewatering, especially in the rainy season, leading to flooding in many wards and communes on the related areas, especially in An Van Duong new urban area.

Besides, in An Van Duong urban area, the key drainage works such as the system of lakes and ditches/drainage channels have not yet been constructed according to the planning, resulting into inundation during and after rain.

Furthermore, there are still old and degraded sewers in the areas, or outlets which are lower than the river level that leads to the backflow of water into the sewers as shown in Figure 6 below, making the flooding more serious.

In addition, due to the lack of tools to provide local people with necessary information when floods occur, human and property damages and losses are still very high.

In the rain event on October 14-15, 2022, many streets were flooded with the average depth of 0.3-0.5m, and even over 1m on both banks of Nhu Y river on the Southern bank of Huong River as can be seen in the Figure 7 below.

It can be seen that, since 2015 and in the following years, many investment projects for construction and enhancement of the drainage network of Hue city have been implemented in order to complete the drainage system, improve drainage capacity with the purpose of reducing flooding and environmental pollution in the city, strengthening the city's resilience in the context of climate change and sustainable development of Hue city. However, up to now, flooding has often occurred and hugely affected the lives and activities of local people. Frequent flooded areas on the Southern bank of Huong River include the followings [9].

Xuan Phu Ward is the most seriously flooded area. Due to the low natural terrain, almost the entire area is flooded when it rains. Recently, the ground of City Sports Center and Kiem Hue new urban area has been upgraded and the T7 canal on the extended section of To Huu street has also been built, so it has partly solved the flooding in the area. However, the urban area south of the City Sports Center towards Truong Chinh Street is still regularly flooded.

Vy Da Ward is often flooded when it rains and the water level of Huong River rises. The areas of Vy Da Secondary School, Nam Vy Da planning area and Tung Thien Vuong and Tuy Ly Vuong streets are usually about 0.5m under water after rain.

Phu Hoi Ward is often flooded at the beginning of Ben

Nghe - Hung Vuong, Pham Ngu Lao, Vo Thi Sau, and Tran Quang Khai streets. The level of inundation is about 0.5m and the water recedes 1-2 hours after the rain.

Vinh Ninh Ward: On Phan Boi Chau, Nguyen Thien Ke and Ly Thuong Kiet street, it is flooded about 0.3m in heavy rain due to the small diameter of the existing drainage pipe.

Phu Nhuan Ward: On Nguyen Hue and Nguyen Thi Minh Khai streets, the Nguyen Tri Phuong - Hung Vuong junction area is sometimes flooded due to small drainage pipes. This area is flooded by 0.2 - 0.5m and the water is drainedafter about 1-2 hours.

An Cuu Ward is partially flooded in a short period of time when it rains heavily in Kiem Hue, Kiet Mieu Doi.

Phuong Duc Ward is often flooded locally along Bui Thi Xuan and Duong Xuan Ha streets in a short time when there is heavy rain.

In addition, heavy rain causes flooding in many streets and underground parking places of some high-rise buildings such as SHB Building on Ly Thuong Kiet Street, buildings on Nguyen Van Cu Street, Big C supermarket, Hue City PoliceBuilding on Dong Da Street, etc.

3.4. Measures for improvement of operational efficiency of drainage network and increase of resilience for Hue city under climate change conditions

3.4.1. Consideration of additional parameters for design of drainage network

Up to now, the design of urban drainage system follows national codes, standards and criteria of the Vietnam Ministry of Construction in calculating the size and scale of works and based on systematic analysis of past rainfall events, in particular the frequency with which the rains cause flooding. However, climate change leads to an increased intensity and frequency of extreme rain events resulting in more frequent flooding. Therefore, the design criteria of urban drainage systems need to consider changes that may occur due to climate change. This includes calculating and reviewing information on (1) forecasts for extreme rainfall over the area under consideration; (2) the expected level of performance (or acceptable level of risk); and (3) the expected lifespan of the works. At the same time, the consideration also has to ensure efficiency of the investment cost to avoid wasteful investment.

3.4.2. Application of information technology

The application of software and measurement systems for flood warning has been a popular method applied in many countries around the world. In fact, to be able to provide better information on the possibility and extent of flooding, Hue City Government also needs to further study and invest in disaster prevention and forecasting equipment, measuring equipment with sensors should be equipped at key works such as rivers, ditches, ponds, lakes and in rainwater drainage pipes. Water level or rain measurement data will be transmitted to the Flood Control Agency for analysis, simulation and proposal of flood response activities. The results will be notified to the people through the software application on mobile phones.

For example, "Flood Alert" app has been used on smartphones to provide immediate local and neighborhood flood warnings in England and Wales since 2011 when these countries are regularly flooded, causing billions of dollars in damage. Or in Japan, B-Dash, which is a system that supports the operation of flood prevention equipment consisting of monitoring, measuring, collecting, analyzing and reporting information, has been researched since 2013 and so far, been put into use. In addition, since the 1990s, Osaka in Japan has also installed a dedicated Radar system to measure precipitation and provide information for people and authorities.

3.4.3. Approach to sustainable drainage solutions

Inundation in urban areas is mainly caused by the concreting of the ground in urbanization process, which severely reduces the amount of rainwater infiltration into the ground and flows into water receiving sources such as ponds, lakes, and canals. Much of the rainwater flows directly into the drainage system, causing overload and flooding only shortly after the rain begins. To solve this situation, Sustainable

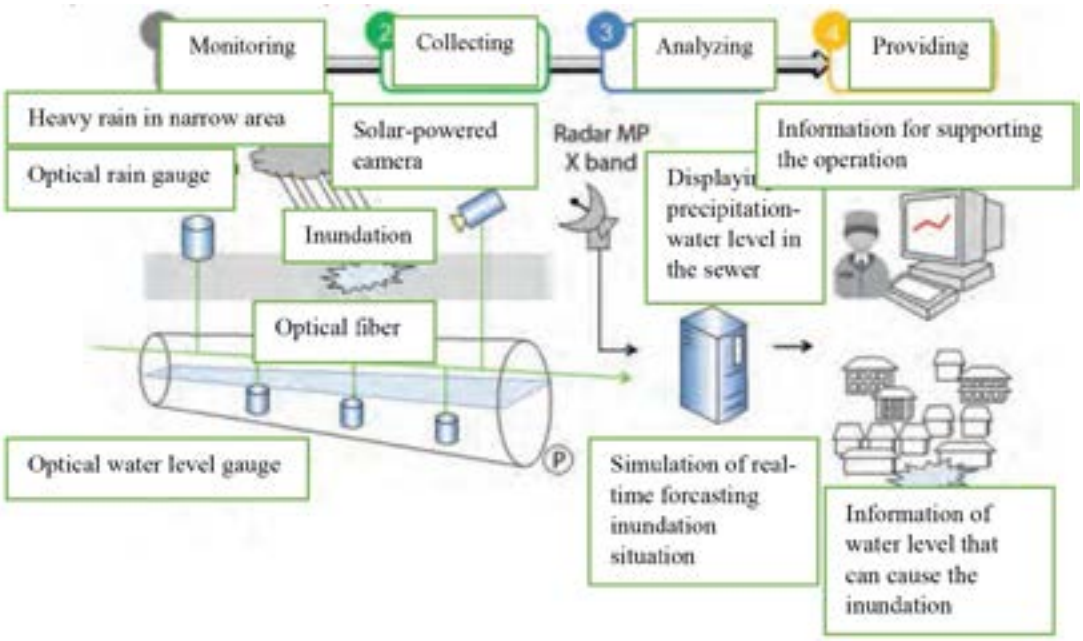

Fig. 7. Flood prevention system in Japan [14]

Fig. 8. Sustainable Urban Drainage Solutions - SUDS[15]

Urban Drainage Solutions (SUDS) – an integrated solution of structural and non-structural solutions is very suitable and necessary.

The principle of SUDS is directed towards maintaining the natural characteristics of the flow in terms of volume, intensity and quality, maximum control of runoff from the source, minimizing areas of direct drainage, storing water in situ and allowing it to seep into the ground, while controlling pollution.

Key benefits of SUDS include i) Resolving inundation; ii) Preventing water pollution and reduce environmental pollution in general; iii) Ensuring the harmony of the natural landscape, greening the urban area; iv) Ensuring habitat for wildlife, and v) increasing diversity etc.

According to a study by GIZ-Ministry of Construction in 2016 on building solutions with an interdisciplinary approach to flood control, researchers have come up with groups of works that have a positive impact on increasing energy urban flood resilience and adaptation that can be studied and applied in Hue city as shown in Figure 8.

On the southern bank of Huong River, there is a large system of key drainage works with such rivers as Huong, Nhu Y, An Cuu, Nhat Dong and Phat Lat, and drainage channels such as Moc Han, Ba Niem, Nhat Tri, etc. and the system of ponds and lakes. Therefore, in order to ensure effective drainage, large water storage area, air conditioning, and beautiful landscapes for the city, the City government should pay attention to upgrading the efficiency of these works through embankment, anti-subsidence banks, regular dredging, etc.

In addition, in urban areas as well as new urban areas of AnVan Duong, it is necessary to make careful consideration on the use of materials that allow water infiltration in large public areas such as squares, parks, and parking lots, and limit of concreting and providing more lawns, trees, lake surface, etc.

References

1. *WB&ADB, Vietnam-Climate-Risk-Country-Profile, [Online]. Available: https://openknowledge.worldbank.org/handle/10986/36367 (2021)*
2. *LAWA, Impacts of Climate Change on Water Management: Stocktaking, Options for Action, and Strategic Fields of Action (LAWA Climate Change Report 2017)*
3. *Q. Zhou, A review of sustainable urban drainage systems considering the climate change and urbanization impacts,Water, vol. 6, no. 4, pp. 976–992 (2014)*
4. *D. Fiorillo, F. De Paola, G. Ascione, and M. Giugni, "Drainage Systems Optimization Under Climate Change Scenarios," Water Resour. Manag., doi: 10.1007/s11269-022-03187-0 (2022)*
5. *Z. Yazdanfar and A. Sharma, Urban drainage system planning and design – challenges with climate change and urbanization: a review," Water Sci. Technol., vol. 72, no. 2, pp. 165–179, May 2015, doi: 10.2166/wst.2015.207 (2015)*
6. *H.-K. Chang, Y.-C. Tan, J.-S. Lai, T.-Y. Pan, T.-M. Liu, and C.-P. Tung, "Improvement of a drainage system for flood management with assessment of the potential effects of climate change," Hydrol. Sci. J., vol. 58, no. 8, pp. 1581–1597, doi: 10.1080/02626667.2013.836276 (2013)*
7. *Black&Veatch, Design Explanation_Bidding package ICB2 &3_ Project on Improvement of Water Environment of Hue City (2013)*
8. *Hue University, "Assessment of the flooding and drainage capacity of Hue City due to the impact of urban areas taking into account the impact of climate change (2017) http://huegeosciences.edu.vn/vi-vn*
9. *Department of Natural Resources and Environment of Thua Thien Hue Province, "Comprehensive report on Climate sssessment of Thua Thien Hue Province (2021)*
10. *Department of Natural Resources and Environment of Thua Thien Hue Province, "Summarizing report on developing and updating action plan to respond to climate change in Thua Thien Hue Province", 2021*
11. *ADB, "Secondary Green Cities Development Project-Hue City Subproject (2017). https://www.adb.org/projects/47274-003/main#tabs-0-2*
12. *ICC, "Design Report of the Project on Improvemenet of Water Environment of Hue City- Phase I (Fund savings) (2022)*
13. *H.Oanh,"Flooding situation in Thua Thien Hue province", https://dangcongsan.vn/anh/ghi-nhan-tinh-hinh-lu-lut-tai-thua-thien-hue 622053.html (2022)*
14. *Suzuki Hiromasa,"Flooding Control in Osaka city, Japan at Vietnam – Japan Workshop in stormwater management and flood control"(2018)*
15. *GIZ, "Introduction on sustainable urban drainage systems (SUDS policy brief. Flood Proofing and Drainage for Medium-sized Coastal Cities for Adaptation to Climate Change" (2016)*

Furthermore, like other provinces with hydroelectric works, the management of drainage in Hue city is more difficult because the operation of the reservoir would also lead to floods. The hydrometeorological monitoring equipment in the upstream area, equipment for warning, building and updating flood maps, and measures to ensure downstream safety are still very limited. Along with that, the operation, regulation and discharge of floods, as well as information on flood discharges of some reservoirs are still inadequate, making it difficult for response in the downstream area, causing huge damages. Therefore, inter-sectoral coordination in the operation of the drainage system is essential to minimize damage in the events of flooding.

4. Conclusion

The research results reveal that the drainage system on Southern bank of Huong River has been recently improved with aim to enhance the drainage capacity for urban areas via such project as the Japanese ODA funded project, ADB funded project or local funded projects. However, under the influence of climate change, the weather is becoming more and more extreme and the unseasonal rainfall is increasing, the sewer network is still not able to drain in time, causing flooding in many locations on the Southern bank of Huong River. In addition, according to the climate change scenarios, the annual average temperature in Thua Thien Hue province will increase by 1.9ºC and 3.5ºC for RCP4.5 and RCP8.5, respectively; and the annual rainfall tends to sharply increase 26-31% at the end of 21st century.

Therefore, in order to enhance capacity on prevention of flooding risks and effectively respond to climate change, a holistic and integrated approach is needed. Within the scope of the research, the authors propose a number of technical measures such as consideration of additional parameters in the design of sewers, use of flood warning software, and approaching sustainable drainage solutions to improve the management capacity of the drainage system, adaption to flood risks, minimization of damages to local people as well as ensuring the sustainable development of the City./.

Technical process of operation of bubbling...

(continued on page 67)

Make sure the meter or water level display element is working properly

Ensure the cleanliness of the filter installed at the pump suction

Make sure the pump surroundings are clean of foreign substances and no chemicals are spilled there, for safe operation purposes.

Periodically check the pump inlet pressure and the operation of the pressure reducing valve.

(20) Mechanical dust collector

Visually check to see if there is a leak at the mechanical dust filter output flange.

Check the corners of the ash hopper to see if there is a leak.

Assess the level of leak, if serious, plan to stop the incinerator earlier than usual for repair. Stopping early can reduce damage to the valves.

Check the temperature of the bearings, if high temperatures are detected use the recommended lubricant.

3.3. Procedure for stopping solid waste incinerators

Just like when starting the incinerator, the process of stopping the incinerator must strictly comply with the regulations stated in the National Technical Regulation on incinerators QCVN 61-MT:2016/BTNMT. At the same time, the operator needs to follow the basic steps shown in Figure 3.

Conclusion

Fluidized bed incinerator technology (BFB, CFB) to treatment domestic solid waste and convert it into energy is a modern technology that requires the construction of very strict and meticulous operating process. With 3 basic processes that have been detailed and clearly outlined by the research team for each level from starting, operating to stopping the incinerator, this will be the necessary content to proceed with the implementation of training for direct and indirect managers can apply it correctly in real-life conditions, ensuring the best operating efficiency of the incinerator system, following technical and safety procedures. Besides, the research results are also reference documents to serve in training and scientific research in the field of environmental engineering./.

References

1. *Prime Minister of the government, 2018, Decision 491/QD-TTg dated May 7/ 2018 "on adjusting the national strategy on integrated solid waste management to 2025, vision to 2050"*
2. *President of Congress, 2022, Law on Environmental Protection 2020 (promulgated and amended by the Government according to consolidated document No. 21/VBHN-VPQH dated December 29, 2022*
3. *Bary Wilson et al. (2013). A Comparative Assessment of CommercialJFE Engineering Corporation (2014), Introduction of JFE's Environmentalsolution Technologies.*
4. *Nickolas J. Themelis, Charles Mussche (2013). Municipal Solid Waste Management and Waste-To-Energy in The United States, China and Japan. Paper presented at the 2nd International Academic Symposium on Enhanced Landfill Mining, 14-16/10/2013, Houthalen-Helchteren, Belgium.*
5. *Tchobanoglous et al. (1993), Intergrated Solid Waste Management, McGraw- HillInc, USA.*
6. *Yachiyo Engineering Co., Ltd. et al. (2013). Final Report – Study on the industrial waste treatment and waste-to-energy project in Binh Duong province, The Socialist Republic of Vietnam.*
7. *Waterleau. Waste to Energy – Integrated Solutions for the Thermal Treatment of Toxic and Non-Toxic Waste (online), từ http://www.waterleau.com/files/Waste_to_energy.pdf*
8. *Nghiem Van Khanh, Nguyen Hong Van, 2023, University-level scientific research project 2022 "Building technical process for management and operation of fluidized bed incinerators (BFB, CFB) to treat domestic solid waste and convert it into energy"*

Proposing solutions to control watersupply reserves and quality for urban areas andindustrial zones in Phu Yen provinceto response to climate change

Nguyễn Thị Ngọc Dung, Nguyễn Văn Nam, Vũ Bình Sơn

Abstract

Currently, along with the economic development, the urbanization process has been taking place strongly, putting great pressure on the water supply for urban areas and industrial zones, leading to conflicts, overlapping and obstacles to the water supply management.Proposing solutions for controlling water supply reserves and qualitywith technical solutions such as: controlling the management according to the water supply reserve planning; monitoring; the process of early warning and quality control of water supply sourcesto achieve the goal of safe water supply (ensuring the reserves and quality of water supply) for urban areas and industrial zones. The management of water supply sources in Phu Yen Province is very important for the sustainable development of urban areas and industrial zones.

Key words: *water supply reserves; water supply quality;urban areas; industrial zones; climate change*

BOD: Biochemical Oxygen Demand

COD: Chemical oxygen demand

WQI: Water Quality Index

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1. Introduction

Our country is implementing the fourth industrial revolution (Industry 4.0) in the fields of social life, along with the rapid urbanization process, the demand for water use for economic development, serving the growing population is increasing. The economic restructuring requires an appropriate change in the structure of water use. On the other hand, climate change is causing many threats to the water resources in Vietnam, including Phu Yen Province. Water is increasingly scarce, declining in both quantity and quality. Accompanied by severe droughts and floods in both scale, extent and time, leading to difficulties in water supply for the needs of use. Under the impact of climate change, the reserves and quality of water supply for urban areas and industrial zones (IZs) in Phu Yen Province are unstable. Droughts caused by heat, waterlogging due to rain and floods, water pollution from sewage and waste and salinization by sea water intrusion due to the influence of sea level rise have become common in many areas of Phu Yen Province. [1] [2]

The management of water supply for urban areas and industrial zones in Phu Yen Province is still limited, inadequate, not meeting the actual requirements and there is no solution to actively respond to the increasing climate change. Currently, along with the economic development, the urbanization process has been taking place strongly, putting great pressure on the water supply for urban areas and industrial zones, giving rise to conflicts, overlapping and obstacles to the water supply management. The apparatus, mechanisms and policies on management of water resources already exist, but need to be supplemented and completed to be suitable for the renovation period. At the same time, it is necessary to improve the water resource management capacity to approach the 4.0 industrial revolution in Phu Yen water industry in particular and Vietnam in general. [1][2]

To achieve the goal of safe water supply (ensuring reserves and quality of water supply) for urban areas and industrial zones, the management of water supply in Phu Yen Province is very important for the sustainable development of urban areas and industrial zones. Therefore, “Controlling water supply reserves and quality for urban areas and industrial zones in Phu yen Province to response to climate change” is a practical and urgent study.

2. Overview of water supply for urban areas and industrial zones in Phu Yen Province to response to climate change

Phu Yen Province has a total of 9 urban areas. According to urban classification, there is one Class-2 Urban area of Tuy Hoa City, two Class-4 Urban areas of Song Cau Town and Dong Hoa Town; and 6 Class-5 Urban areas such as La Hai Town, Phu Hoa Town, Cung Son Town, Hai Rieng Town, Chi Thanh Town and Phu Thu Town. In the province, there are 3 centralized industrial zones including Hoa Hiep Industrial Zone, An Phu Industrial Zone, and Northeast Song Cau Industrial Zone, especially, there are 10 industrial clusters established in the province, investing in infrastructure and operating. [2] [3]

Currently, the urban water supply system is managed by Phu Yen Water Supply and Sewerage Joint Stock Company with 9 water treatment plants providing treated water for 9 cities and 3 big industrial zones with a total capacity of 47,400 CMD. Of which, the supply for 09 urban areas is 33,940 CMD and 3 big industrial zones is 13,460 CMD.[2] [3]

a. Overview of water sources and water reserves for urban areas and industrial zones in Phu Yen Province

- River water source

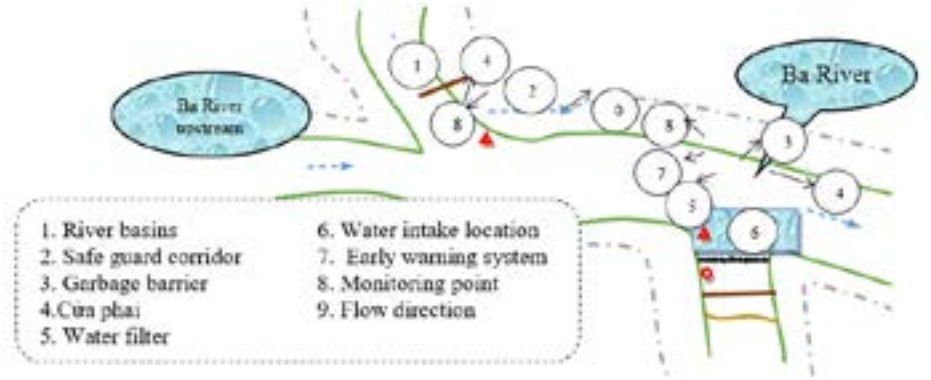

Figure 1. Proposed management diagram of River Ba surface water supply

Mainly based on surface water of 4 main river basins. Most rivers and streams in the area have narrow basins, large river bed slopes, and the flow depends on rainfall.

- Lake water source

There are many reservoirs with large useful capacity to be considered as a source of water for domestic use. [4] [5]

- Groundwater source.

Current exploration and survey documents show that underground water resources in Phu Yen Province are quite complex, this water level has medium and small reserves, and can be exploited and used for various users. individual water.[4] [5]

- Rain water source

The rainy season in Phu Yen Province comes late and ends early, lasting only 3-4 months (from September to December), the average annual rainfall is from 1,600 - 2,100mm. There are 4 months of average rainfall over 100mm from September to December. The dry season lasts 9 months, from January to September with the water volume reaching 25-35% of the whole year. Morevoer, there are two dry periods inApril and August, the amount of water in the dry season is approximately 2% of the annual volume. [4] [5]

b. Current situation of water supply quality for urban areas and industrial zones in Phu Yen Province, impacts of climate change on water resources

- Current situation of river water quality

The Ba River

According to the results of monitoring the quality of surface water environment in the Ba River basin over the years, it is still quite good. However, compared to the 2011-2015 period, the water quality of the Ba River in the 2016-2020 period tends to decrease, especially in the dry season, the water source is locally polluted at some monitoring points.[4] [5]

The Ky Lo River

In general, the results of water quality monitoring in the Ky Lo river basin from 2016 to 2020 are still quite good. However, compared to the 2011-2015 period, the water quality in the 2016-2020 period showed signs of gradualdecrease. Especially in the dry season, water sources are polluted locally at monitoring points: Nutrient pollution through nitrate content (NO3-); organic pollution through the content of BOD5, COD; microbiological contamination through the content of Coliform, E. Coli.[4] [5]

The Ban Thach River

The WQI index at locations in the Ban Thach River basin is low, the water is polluted, it is mostly used for irrigation purposes.

General comments on the current situation of river water quality:In general, the water quality of the main rivers is relatively good and ensures enough reserves for use demand in Phu Yen Province. [2] [3]

- The quality of the Lake water

Most of the lakes have good water quality, which can be used as raw water for domestic purposes. But at present, there are no factories, or urban water supply plants that use raw water from reservoirs.[4] [5]

- The quality of groundwater

Coliform content at all underground water monitoring points in the province has exceeded the standard value. On the other hand, in saline aquifers. It is forecasted that after 2020, Phu Yen groundwater level may decrease significantly. Therefore, according to the water source planning, priority should be given to using surface water for daily-life and production needs, reducing and eventually limiting the use of groundwater in the direction of gradually transforming it into a strategic backup water source in the future.[4] [5]

c. Impacts of climate change on surface water

Climate change impacts on surface water resources: changing rainfall, rainy season distribution and increasing evaporation will change the water balance of the region. The rainy season will be shifted, expanded, narrowed, and the changes in rainfall will lead to the change in the flow.

It can be said that the impact of climate change on water resources is reflected in factors such as: flow regime of rivers in the province due to change in rainfall, rainfall distribution in different regions and change in the duration of the rainy season. These changes can cause flooding in the rainy season but prolonged drought in the dry season.[5] [6]

Tides and saltwater intrusion:The tidal regime in Phu Yen is mainly diurnal and irregular. During the dry season, the tides bring salt into the estuary every day.

c. Situation of sedimentation and erosion of riverbanks and estuaries.

According to survey data, riverbeds and estuaries of Da Rang, Ky Lo and Da Nong rivers have been eroded and accreted regularly.[5] [6]

Situation of saltwater intrusion

The rivers in Phu Yen Province all directly flow into the East Sea, so salt from the sea follows the tides to infiltrate into rivers, canals and fields, especially in the dry season when the river water dries up.[5] [6]

3. Proposing solutions for controlling water supply reserves and quality

a. Proposing management control solutions according to the water supply reserve planning

- Develop plans for the development of water supply systems to meet the needs of treated water use in urban areas and industrial zones.

- Make short, medium-term and long-term investment plans for the development of water supply systems in each period.

- Monitor, control and manage the process of increasing water demand according to the development of urbanization in practice.

- Search, arrange and allocate investment capital appropriately, to avoid overlap or lack of capital.

- Prioritize the exploitation of surface water sources, on river systems with abundant reserves

- Prioritize the exploitation of raw water sources for people's living needs.

- Reduce and move towards limiting the use of groundwater in the direction of gradually turning into a strategic backup water source in the future.[2] [8]

b. Proposing solutions for monitoring water supply quality for urban areas and industrial zones in Phu Yen Province under climate change conditions

Develop a map of water supply monitoring points for urban areas and industrial zones in Phu Yen Province by 2030. Proposing 21 water supply monitoring points for urban areas and industrial zones including 11 monitoring points for separate water supply for urban and industrial zones; 05 monitoring points for combined water supply for urban areas, industrial parks and irrigation. Moreover, we have 05 observation points for water sources affected by sea level rise: sugar factories, starch production, industrial activities in upstream areas and waterway traffic as well as irrigation. [2] [8]

c. Proposing the process of early warning and quality control of rivers used for water supply (Taking Ba River at the location of the water intake work for Tuy Hoa Water Company as typical)

Proposal for management of surface water supply in Ba River, water grab location in Hoa Thang commune provided for Tuy Hoa city urban area.

Control of basins flowing into the Ba River: Currently, on the Ba River there are many small basins flowing into the Ba River, so it is necessary to review and strictly inspect each basin to take measures to handle. For small tributary basins only when the rainy season flows from the mountainside, connecting with each other to the basin with water flowing all year round will flow into the Ba River basin. Conduct water quality control from the basins by placing monitoring points at the adjacent location between the basins with the Ba River as in Figure 3.1[2]

Proposing the process of early warning and quality control of Ba River water supply

- The water quality sensor is responsible for measuring the water quality at the installation site, then transmits the signal to the signal processor; and then the signal processor has the function of analyzing indicators of water quality. Indicators are installed into the signal processor automatically projected on current regulations and standards.

- When the water signal exceeds the allowed index, the signal processor acts on the telephone broadcaster alerts the registered subscriber number (System Operations Center). The person responsible for deciding whether to close or open the doors.

- When the central processor receives the signal transmitted from the phone wave, it automatically analyzes if the water exceeds the allowable index and the controller will close itself.[2]

The proposed technical solutions have high practical significance and can be applied in the management of water supply for urban areas and industrial zones in Phu Yen

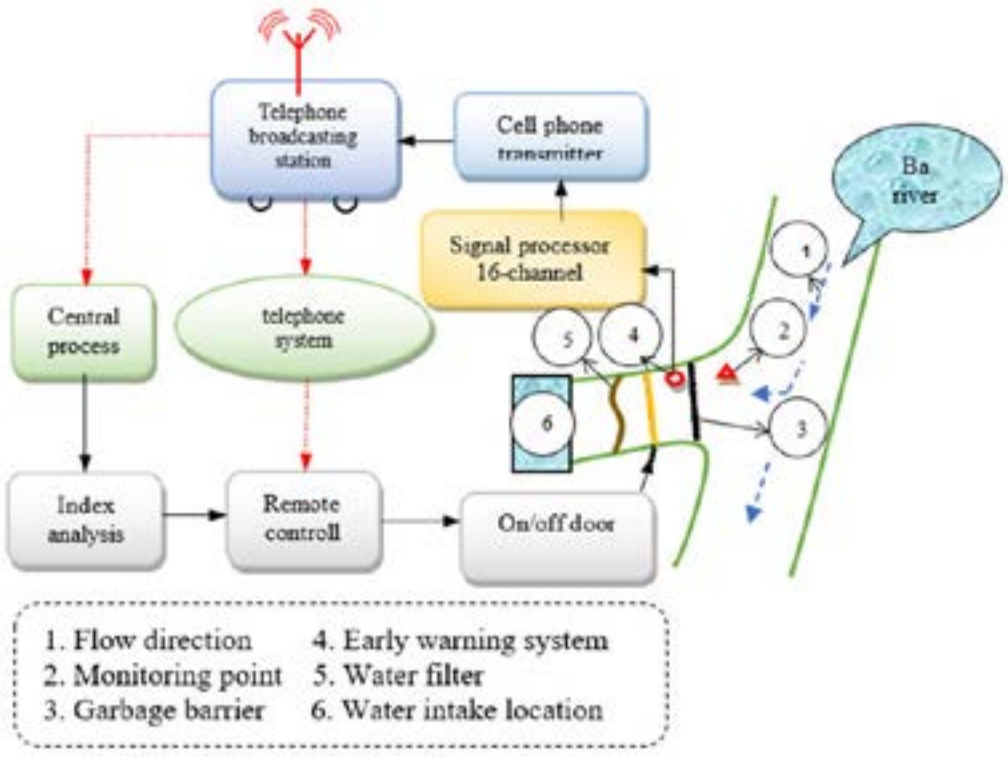

Figure 2. Proposing the operation process of the early warning system, controlling the quality of the Ba River [7]

Province, contributing to improving the quality of water supply services according to Orientation of water supply services in urban and industrial areas until 2025 and vision to 2050.

4. Conclusions

The study proposed solutions to control water supply reserves and quality in order to achieve management objectives including management control solutions according to the water supply reserve planning; solutions for monitoring the quality of water supply for urban areas and industrial zones in Phu Yen Province under climate change conditions. Moreover, proposing the process of early warning, controlling the quality of River used for water supply (Taking the Ba River at the location of the water intake workfor Tuy Hoa Water Company as typical).

The results of the proposed study are practical, which can help Phu Yen provincial managers to objectively see the current situation of water supply and the solutions to control water supply reserves and quality for urban areas and industrial zones in Phu Yen Province. Based on the study results,proposing plans, solutions and decisions for urban water supply activities in general and expanding the scale of urban water supply projects in the province in particular to achieve the set goals./.

References

1. *Circular No.08/2012/TT-BXD dated November 21, 2012 of Ministry of Construction on Guiding the implementation of safe water supply ensuring.*
2. *Vu Binh Son. Doctoral thesis (2021) Managing water supply for urban areas and industrial zones in Phu Yen Province to respond to climate change.*
3. *Decision No. 2502/QD-TTg of the Prime Minister dated December 22, 2016: Approving the Adjustment of the Orientation of water supply services in urban and industrial areas until 2025 and vision to 2050*
4. *People's Committee of Phu Yen province (2020), Decision No. 749/QD-UBND dated May 11, 2020 of the People's Committee of Phu Yen province on plans to prevent and combat drought and salinity causing lack of domestic water in 2020 in the area. Phu Yen province table.*
5. *Vu Binh Son. Factors affecting water supply management for urban areas and Industrial zones in Phu Yen Province in response to climate change. No. 11/2019, ISSN 1859 - 459X,Vietnam Bridge and Road Magazine.*
6. *Public disclosure authorized (2010), Climate Change and Urban Water Utilities: Challenges and Opportunities.*
7. *Phu Yen Water Supply and Sewerage Joint Stock Company (2019) – Report on the implementation of the water supply management plan in Phu Yen province.*
8. *Anna Hurnimann and Elizabeth Wilson (2018): "Sustainable Urban Water Management under a Changing Climate: The Role of Spatial Planning"*

Smart city management and development...

(continued on page 37)

urban spatial planning, thereby proposing smart solutions for operating technical infrastructure systems, construction and construction management, and introducing experience in applying GIS in implementing general urban planning in Hanoi and Vietnam. These are important studies to effectively implement the three main pillars of smart city development associated with digital transformation in Vietnam as stated in Project 950/2018.

Currently, in the localities in Vietnam, each different province/city is gradually building its own "smart city" according to different criteria and fields, depending on the size, nature of the city, economic conditions, culture - society, desired level of investment and the problems the city faces; In addition, the current government policies for smart city construction are lacking specific studies and guidelines. Based on practical experience, by studying the effectiveness of technology in system operation and inheriting the achievements of the 4.0 industry revolution, the research of the article will be the basis for localities to effectively apply and deploy the management and development of smart cities, as well as an important premise to realize the sustainable smart city development project in Vietnam associated with digital transformation.

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References

1. *Government of the Socialist Republic of Vietnam, Resolution No. 50/NQ-CP dated April 17, 2020 promulgating the Action Program to implement Resolution 52/NQ-TW*
2. *Government of the Socialist Republic of Vietnam, Decision No. 950/QD-TTg dated August 1, 2018 approving the Project "Sustainable smart city development in Vietnam for the period 2018 - 2025 and orientation to 2030"*
3. *Luu Duc Minh (2022) Smart City – An important motor for Vietnam's comprehensive development, Construction and Urban Magazine, Academy of Managers for Construction and Cities*
4. *Luu Duc Minh (2021) Chapter 4: Some technology solutions in management and Smart City development, Training materials on Smart City development management, Academy of Managers for Construction and Cities*
5. *Notes summary Smart City construction Project vinh phuc province 2022-2025 orientation to 2030 (2023) Department of Construction of Vinh Phuc rovince.*
6. *Politburo of the Communist Party of Vietnam, Resolution No. 52-NQ/TW dated September 27, 2019 on a number of guidelines and policies to actively participate in the 4th industrial revolution*
7. *Rotterdam-Delft3D-Flexible-Mesh-using-3D-interactive-modelling3-1366x768.png (1×1) (deltares.nl)*
8. *Le Hoang Trung, Nguyen Hoang Minh "Urban development approach to-wards smart cities", Jounal of construction 01-2023, 86-92.*

Enhancing Policies to Foster a Healthy Real Estate Market in the Context of the Fourth Industrial Revolution

Pham Trong Thuat[1], Bui Manh Hung[2]

Abstract

The Fourth Industrial Revolution (Industry 4.0) is rapidly unfolding, profoundly impacting all aspects of society, including the real estate sector. This field is experiencing numerous changes under the influence of technology and the internet. Consequently, countries, including Vietnam, need appropriate analysis and assessments to grasp, refine, and adapt to Industry 4.0, encompassing various sectors, including the real estate market. This article presents research on the practical development, the impacts, and the application of Industry 4.0 technologies in the real estate market in Vietnam. Through this examination, it evaluates, forecasts, and recommends solutions to foster a healthy real estate market and improve the mechanisms of real estate market development in the foreseeable future.

Key words: *Fourth Industrial Revolution; real estate; real estate market*

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1. Problem Statement

The Fourth Industrial Revolution, commonly known as "Industry 4.0" or "Technology 4.0," focuses on digital technology with the aid of the Internet of Things (IoT), real-time data access, and the introduction of cyber-physical systems. Industry 4.0 offers a comprehensive and interconnected approach, enabling the integration of physical and digital realms, as well as fostering collaboration and efficient access among economic entities. It empowers businesses to gain control and comprehensive understanding of all aspects of operations, utilizing real-time data to increase productivity, streamline processes, and drive growth.

Real estate (RE) is one of the few sectors that has shown adaptability and development within Industry 4.0. The application of this technology has become a prominent trend in the real estate market. Technology 4.0 is optimally utilized in the field of real estate, including customer searches, property management, and business development. The influence and assistance of Technology 4.0 contribute to the healthy growth of the real estate market, including automated real estate operations, enhanced security for real estate projects, improved supply chain management, more effective real estate management, and easier access to customers [1].

2. Study on the Practical Development of the Real Estate Market in Vietnam

2.1. Current Situation of the Development of the Real Estate Market in Vietnam

a. Regarding the market scale

The real estate market currently plays a significant role in the economy and ranks among the top 20 primary economic sectors, ranking 9th in terms of value. It has direct connections with financial markets, currency markets, stock markets, capital markets, construction markets, material and equipment markets, and labor markets. Presently, the whole country is estimated to be carrying out over 5,000 projects (with a total investment capital of over 4.5 trillion VND), which is more than triple the number compared to 2009. There are over 15,000 real estate businesses with more than 1,000 real estate trading floors.

In the last five years, foreign direct investment (FDI) in the real estate sector exceeded 18 billion USD, ranking second among all FDI sources invested in Vietnam. As of March 2023, newly registered FDI, adjusted FDI, and capital contribution from foreign investors in the real estate business sector ranked second among all fields attracting FDI, with a total investment capital of nearly 2.7 billion USD, accounting for 30.3% of the total registered investment capital. Statistical data shows that the real estate market is seen as an attractive investment channel by investors, and it is predicted to attract a large number of new investors in the future. [6]

b. Regarding mechanisms and policies

Numerous new policies have been timely enacted, becoming effective tools for managing, operating, exploiting, and utilizing land, as well as promoting the development of the real estate market nationwide. Prominent policies, such as land use and land rent exemptions or reductions, have been improved and updated to maximize their effectiveness, reflecting the state's preference and encouragement for entities in need of land exploitation and investment. Legal procedures for conversion, transfer, and leasing of land use rights are increasingly perfected and transparent.

Tax policies have contributed to addressing initial land misuse issues, creating a basis for effective land use, contributing to the state budget, and allocating resources to better meet the housing needs of the people. The mechanism for auctioning land use rights has been frequently reviewed, timely

issued, with public and transparent information, reasonable financial obligations for land-use rights projects drawing closer to reality, reducing negative issues. Land valuation, rent, land use fees, and other fees are reasonably regulated.

However, the legal framework for land and real estate market operations still has many limitations and potential risks that need to be adjusted, supplemented, and updated to create a business environment that is open, equitable, overcoming bottlenecks, adhering to market principles and rules, and attracting large investors to Vietnam. [7]

c. Regarding competitive capacity

Institutional systems, mechanisms, policies, and factors determining the productivity of the economy are crucial aspects of sustainable competitive capacity, forming the level of prosperity of a nation. The quantification of Vietnam's sustainable competitive capacity in the real estate sector is identified through the following aspects:

Natural capital and resource competitiveness in the natural environment, including existing resources in Vietnam, is still modest and not yet a superior factor compared to many countries. Resource exploitation and utilization still face many limitations and shortages that need restructuring.

Social capital, health, social security, security, freedom, equality, and people's satisfaction with their lives are given priority. In 2022, Vietnam's happiness index continued to improve, ranking 77th out of 150 countries, two ranks higher than in 2021. The effectiveness and strength of financial, land, real estate, and other resources have been fundamentally improved by increasing the proportion of scientific and technological applications in industrialization and modernization. However, it is still slow compared to expectations.

Intellectual capital, innovation, the ability to create assets, and job opportunities through innovative and value-added industries in Vietnam, in general, and the real estate market, in particular, are experiencing strong transformations but are only in the early stages. [2]

d. The current situation of real estate businesses' operations

According to the compiled data from the Ministry of Construction, the number of newly established real estate businesses (7,124, a 31.9% increase) and the number of businesses returning to operation (1,769, a 77.3% increase) in 2022 have grown significantly compared to the same period in 2021.

In 2022, with some changes in recovery in some segments, real estate businesses have gradually recovered compared to 2021. According to statistics from the General Statistics Office, in the third quarter, the real estate business sector achieved growth rates of 16.65% and 11.75% compared to the same period in 2021.

However, given the current market situation and macroeconomic policy adjustments by the government, real estate businesses still face many difficulties and challenges. Numerous market barriers and bottlenecks have not been resolved, preventing businesses from implementing investment projects, which directly affects the quantity and quality of supply in the market. [4]

2.2. Identifying the Limitations of Sustainable Development in the Real Estate Market

In addition to the positive aspects, the land management, planning, and real estate market development in Vietnam have still faced unsustainable limitations, primarily identified around the following issues:

a. Regarding the economy

State land management and real estate market operation are still hesitant, lacking strictness, and policy supply-demand and market price control are not well-balanced. Widespread discrepancies exist between the land prices set by the government and the market prices. The appraisal of project prices in the same area and the adjustment of state-regulated prices based on market prices still face many shortcomings, creating loopholes for price manipulation by interest groups and affecting economic development.

Real estate market prices sometimes experience rapid and unrealistic surges, with each price spike multiple times higher. The disparity between real estate prices and the average income per capita in the same area exceeds reasonable levels, with some areas having much higher prices compared to major cities in developed countries. The situation of interest groups inflating prices and laundering money through buying, selling, and transferring real estate, along with asymmetric and non-transparent information, causes market turbulence.

Policies related to land allocation, land recovery, financial obligations, land use rights, compensation negotiations, and related management responsibilities are not sufficiently robust and comprehensive. They often overlap and have prolonged implementation periods, leading to many frozen projects, resulting in damages to investors, citizens, and the state's economic development plan.

Long-lasting suspended planning exists in many urban areas, causing imbalances among the three elements of planning. Economic and industrial zone planning requires the retrieval of large agricultural land areas, and overall project efficiency is low, with slow infrastructure completion and low project coverage. The management and use of agricultural land and land with origins from national agriculture and forestry estates, land used for religious, spiritual, and cemetery purposes, are overlapping and inconsistent.

The number of real estate brokers is relatively high, while the management is still loose. Many self-established brokers lack professionalism, have not undergone training, and hold various unaccredited professional certificates, leading to asymmetrical information that confuses the real estate market. Transaction price manipulation below actual prices and tax evasion cause a loss to the state budget. The overall transparency of information in the industry is still limited, and national-level management of taxes, land, and real estate is slow to meet requirements. [3]

b. Regarding social welfare

The increasing population and economic development create pressure on sustainable development. The trend of migration to urban areas increases urban population growth, leading to urban pressure with large residential areas and real estate-related complex social issues. The aging population requires the provision of real estate products suitable for different age groups, leading to an expansion of the real estate market.

Non-traditional security issues related to land and real estate undermine economic and social security, and prolonged disputes over suspended planning exist. People's awareness of land and real estate laws, order, and civility is still relatively low in compliance. [2]

2.3. Causes of the Limitations in Sustainable Development of the Real Estate Market

The limitations in the sustainable development of the real estate market in Vietnam originate from the following main causes:

Firstly, the framework of land management policies and legal procedures for sustainable real estate market development is still incomplete and overlaps, despite significant changes in awareness, approaches, and updates over different periods. The land management process still heavily relies on a "request-grant" mechanism.

Secondly, the general perception of land as a natural resource, a special type of non-human-created asset and commodity, is considered a valuable production material and a precious resource of the nation and land users. As a unique commodity, its management and operation processes, from planning, land use plans, organization, implementation, exploitation, utilization, to inspection and monitoring, all require a "special" mechanism to create a sustainable real estate market.

However, at present, a clear "special" mechanism and policy framework have not been established for this "special commodity" in the context of sustainable real estate development. This framework should ensure that land resources and real estate products generate substantial and harmonious benefits for the state, citizens, businesses, and society as a whole, reducing wealth disparity and minimizing risks during the development process.

2.4. General Assessment and Forecast of the Real Estate Market in Vietnam

a. General Assessment of the Real Estate Market in 2021-2022

The consequences of the real estate fever in 2020 and 2021 have left many repercussions, and the signals of the market in 2022 are as follows:

Policy regulations implementing the Program for Economic and Social Recovery and Development have positively impacted various segments and types of real estate targeted for policy beneficiaries.

Regulations have affected market participants and the development of the real estate market in a healthy, sustainable, and efficient direction. [2]

However, from the current market situation (specifically, regulations related to capital inflows into the real estate market), it is evident that the real estate market's issues have not been significantly improved.

Imbalance of supply and demand in the real estate market, especially evident in the shortage of affordable housing and social housing.

Real estate prices (specifically housing and land prices) remain high, even though transactions in the market have slowed down, and some areas experience stagnation without any transactions.

Credit sources in the real estate market are imbalanced, leading to limited credit availability and difficulty for secondary home buyers and investors to access capital.

Legal regulations and procedures related to land and real estate projects lack synchronization and consistency among relevant laws in the real estate market.

Support services for the real estate market (brokers, real estate trading floors, market information) lack standardization, professionalism, and transparency.

b. Forecast of the Real Estate Market in Vietnam in the Coming Years

- Market volatility in the real estate sector as banks strictly control borrowing for real estate to limit speculation activities, promote market transparency, and mitigate real estate bubbles. This is essential to foster a healthy market, reduce risks for the economy, as most investors rely on financial leverage.

The first real estate forum with the topic "Forecasting the recovery time of the real estate market and investment recommendations" on September 28, 2023 commented: (i) The current real estate market is not in crisis but in general difficulties of the world. This is a period of purifying the market in a more open, transparent and effective direction; (ii) The real estate market has been recovering, compared to the golden time, only recovering about 20-30%. The real estate market will follow a better scenario, starting from the beginning of the first quarter of 2024, because interest rates have been decreasing; The policy penetration at this time will also be better. In addition, at that time, the economic and macroeconomic recovery situation of Vietnam and the world will also be clearer.

- When Vietnam effectively controls the pandemic and surpasses the disease, it will become a bright spot in terms of both epidemiological and economic safety, attracting foreigners to invest, live, and work. This will create significant demand for the real estate market in the near future.

3. Impact and Application of Industry 4.0 Technology on the Real Estate Market in Vietnam

3.1. Study on the Impact of Industry 4.0 Technology on the Real Estate Market

The summary of the impacts and assistance of Industry 4.0 on the real estate market can be described as follows:

a. Real Estate in the 4.0 era cannot overlook the presence of Facebook social network: In the 4.0 real estate era, by simply browsing on Facebook to search for information about a project, within a very short time, the phone (or computer) will be flooded with images and advertisements of that project. This is the trend for real estate agents to reach customers through the application of Industry 4.0 technology.

b. Technology facilitates the automation of real estate business: Industry 4.0 is a global trend in automation and data exchange through digital convergence with core elements such as AI, Internet of Things (IoT), Big Data, Blockchain, etc. From providing visual project information to connecting buyers and sellers, it helps enhance market transparency as all information from developers is made public for customers to easily verify and compare. This minimizes costs and labor.

According to experts, Vietnam has more than 70 million digital technology users, of which about 93-95% use smartphones, and the housing market of nearly 100 million people is valued at up to 24 billion. USD;

Research from Batdongsan.com.vn shows that more than 80% of home buyers choose online channels as the main information channel to learn about markets, projects, regions, and evaluate quality, environment, and legality when needed. Learn about a real estate product. About 49% of participants sought more support information from offline channels and 74% of them chose direct consultation before deciding to buy real estate;

According to reports, the IoT (Internet of Things) market scale on June 15, 2023 in Vietnam is estimated to reach nearly 4 billion USD by 2023 and could reach more than 15 billion USD by 2030, thereby creating Many opportunities for businesses pursuing this field.

In the real estate field, there are property management software like Landsoft that maximizes reporting tools and provides comprehensive project information to agents and developers, continuously supporting better management of real estate projects.

c. Industry 4.0 technology enhances cybersecurity for real estate projects: The 4.0 technology era has fast and exponentially increasing information transmission, minimizing communication gaps between different groups and individuals in geographical terms, reducing information leaks and security vulnerabilities caused by hackers.

When technology is applied to real estate management and business, the convenience of software ensures absolute information security, ensuring safety in brokerage and business transactions.

d. Building supply chain thinking: Combining supply chains and production has achieved many successes, giving rise to the terms "Industry 4.0" and "smart production." Technical innovations in real estate are increasing, leading to changes in supply chains in the near future.

e. More efficient real estate management: The advancement of Industry 4.0 is an outstanding solution that empowers the real estate sector, enhancing the legitimization of technology's role in real estate management and business. Additionally, for successful real estate business, developers must possess a certain understanding of the model, concept, and collaboration between relevant parties to ensure the project's implementation and feasibility.

The most crucial factor for developers is to carry out effective real estate project management. When executing a project, it requires efficient project management solutions to oversee the entire project, facilitate easy access to potential customers, and keep them updated on the project's status. This helps build trust among customers and establishes the developer's credibility, creating a strong appeal for the real estate project.

f. Easy access to customers: With the application of Industry 4.0 technology, real estate agents will not have to exert too much effort in finding target customers and spending money on advertising. Meanwhile, customers do not have to put much effort into finding a home that suits their needs. Therefore, advertising and marketing become more effective and cost less. For customers, they can easily find suitable products through a range of websites providing product information and advice.

3.2. The Application of Industry 4.0 Technology in Real Estate

The application of Industry 4.0 technology in the real estate industry is becoming increasingly powerful, making the work of those involved in the sector easier, more efficient, and cost-saving.

The use of Industry 4.0 technology in real estate facilitates easier and more convenient connections between buyers and sellers in the market. Instead of traditional phone calls and direct meetings, transactions can now be conducted through the internet and online applications, searching for real estate information via the internet, experiencing virtual tours with 360-degree views, virtual reality (VR), or augmented reality (AR).

Applying technology to the real estate market enables visual representation of project information and seamless connection with customers. This application optimizes management, information acquisition, and customer communication for investors, sellers, and real estate agencies.

Blockchain technology assists customers and businesses in handling large transactions without intermediaries, thanks to its high security and reliability. Smart contracts using blockchain technology record property transactions (buying or renting). Buyers directly send their encrypted information to the sellers.

Financial solutions like FinSo, Fintech Platforms connect project owners with investors through fractional real estate investment (Tokenization) with peer-to-peer (P2P) lending financial leverage. This technological product helps address the challenge for individuals who want to invest in large real estate projects but lack sufficient capital to participate.

Artificial Intelligence (AI) is extensively used in various aspects of the real estate sector, providing improved property searches for customers and helping agents find potential clients, thereby increasing real estate sales rates.

Management software such as Landsoft, Bee Rem, and others continuously support real estate agencies in effectively managing production processes, project management, and information retrieval.

Marketing channels like Facebook ads and Google ads support the search for potential customers without intruding on their privacy, thus increasing the chances of customer retention.

4. Recommended solutions to promote the healthy development of the real estate market in the near future

To address the difficulties in the real estate market and prevent it from becoming a factor causing high inflation, it is essential to effectively control the flow of investment capital into the real estate market to combat speculation and avoid market freezes that could negatively impact financial institutions and society. The following are some recommended solutions:

4.1. Short-term solutions to overcome difficulties in the real estate market

a. Group of solutions to adjust the supply for the real estate market

Review and handle ongoing and allocated urban development and housing projects to classify projects that will continue, projects that need temporary suspension, and projects that require adjustments in structure and housing types to align with market demand and social resources.

Urgently conclude the review of legal procedures for projects to be promptly implemented, especially large projects. Accelerate administrative procedures, resolve difficult legal issues for projects under the jurisdiction of local authorities to promote dissemination; focus on approving investment decisions, land leasing, and land use conversion.

Create a list of land fund review projects, complete legal procedures, select investors to implement social housing projects, housing for industrial zone workers, and redevelopment of old apartment buildings. Focus on effectively implementing the plan "Investing in at least 1

million social housing units for low-income individuals and industrial zone workers from 2021 to 2030".

Guide and support real estate businesses to proactively adjust their business activities, restructure to be appropriate through measures such as price reduction, adjusting the product structure to align with the market's ability to pay, applying flexible sales methods, and encouraging rental and rent-to-own models.

Continue to improve the legal framework for urban management, housing development, and real estate business, focusing on strengthening state management, effectively controlling urban planning, land use planning, housing development planning, and real estate prices to match each locality's socio-economic development plan and market demand.

b. Group of credit solutions for the real estate market

Continue to expand credit room for the real estate sector at a reasonable level, suitable for the financial capacity of credit institutions and the State Bank's monetary and credit policy, with a focus on lending to projects that are nearing completion and social housing projects with appropriate interest rates, excluding this debt ratio in the total real estate outstanding loans under control.

Issue lending criteria for different types of real estate, limiting excessive credit concentration on luxury real estate and focusing credit capital on social housing projects and commercial housing projects with high efficiency and good consumption, meeting the actual needs of the people.

Review and expedite the credit approval process for effective production and business real estate projects with high capital recovery potential. At the same time, proactively handle and submit to competent authorities for decision-making on granting credit exceeding the permitted limit for national key projects and projects serving socio-economic development requirements.

Expand credit while controlling credit quality, strengthen the appraisal and supervision of loan use to ensure compliance with the intended purposes, and limit the occurrence of new bad debts. Review and assess the debt repayment capacity of borrowers, including real estate businesses, to appropriately restructure the debt.

Strengthen the guidance and direction for companies to issue corporate bonds in the domestic market and offer corporate bonds to the international market. Create favorable conditions for companies in general, and real estate companies in particular, to continue issuing corporate bonds, fulfill debt repayment obligations, and minimize the "domino" effect risk. The government should create favorable conditions for developing alternative channels such as the stock market, bonds, public investment, attracting foreign direct investment, and mobilizing long-term capital for the real estate market.

4.2. Group of long-term solutions

a. Strengthen the management and control to ensure the balanced development of the real estate market supply and demand

Enhance inspections and control over the annual land use planning, aligning it with urban development plans and the actual real estate market situation. Strictly handle violations in land management and use.

Strengthen the management and control of the real estate market. Increase the responsibilities of central government agencies when reviewing and approving real estate business investment projects, ensuring the healthy and balanced development of the market, especially in residential real estate.

Increase the responsibility of local authorities in implementing urban development work according to plans. This is a core tool to control the urban development process and restrict rampant development projects. Local authorities must develop and be responsible for implementing investment plans according to their own proposals.

Review and prohibit the implementation of projects that are not part of the planning, lack infrastructure connectivity, and urban services. Strictly enforce regulations on land subdivision, plot sales, and the sale of unfinished houses in housing development projects. Strictly control the progress commitments of investors and homebuyers in infrastructure construction and housing completion. Implement penalties for real estate developers who delay the launch of projects, waiting for price increases.

Study the use of appropriate tax tools (real estate transaction tax, income tax, property tax, etc.) to regulate and stabilize the real estate market and prevent speculation.

b. Enhance transparency and openness of the real estate market; improve the information system and forecast the real estate market

Accelerate the development of urban area planning, provide complete information about the formation process, and implement detailed planning projects and investment construction projects. Strengthen propaganda and provide information to residents in planned areas and investors with genuine investment needs.

Establish a unified real estate market information system from central to local levels, requiring localities and businesses to submit accurate, concentrated, complete, and timely reports, as a basis for policy planning and contributing to the transparency of the real estate market.

Improve the quality of real estate trading floors, raising requirements for personnel, expertise, and minimal facilities for their operation.

Establish a real estate data center, established by the government to control the supply and demand on the market, and formulate reasonable regulatory policies and control real estate transactions through trading floors. The center will be updated with information from developers and real estate trading floors during the transaction process.

Study and establish mandatory conditions for developers when bringing real estate products to the market, ensuring transparency (such as regulations on the number of real estate units offered for sale, pricing, etc.); [4]

Intensify non-cash payment in real estate transactions to control and assess transactions while also providing a basis for building future land price databases.

5. Enhance policy mechanisms to develop a robust real estate market

5.1. Improve policies for controlling and preventing real estate speculation

To limit real estate speculation, the experience of many countries shows the need to implement various synchronized measures, including using tax policy tools to regulate income from the use and transfer of real estate into the state budget and indirectly adjust real estate speculation behaviors. The

provisions related to limiting real estate speculation are often integrated into various tax regulations.

Considering Vietnam's current market conditions and difficulties, the consideration and implementation of tax policy tools will require a well-planned roadmap. Nevertheless, this approach is necessary to help restrain the resurgence of real estate speculation, which could lead to price bubbles and market stagnation, as experienced recently.

5.2. Completing policies to reduce input costs of the real estate market

Consider regulating price control from the foundation design and total investment level during the project planning phase for supported types of housing. Additionally, study investment management mechanisms suitable for different types of real estate in this project with the aim of minimizing costs.

Examine the conditions for allowing land use payments according to the proposed business progress, providing opportunities for businesses to invest in construction and reduce reliance on bank loans. Alongside this, provide guidelines for calculating installment payments (based on market fluctuations or actual floor area at the time of payment).

Continue to explore the establishment of non-bank credit institutions to develop financial tools for the real estate market and promote market instruments (such as real estate securitization). Establish a dedicated framework for real estate lending, leveraging sources such as government budgets, government bonds, contributions from other financial institutions, etc., to develop a sustainable and stable real estate market in the medium and long term.

Accelerate research on the application of modern construction technologies and suitable building materials to improve quality, reduce costs, and shorten construction time, tailored to the specific conditions of each locality.

5.3. Ensure consistency in the legal system; closely manage and ensure the safety and stability of the real estate market

a. Ensuring consistency in the legal system:

On June 19, 2023, the Minister of Construction presented to the National Assembly the "Draft Law on Real Estate Business (amended)". This draft law is in line with the provisions of the 2013 Constitution and compatible with relevant international treaties of the Socialist Republic of Vietnam.

In terms of ensuring consistency in the legal system, it is necessary to continue reviewing the draft law and cross-referencing it with other relevant draft laws. The amendments to these draft laws must guarantee the uniformity of the legal system, align with the overall policy direction, and not create barriers to economic and social development. They must fully address the nature and essence of business activities, focusing on seeking profits, in line with the concept of business under the Enterprise Law.

Further reviews, amendments, and additions to administrative procedures for real estate investment and business should be carried out in a transparent and straightforward manner, facilitating investors and reducing implementation time. Additionally, provisions that overlap or contradict each other in property registration should be clarified to ensure the consistency and coherence of the real estate business legal system.

Continued review and adjustment of the Land Law (amended) and the draft Law on Housing (amended) are necessary to unify the definitions and principles regarding residential business, construction works, land use rights with technical infrastructure in real estate projects, and the transfer of real estate projects. Such regulations should be governed by the Law on Real Estate Business, while other relevant laws should refer to these provisions without restating them.

b. Tight management and ensuring a safe and stable real estate market

After nearly 8 years of implementation, the 2014 Law on Real Estate Business and its guiding documents have achieved certain results. However, they have also shown some limitations and deficiencies that need to be amended and supplemented.

Completing the legal framework for real estate business to develop the real estate market based on tight management, ensuring safety, health, stability, and smooth operation; restructuring the real estate market; using resources efficiently and economically; establishing a real estate market information system connected with land information; developing urban areas and real estate projects in line with rational land use planning and implementation timeline to balance supply and demand and create a suitable real estate price landscape, thus overcoming land speculation and ensuring the harmonization of the interests of the state, businesses, and people.

Continuing to promote decentralization, delegation of authority, administrative procedure reform coupled with control and supervision to ensure unified management from the central to local levels in the real estate market. Enhancing mechanisms and policies to develop a stable and healthy real estate market, ensuring the operation of real estate business relationships according to market mechanisms in the context of a socialist-oriented market economy.

5.4. Enhancing other relevant policies related to the real estate market

a. Prohibit collecting money for the sale or lease-purchase of future-formed real estate that does not comply with regulations

To complete the legal framework for entities participating in the real estate market, it is essential to establish clear business and transaction rules for these entities. This includes creating a legal foundation and framework for the operation of the real estate market. In a timely manner, the regulatory authorities should institutionalize policies, directions, and strategies for the real estate sector and its business activities, ensuring the stable, healthy, transparent, and accountable development of the real estate market.

The existing laws and regulations should be improved to be more in line with the current reality. Any shortcomings or limitations should be addressed, ensuring consistency and coherence between the provisions of the Real Estate Business Law and other relevant laws. Additionally, current regulations on different types of real estate brought into business should be clarified, along with business activities related to land use rights transfer and land leasing, in accordance with the relevant laws on real estate business. New content on "Real Estate Market Regulation" should be introduced to stabilize the real estate market in cases of overheating or stagnation.

Revisions and supplements should be made to regulations concerning existing residential and construction projects, as well as those forming in the future. This includes regulations

on residential and construction business, land use rights business, real estate project transfers, real estate business contracts, real estate service business, the establishment and management of information systems and data related to housing and the real estate market, and state management of real estate business.

b. Regulations on businesses dealing with future-formed construction projects

Establish a legal framework for this type of real estate to ensure transparency and protect the legitimate rights of investors, customers, and buyers while complying with the principle of non-retroactivity. Introduce new prohibited acts, including collecting money for the sale or lease-purchase of future-formed real estate that does not comply with regulations. Prohibit using illegal means to secure the future-formed real estate payment from the buyer or lessee, ensuring consistency and coherence with the Civil Code, Investment Law, and better alignment with practical conditions.

Clarify the necessity and grounds for proposing regulations, especially based on practical conditions and where necessary. Avoid duplicating content already stipulated in the Civil Code regarding the "deposit" in future-formed real estate transactions.

Improve the legal basis for the operation of professional and efficient real estate trading floors. Research provisions to allow parties to choose whether to transact through the trading floor or not, to ensure their interests due to the lack of practical basis and uncertainty about the necessity. [5]

6. Conclusion

The Fourth Industrial Revolution, also known as Industry 4.0, is gradually permeating every aspect of life, and the real estate market is no exception to this trend. A stable and healthy real estate market will have a positive impact on the country's economic and social development. On the other hand, an unstable real estate market, irrational prices, or prolonged stagnation will have negative effects on economic development, creating difficulties in providing housing for the population and leading to various social issues.

Studying the current situation of the real estate market in Vietnam, many businesses and investors are concerned, and individuals with actual needs are also uncertain about whether this is the right time to invest in land or housing.

In the coming time, the Vietnamese real estate market will undergo filtration and adjustment, and investors' capital allocation will be carefully calculated and more rational. Along with the improvement of policies to develop a healthy real estate market, promising opportunities for high-profit investments will emerge for both customers and the real estate market as a whole./.

References

1. *Ministry of Industry and Trade (2023), Impact of Industry 4.0 on the manufacturing industry, moit.gov.vn (June 20, 2023);*
2. *The Government and the Central Economic Commission (2022). 5th vietnam economic forum, Vietnam Economy in 2023: Stabilizing Macroeconomy, Secured Major Balances, Steadily Overcoming Challenges.*
3. *Prime Minister of the Socialist Republic of Vietnam (2022). Directive 13/CT-TTg dated August 29, 2022 on a number of solutions to promote the safe, healthy and efficient development of the real estate market.*
4. *Dang Hung Vo: "Remove bottlenecks for the real estate market in 2023", https://tienphong.vn/thi-truong-bat-dong-san-hien-nay-kho-khan-hon-10-nam-truoc-post1532743.tpo (May 9, 2023)*
5. *Government Electronic Newspaper (2023). The seminar "Bright spots on mechanisms and policies for Vietnam's real estate market" was organized by the Vietnam Association of Realtors (VARS) in Ho Chi Minh City on February 25, 2023.*
6. *Chinhphu.vn (2023). Foreign Investment Agency (Ministry of Planning and Investment), accessed May 2, 2023.*
7. *Nguyen Anh Tuan - Foreign Investment Department (Ministry of Planning and Investment). Workshop on economic assessment and forecasting in the last months of 2023.*

Applying forecasting demand for traffic model...

(continued on page 62)

However, the study has certain limitations, including the quality of the input dataset and the consideration of various scenario divisions for different transportation modes, which might affect the model's accuracy. Nevertheless, despite these limitations, the application of the forecasting model has shown promising results compared to not using any forecasting model. Therefore, future studies are proposed to involve surveying and collecting data with multiple years' worth of data, running the model with various scenarios (such as with and without public transportation, and different planning stages) to further enhance the accuracy and robustness of the research.

Acknowledgements

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References

1. *McNally, M. G. (2007). The four-step model. In Handbook of transport modelling (Vol. 1, pp. 35-53). Emerald Group Publishing Limited.*
2. *UN-Habitat, Envisaging the Future of Cities, 2022.*
3. *Ministry of Construction, Vietnam (2008) QCVN: 01/2008/BXD. National technical regulation on construction planning. Accessed July 2023 https://thuvienphapluat.vn/van-ban/Xay-dung-Do-thi/Quyet-dinh-04-2008-QD-BXD-quy-chuan-ky-thuat-quoc-gia-ve-quy-hoach-xay-dung-64619.aspx*
4. *Ministry of Construction, Vietnam (2021) QCVN 01:2021/BXD. National technical regulation on construction planning. Accessed July 2023. https://thuvienphapluat.vn/van-ban/Xay-dung-Do-thi/Thong-tu-01-2021-TT-BXD-QCVN-01-2021-BXD-Quy-chuan-ky-thuat-quoc-gia-ve-Quy-hoach-xay-dung-474747.aspx*
5. *Government of Vietnam (2023) Decision No. 323/QD-TTg of the Prime Minister: Approving the Adjustment of General Planning of Hai Phong City to 2040, Vision to 2050.*
6. *McNally, Michael G (2000) "The four step model". https://escholarship.org/content/qt7j0003j0/qt7j0003j0.pdf p. 4*

GIS in Smart urban planning and management: Lessons learned for Vietnam

Bui Thi Ngoc Lan

Abstract

Currently, smart urban planning is a development trend in many countries around the world, including Vietnam and urban development projects are associated with the 4th scientific and technical revolution. Smart urbanization can be understood as where information and communication technology (ICT) is most compatible with the existing infrastructure layer communication system, which is then coordinated and managed digitally [16]. In particular, smart urban planning and management play a crucial role in achieving expectations for smart urban development as well as many sustainable development goals.Smart urban planning and management need technology to analyze raw data into readable data, which is a geographic information system (GIS). Through the analysis of the role of GIS in the management of smart urban planning in some countries around the world and the study of the potential for smart urban development in Vietnam, the article draws lessons from the application of smart urban planning in Vietnam.

Key words: *GIS, smarturbanization, smart urban planning and management, experiences, lessons*

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1. Introduction

Smart city has been becoming nowadays a very popular topic that not only in developed countries but also in developing countries. There are variety of definitions for smart city in different fields and regions. Generally, it aims for a sustainable city development through the optimal management of the resources and potential, offering a comprehensively higher quality life to the citizens [20]. Today, smart urban development is an important way for Vietnam to effectively capitalize on the opportunities of the Fourth Industrial Revolution (Industry 4.0) and progress toward sustainable development.

Vietnam has a policy of actively participating in the Fourth Revolution in order to integrate into the global development trend (Resolution No. 52 of the Department of Political Affairs). In 2018, the Prime Minister issued Decision No.950/QD-TTg dated August 1, 2018 on Vietnam's sustainable smart urbanization for the period 2018-2025. In which three pillars for smart city development in Vietnam have been identified: (i) smart urban planning, smart city management; (ii) Smart urban utilities based on urban databases and (iii) Science and technology application [11].

According to statistics from the Department of Urban Development (Ministry of Construction), as of December 2022, the total number of urban areas in Vietnam is 888, of which 48/63 provinces and centrally run cities have been and are implementing the smart city development projects [8]. In order to ensure the success of smart city development projects, it is necessary to emphasize the role of smart urban planning and management in building spatial data infrastructure for e-government and smart city building, with particular emphasis on raising awareness of the role of digital transformation in smart city planning and development management and the application of digital map technology platforms (GIS technology) to serve digital conversion in smart urban management (digital planning profile management application, planning evaluation support application, monitoring of planning implementation, etc.).

Geographic Information Systems (GIS) are useful technologies for managing and processing integrated urban data with other forms of data to turn it into useful information to help municipal authorities choose locations, manage infrastructureand provide urban services in a reasonable way. GIS, with its constant development over the last few decades, has continuously affirmed its irreplaceable position in space research and analysis [6]. Use of GIS in smart urban planning helps and guides planners for an orderly development of settlements and infrastructure facilities within and outside urban areas [18].

To be able to analyze the role of GIS in smart urban planning and management, we must first define smart city planning management concepts. Simultaneously, investigate and select the appropriate scale and level, as well as the key factors required for the successful implementation of smart urban development.

The application of smart urbanization in Vietnam is necessary, but each locality and municipality has its own characteristics, strengths, potentialand challenges, so managing smart urban planning in each sector, each locationand each phase is a very important task. Therefore, the main method of this article is to evaluate the overall overview of smart urban planning and management, practicesand guidance for smart urban development in Vietnam, study the management of smart urban planning through the GIS systems of some countries in the world and draw lessons for Vietnam.

2. Overview of Smart cities, Urban planning and management and Geographic information systems (GIS)

2.1 Smart cities

The term "smart city" refers to a new level of development in modern cities in which information and communication technology (ICT) contributes to the management and operation of the city, bringing many benefits to both residents and

administrators and creating a better living environment [16].

Smart cities are defined in various ways, but there is no scientific definition. It is a city management model that employs information technology and artificial intelligence to manage cities, improve urban living standards, improve the quality of city government services and make efficient use of energy and natural resources.

According to Bakici and colleagues (2012), a smart city is a city that uses high technology to connect people, informationand elements in the city to create a green, sustainable city with a competitive economy, innovationand an increasingly improved quality of life.

Furthermore, it is clear that there are two major points of view in the vision of smart cities: technology and humans [1]. However, smart cities must have the following characteristics from any perspective: Smart cities are geographically defined urban areas with "smart" integration based on the ICT platform of urban infrastructure, with the goal of improving the effectiveness of urban governance, people's quality of lifeand sustainable development [16].

According to Public Letter No.58/BTTTT-KHCN dated January 11, 2018, a smart city is defined as an urban or residential area that uses appropriate, reliable, innovativeand innovative information and communication technologies and other methods to enhance the effectiveness, efficiency, analysis, forecasting, provision of servicesand management of urban resources involving people; improve the quality of life and workforce; and enhance the economy and society.

Figure 1. The smart city components [10]

Figure 2. Characteristics of Smart City [14]

Smart city is knowledge based city that develops extra ordinary capabilities to be self-aware; functions 24 hours and 7 days a week; communicates, selectively, knowledge in real-time to citizen end users satisfactory way of life with easy public delivery of services, comfortable mobility, conservation of energy, environment and other natural resources and creates energy face to face communities and a vibrant urban economy even at a time of national economic downturns [5]. The main objective of a smart city is to optimize city functions & encourage economic growth with a clean & sustainable environment while also enhancing a decent quality of life for citizens by using smart technologies and data analysis [13].

Smart urban development is a priority in the development of new urban areas and new construction projects in Vietnam during the current development era. As a result, the study and analysis of smart city features are critical to the successful implementation of smart urban planning and management. The following are the key characteristics of smart cities: (i) sustainability; (ii) quality of life; (iii) urbanization; and (iv) urban intelligence.

When it comes to smart cities, research frequently looks at technology to answer the question of what technologies can be used in a city to qualify it as a smart city. There are numerous studies and architectural opinions, but researchers all agree that smart cities require technologies such as those depicted in Figure 3 below.

To summarize, smart city is the city of tomorrow, which tries to identify a smarter option from legacy system for maximizing the end-user satisfaction and accelerating urban socio-cultural and economic development. Smart city is knowledge based city functioning on most latest and updated information on automated decision-making and rapid action for individuals [5].

Smart urban planning and management

Urban planning is the organization of space, architecture, urban landscape, technical infrastructure systems, social infrastructureand housing to create a suitable living environment for the people living in the city. It is expressed through urban planning [17].

In order to adapt to the market economy's rapid growth, urban planning is one of the most important tools for managing and guiding urban development. In other words, urban planning plays an important role in the country's economic development, including: (i) The role of identifying spatial and architectural indicators as the basis for the implementation of land use projects, infrastructure developmentand renovation of new urban buildings; (ii) The role as a tool for implementing and guiding investment in urban development on a basis that accurately reflects socio-economic and economic development trends; (iii) The role of stimulating mechanisms to ensure adequate, sustainableand well-managed provision of infrastructure and public services on the basis of commercialization of these services; and (iv) Effective management of the use, adjustment, purchase and investment of land development for all urban development purposes.

Urban planning involves many functions, scales, sectors and stages. In general, the functions of urban planning can be classified into general administration, development control, plan making and strategic planning. At this stage, urban management is a very important topic for governments and international development organizations around the world and in Vietnam. For a sustainable urban development with identity, development is inseparable from stability, for which

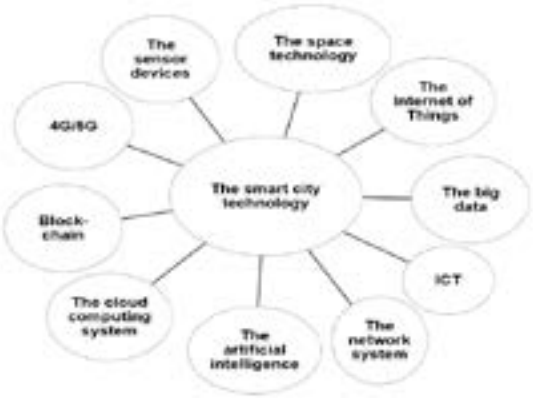

Figure 3. Technology makes smart cities

Figure 4. Components of GIS

urban management has always been a crucial task.

Urban management is the process of influencing urban activities by means of mechanisms and policies of urban management entities (government levels, social organizations, departments and functional departments) in order to change or maintain their operations [6]. Urban management focuses on three main areas of management: (i) spatial development management; (ii) urban service provision management (technical and social infrastructure); and (iii) management of urban order, safety and social justice.

Smart urban planning is to identify models of urban development, modes of movementand systems that serve the problem of human mobility, ensure the efficient use of land, adapt the way of production, consumption, culture, serve the problems of learning, recreation, health of people in a systematic way and connect to create the power of connectivity in smart cities.

Smart urban planning starts with researching and evaluating real-world human problems and needs (based on big data) and thus providing practical solutions by using data science to determine the size and location of functional areas (mini-parks, playgrounds, pavements, green spaces or gardens in urban spaces, pedestrian streets, bicycle paths, traffic circles, etc.) instead of merely guessing where these functional spaces and utilities are needed.

Smart urban planning and management is the process of impacting smart urban planning activities. Smart urban planning and management has a role to play in building smart cities in a planned way and managing intelligent cities according to the route and the plan. From there, we aim to step by step optimize the management of urban development, improve the quality of life for urban people and create opportunities for human, economicand social development.

Geographic Information System (GIS)

In line with the Party's and Government's initiatives, Vietnam is determined to develop sustainable smart cities, which emphasize the restructuring of information technology infrastructure, the formation of a number of digital platforms for common use for cities and urban areas, accelerating digital transformation in urban management activities and building e-government towards digital governance in cities closely linked to smart urban development [12].

In order to manage intelligent urban planning, the application of modern technologies is essential, one of which is GIS. GIS with spatial analysis functions helps smart urban planning processes while also helping sustainable smart urban governance, especially infrastructure management (see Figure 1).

Geographical Information Systems (GIS) are a fast-growing new technology. GIS is a technology to capture, store and manipulate, analyze and visualize spatially referenced data. It is used for spatial analysis and modeling. GIS allows viewing, interpreting and visualizing data in many ways that reveal relationships, patterns and trends in form of maps, reports and charts. It helps in delivering creation of multiple scenarios in time. It integrates hardware, software, data and people for capturing, managing, analyzing and displaying all forms of geographically referenced data [5].

GIS is also a part of spatial information systems. They processand generate spatial information (through cartographic and photogrametric products, statistical reports etc.). GIS products mainly with spatial containing, are result of the integration of spatial information and other data with multithematic character. In GIS real world models generally come in mapping and imaging formats [18]. Parts of the Geographic Information System: (i) people; (ii) spatial data and attribute data (data); (iii) analysis methods (analysis); (iv) informatics software (software); and (v) computer hardware (hardware).

Nowadays, GIS for smart cities has become an essential part of our daily lives. GIS also gives an IT infrastructure that includes not only every stakeholder but also every activity (starting from planning & conceptualization to development & maintenance) of the smart city. It enables to collect the location-based data as well as maintain the spatial database and confirms a seamless flow of information/data and links to the requirements of various stakeholders. The applications of GIS in smart city planning are countless. The city always has a dense population & more infrastructure [13]. As a toolbox, GIS allows planners to perform spatial analysis using geoprocessing functions such as map overlay, connectivity measurementand buffering.

Benefits of application of GIS in Smart cities: (i) Smart cities can create smart communities to analyze and find issues for local community; (ii) It produces citizens who are in continuing and lifelong education; (iii) Smart cities can identify appropriate representatives for multi level local governance as part of self organizing policy; (iv) Smart Cities can reduce resource consumption, energy and water, reduction in carbon emission; (v) Improve utilization of existing infrastructure capacity, improving quality of life; (vi) Can provide real-time guidance on how best to exploit multiple transportation modalities, make new services availableand (vii) GIS can help visualizing spatial impacts of situations and migratory

patterns and help in planning for urbanization [5].

Smart urban planning is one of the main applications of GIS. Urban planners use GIS both as a spatial database and as an analysis and modelling tool. The applications of GIS vary according to the different stages, levels, sectorsand functions of urban planning. With the increase in user-friendliness and functions of GIS software and the marked decrease in the prices of GIS hardware, GIS is an operational and affordable information system for planning. It is increasingly becoming an important component of planning support systems. Recent advances in the integration of GIS with planning models, visualisationand the Internet will make GIS more useful to urban planning. The main constraints in the use of GIS in urban planning today are not technical issues, but the availability of data, organisational changeand staffing.

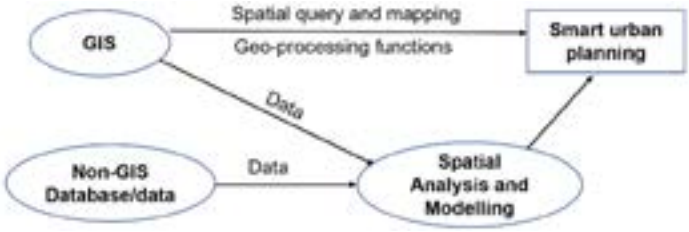

Figure 5. GIS and Smart urban planning

Conclusion GIS can be used throughout the life cycle of a smart city – from site selection, design and construction to use and maintenance. GIS is an ideal technology that has the ability to scale across any expanse, from the individual asset within a building to a virtually global context tying all aspects of a Smart city planning and development.

Experiences of countries with the use of GIS in smart urban planning and management

This article discusses the use of GIS in smart urban planning and management in a variety of countries around the world. GIS and technologies related to Smart urban idea are well known in the analyzed cities.

3.1 India

Smart Cities in India Lavasa in Maharashtra is India's first e-city. Lavasa homes will offer touch-point automation, occupancy-based lighting, door and motion sensors, beam detectors and on-call transport services. GIFT City in Gujarat have a central command centre to monitor the city-wide IT network and respond quickly during emergencies, energy efficient cooling systems instead of air condi-tioningand high-tech waste collection systems. Cars will remain outsideand there will be moving walkways to get to the city centre.; Bangalore opting for geographic information systems (GIS) to standardize property tax administration [15].

In addition, GIS applications are widely used in smart cities, including: Aligarh Smart City uses GIS for city planning and estate management. Bihar Sharif Smart City utilizes GIS for property tax analysis; Moradabad Smart City uses GIS for road and traffic network analysis; Agra Smart City uses GIS for water supply networks and sewerage network analysis; Ranchi Smart City uses GIS for solid waste analysis, etc. A few significant applications of GIS in smart city projects with screenshots are depicted below [13].

Figure 6. Using GIS for city planning in Aligarh smart city [13]

3.2 Malaysia

GIS technology has long been applied in planning activities, which essentially include plans formulation as well as development control (Johar et al., 2003). Federal Town and Country Planning Department had published the manual for preparation of development plans at various levels, with provision that all plans need to utilise GIS technology in their formulation. As in the case of Pekan district, the GIS database was developed for facilitating the preparation of the District Local Plan. The district covers an area of about 380,500 hectares, located in the east coast of the State of Pahang. A well-integrated lotbased GIS database and base map were designed to meet the local authority's requirement. At this level, spatial analyses involve determination of land suitability and allocation using the multicriteria evaluation technique (refer Figure 7) [19].

GIS for development control has been applied in the City Hall of Kuala Lumpur through the development of an integrated system that can be seen as an innovative approach to urban planning. In the case of Development Control System for City Hall of Kuala Lumpur, GIS application has been integrated with several other subsystems for urban management, particularly development control. Figure 8 shows the interactive maps application for City Hall of Kuala Lumpur whereby GIS was adopted and incorporated with the information system for planning for the purpose of development control [19].

3.3 China

In China, 3D GIS applications in Shanghai to become a smart city to Live. In 2020, Shanghai won the World Smart City Award for its projects to make the city more livable, sustainableand economically prosperous. One of the most notable highlights in Shanghai is the development of a 3D geospatial model of the entire city. 3D GIS is practical in a virtual environment with geographic coordinates that can even model both indoor and underground spaces.

The Shanghai Surveying and Mapping Institute has successfully deployed 3D GIS in urban planning, urban layout management, cultural heritage conservation, weather forecasting, fire controland many other activities. Shanghai's 3D GIS model covers all buildings and outdoor spaces but also maps both the interior of buildings and underground systems such as pipelines. The biggest

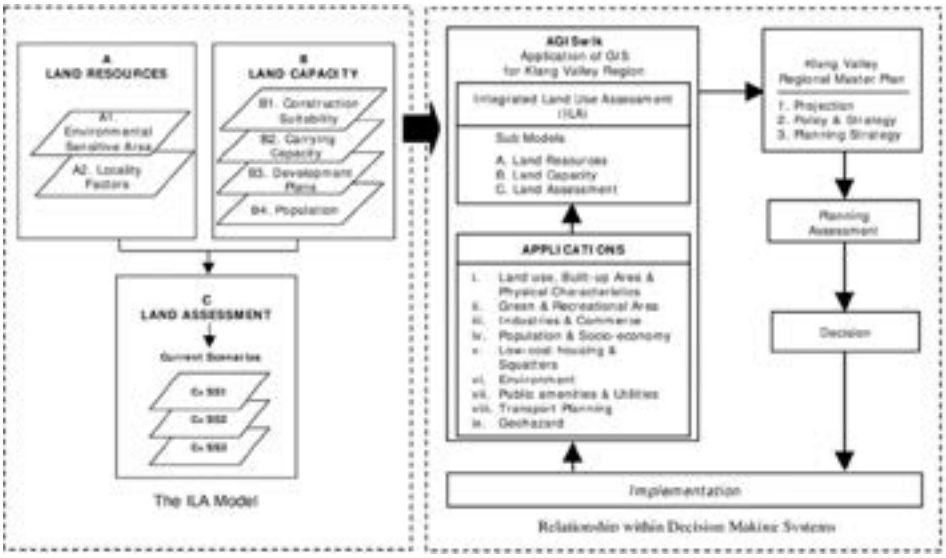

Figure 7. Model developed and implemented for Integrated Land Use Assessment of Klang Valley [19]

advantage of 3D GIS is the availability of huge amounts of data, including big data sets and live dynamic data, at any location and at any time [2].

3.4 Another countries

The USA is one of the leaders in GIS technology, with a national data system that is very well built on the basis of national and international standards. Los Angeles City planning has developed a map and area information access system (ZIMAS). The system is an invaluable GIS resource that stores land planning and use information across the city, with layers of information needed to balance competitive priorities and solve complex problems, such as optimizing new land use to fit the growing population. People access ZIMAS using a web browser or a smartphone app. In Paloma, California, since 1994, experts have connected different software, including GIS, to simulate the development of the city in different scenarios. The calculation and forecast of population, employment, housing, utilitiesand public transport are done on dedicated software and then automatically entered into the GIS as an input to land use planning and functional zoning. The entire planning process is almost automated. This has enabled planning and management agencies to make decisions accurately, objectivelyand quickly whenever there are fluctuations in social or natural environmental factors.

In Japan, GIS applications have been widely used in every field. The '1990s applied multidisciplinarity (agriculture, archaeology, earth science, transportation, construction planning, land managementand education). Japan has applied GIS in construction management and planning through the government, related ministriesand planning training in universities.

In France, in urban development planning, GIS is successfully applied in national territorial planning, regional planningand urban planning due to its rich national data base and national standards in terrain, geography, non-picture maps, statisticsand many other specialties [4].

From the experience of the above countries, we can support smart urban planning in Vietnam by building a database of GIS and integrated maps, 3D GIS, and a system of access to maps and regional information that is widely applicable in all areas such as: intelligent transportation, intelligent energy, national territory planning, regional planning, urban planning, and property management; providing water and analysis systems for drainage systems; urban layout management; cultural heritage conservation; weather forecasting; fire control; management; storage of land planning and use information; development control; etc.

4. Some lessons for Vietnam

Vietnam has also been a member of the ASEAN Smart City Network since 2018, with three member cities: Hanoi, Hochiminh and Danang. Today, many cities and municipalities in Vietnam have been developing smart cities on platforms and solving various urban problems. But the majority of the focus is on applying utilities and taking utilities to promote smart city brands, not going deeper into smart urban planning. In other words, there is some embarrassment in implementing smart urban developmentand it seems that utilities are always the first thing to be mentioned when talking about smart urbanization nowadays in many Vietnamese municipalities [11].

According to statistics, by the end of 2022, there has been 54 of the 63 provinces across the countryand cities have and are implementing smart urban projects. 30 provinces and towns approved the Smart Urban Development Scheme, Program, or Plan; 15 provinces and cities approved ICT architecture for smart urban development. So far, 38 provinces and cities have deployed the Intelligent Operating Center (IOC) at the provincial level; 21 provinces and cities

Figure 8. Interface for Interactive Maps Application through the information kiosk [19]

are deploying the IOC at the municipal level; and 17 of the 63 provinces have implemented the intelligent tourism service application.

At the moment, when most municipalities are implementing new smart cities, the focus is primarily on the development and provision of services by smart urban utilities, which are primarily connected with e-government and digital government services, rather than on the work of planning and smart urban management to solve problems based on urban problems such as transportation, energyand the environment. Smart urban planning management is, in essence, a digital transformation of scope, urban scaleand people-centricity. This is a constant, long-term processand organizing resources to deploy is a major challenge [7].

GIS technology has recently been applied to a number of urban planning projects. GIS has been applied locally to manage databases of construction planning projects (visual display on the GIS Web platform that is easy to search and manage); GIS is used to manage assets and technical infrastructure equipment: plants, lighting, water supply; GIS combines remote sensing technology to create applications for environmental monitoring, forest resource management, water resources, deforestation assessment... and more [3].

However, the results of GIS applications are not actually as desired. Urban planning is mainly based on traditional technology, with AutoCAD design support software and graphics software. Most have not used GIS technology to support planning in urban planning steps like planning tasks, gathering status data, evaluating status and identifying potential for urban development, land use planning, technical infrastructure planning, strategic environmental assessment, urban design, etc [9]. At the same time, the application of GIS in urban management continues to face many difficulties, hampered by policy; regulation is incomplete and unified; many localities do not truly care about and evaluate the role and importance of the GIS; information technology infrastructure in many locations is not ready; the quality of input data used to build databases is poor; human resources with GIS expertise are in short supply...[3]. Thanks to research on GIS in smart urban planning and management in some countries around the world, the article is capable of drawing some lessons for Vietnam as follows:

The first lesson: Developing specific scientific and quantitative paths for GIS applications based on the needs of regulators and analyzing the extent to which GIS applications can be influenced in urban planning management. Therefore, it is necessary to clarify the relevance of the legislative instruments to the area of smart urban planning management, ensuring effective capacity control of planning and smart urban management in the future in Vietnam. This is aimed at applying the GIS geographic information system to enhance the capacity of state management in smart urban planning management. At the same time, urban planning managers can explore more scenarios in the planning process to develop strong and effective long-term strategies.

The second lesson: Building and researching information and data related to the areas of using GIS technology in the functioning of smart urban planning and spreading GIS knowledge to people working in the field of smart urban planning is important because the more people who use it and realize the potential of GIS, the greater the creativity between users and the development and testing of new techniques and methods.

The third lesson: Data analysis and database management concern the development of the analytic environment, which converts real-time and historical data into operational data that improves the security, efficiencyand quality of urban systems. The analytic environment includes engineering, managementand safety software for urban systems as well as advanced digital tools. In smart urban planning, GIS provides tools for (i) geospatial data analysis (distance and direction analysis, geometrical processing, grid models), (ii) spatiotemporal analysis, (iii) spatial statistics (spatial autocorrelation and egression), (iv) surface analysis (surface form and flow analysis, gridding and interpolation methods) and (v) location analysis (shortest path calculation, facility location).

The fourth lesson: Construction of the sensing layer in smart urban planning. This layer includes sensors used for monitoring urban networks and infrastructure. Data could also be enhanced by images, videosand audio files, resulting in the construction of urban big data. GIS offers the possibility to visualize the monitoring system as well as the sensors' characteristics and status. It also provides the possibility to visualize real-time and historical data on GIS maps.

The fifth lesson: Developing GIS application processes in intelligent urban planning management to suit the current legal framework and practical conditions of Vietnam, including: (i) building general GIS application processes; (ii) building spatial database processes; (iii) implementing urban planning GIS app processes; and (iv) GIS application processes in urban planning management. At present, the application of GIS in smart urban planning and management of intelligent urban planning in Vietnam is essential in the context of strong urbanization as well as in the favorable development of information technology in general and GIS specifically.

5. Inclusion

The research conducted showed that GIS plays an important role in smart urban planning and management, which is well known in the analyzed cities. GIS tools are used in the digitization of maps, objects and spaces. Digital maps are made available both for the internal needs of the city and for external users, including residents and investors. Solutions in most cases involve city surveillance, analysis of data from air sensors, or management of information board content. Experience from a number of countries around the world on the application of GIS in smart urban planning and management is seen as a useful suggestion to find solutions for Vietnam. Through practical experience from other countries, the lessons learned contributed to supporting Vietnam in solving limited issues, existing in data analysis, building and managing databases, applying GIS geographic information systems to enhance state management capabilities in smart urban planning management, and building sensor layers in intelligent urban planning to monitor urban networks and infrastructure. Simultaneously developing GIS application processes in smart urban planning management in line with the current legal framework and practical conditions of Vietnam. From there, it contributes to solving some of the difficulties encountered to unify policies, regulate legislation on the digitization of urban planning data from central to local, synchronize, communicate, and complete information storage of the data, and unite the perceptions of departments, industries, and localities on urban planning digitization and synchronous information technology infrastructure./.

References

1. *BinhPhuoc Provincial People's Committee, "Applying GIS technology to build a smart city worth living", https://binhphuoc.gov.vn/, 2022*
2. *Han Minh Cuong (2022), GIS applications support decision-making for sustainable urban development management, https://moc.gov.vn/, Accessed November 9, 2022*
3. *Geographic Information System, Application of Geographic Information System (GIS) in Smart Cities, https://planningtank.com/, 2017*
4. *Nguyen Cong Giang, Dang Vu Khac, Vu Anh Tuan, Bui Thi Ngoc Lan and Ngo Duc Anh, Urban planning management through the geographic information system GIS, Technical and scientific publisher, Ha Noi, 2022*
5. *Le Hao, "Building and developing smart cities in the context of urbanization and digital transformation in Vietnam", https://moc.gov.vn, 2023*
6. *Ban Mai, "Smart City: Select the appropriate model", Vietnam economic times, 2023, Accessed 22 February 2023*
7. *Ministry of Construction, "2020: Ho Chi Minh City will launch Phase 2 of the Smart City Project", https://moc.gov.vn/, 2020, Accessed 26 March 2020*
8. *Dao Thi Nhu, "Smart urban planning towards smart cities", T`he Architectural Magazine, 2022*
9. *Resolution 06-NQ/TW and Programme of Action for Implementation of Resolution 06-NQ/TW issued on January 24, 2022, by the Ministry of Politics on Planning, Construction, Management and Sustainable Urban Development of Viet Nam by 2030, Vision to 2045*
10. *Scanpoint Geomatics Ltd, "Power of gis to empower smart city management", https://www.sgligis.com/, 2022*
11. *B.N.Silva, M.Khanand K.Han, "Towards sustainable smart cities: A review of trends, architectures, componentsand open challenges in smart cities," Sustain Cities Soc, vol.38 No.August 2017, 2018, 697–713*
12. *Vu Anh Tuan, Nguyen Cong Giang, Bui Thi Ngoc Lan and Ngo Duc Anh, Toward the smart city and the role of GIS – Challenges in Vietnam, Proceeding of the 3rd conference on sustainable earth, mine, environment, 2020*
13. *Urban Planning Law No.16/VBHN-VPQH issued on July 15, 2020*
14. *Ahris Yaakup, Ahmad Nazri Muhamad Ludin, Susilawati Sulaiman, Haibenarisal Bajuri, GIS in urban planning and management: Malaysian experience, International Symposium & Exhibition on Geoinformation 2005 - Geospatial Solutions for Managing the Borderless World, Pulau Pinang, 27 – 29.9.05, 2005*
15. *Shinji Yamamura, Liyang Fan , Yoshiyasu Suzuki, Assessment of urban energy performance through integration of BIM and GIS for smart city planning, International High- Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016*

A social scientist in the studio

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the Harvard Business Review on The Making of an Expert states "that outstanding performance is the product of years of deliberate practice and coaching, not of any innate talent or skill." He has also written about research that supports the notion of a '10-year rule' for the acquisition of sufficient experience (assuming the years of experience are truly challenging the person to grow, continually) for a person in any field to reach the international level of notable expertise [see his chapter on "Enhancing the Development of Professional Performance" in Development of Professional Expertise,edited by K. Anders Ericsson]. [14]

Again, this is helpful information for any student (or teacher) in the field, especially as they enter the workforce and consider at what point they may begin to reach the threshold when they might move out on their own.

5. Conclusion

Exposure to perspectives from the social sciences, trained on the activities of learning and teaching, furthers a deeper engagement in the work of fostering new knowledge for students. For me (and, I hope, for my students) these perspectives have framed and reframed the situations of learning and teaching in very productive ways.

I hope these observations aboutperspectives on learning and teaching can contribute to conversations about the relationship between educational practices in schools of architecture in Viet Nam and the USA. In my own work with students, these theories and others interweave in the continual, exciting dynamic of learning and teaching./.

References

1. *Shulman, L. S., (2004). The wisdom of practice: essays on teaching, learning, and learning to teach. San Francisco: Jossey-Bass.*
2. *Liebow, E. (1993). Tell them who I am. New York: The Free Press.*
3. *Boyer, Ernest, and Lee Mitgang. Building Community: A New Future for Architecture Education and Practice. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching, 1996.*
4. *Armstrong, Michael. (1980). Closely observed children. Oxford: University Press.*
5. *Frampton, Kenneth. Modern Architecture: A Critical History (Fifth) (World of Art). Thames & Hudson. Kindle Edition.*
6. *Dweck, C. S. (1999). Self-theories. Philadelphia: Psychology Press.*
7. *Perry, Jr., William G. (1998), Forms of Ethical and Intellectual Development in the College Years: A Scheme. Jossey-Bass.*
8. *Kloss, Robert J. (1994). "A Nudge is Best: Helping Students Through the Perry Scheme of Intellectual Development." in College Teaching. Volume: 42. Issue: 4. Questia Media America, Inc. www.questia.com accessed 05.23.2006*
9. *Kegan, R. (2004). from Fichman, E. unpublished class notes from Thinking Like an Educator course (10.25.2004). Cambridge, MA: Harvard University Graduate School of Education.*
10. *Berger, Jennifer Garvey. (1999). Key concepts for understanding the work of Robert Kegan. Course pack forRobert Kegan's Adult Development course, Harvard Graduate School of Education, Spring 2005: copyright Jennifer Garvey Berger.*
11. *Gardner, H. (1993). Creating Minds. New York: Basic Books.*
12. *Vygotsky, L.S. (1978). Mind in Society. Harvard University Press. Kindle Edition.*
13. *Duckworth, E. "Brown Bag Lunch Series" (02.11.2005). Friday February 11, from 12-1pm in Longfellow Hall, room 225; Harvard Graduate School of Education. EF unpublished notes.*
14. *Ericsson, K.A. (2009). Development of Professional Expertise. Cambridge University Press - A. Kindle Edition.*

A social scientist in the studio

Eytan Fichman

Abstract

Studio-based learning is now the standard in architecture education in the world as well as in Vietnam. The design studio is now not just a place to work or meet between lecturers and students or between students themselves to solve design problems, but has truly become a "home" for students in their study time at school. The teacher not only plays the role of a lecturer but also must be a social scientist and apply social science trends in teaching, especially teaching in cross-cultural contexts like Vietnam;this is truly something special. This paper will introduce several branches of particular interest to me such as ethnography, developmental psychology and cognitive science as they might pertain toarchitecture education, using the lenses of a school of applied social science,in order to re-examine local norms and expectations. Exposure to those fields has given me a foundation with many vantage points from which to reflect on architectural education in particular and schooling in the creative arts in general.

Key words: *Architectural education, design education, design pedagogy, expertise, studio culture, pedagogical content knowledge*

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Content

For over 45 years I have been immersed in architectural education, primarily in the northeastern United States, first as a student, then as a teacher, for a time as an administrative leaderat the Boston Architectural College, and, for the last 13 years, returning to teaching, in Hanoi, Vietnam.My 1984 graduate architectural thesis, at Harvard's Graduate School of Design, looked at the relationship between Japanese and Western space, as well as exploring a dialog between form and place-making traditions from east and west. Since 1989 I have had an independent architectural practice.

In the 2004 / 2005 academic year, as I turned 50, I became a full-time student again, at Harvard's Graduate School of Education, bending all mystudiesthere in the direction of design education, especially studio-based learning and teaching. The school of education seemed to me to be a school of applied social science, includingseveral branches of particular interest to me: ethnography, developmental psychology and cognitive science. Exposure to those fields has given me a platform with many vantage points from which to reflect on architecturaleducation in particular and schooling in the creative arts in general. Some of the perspectives I explored in my graduate research were ethnographic. Otherswere psychologically developmental, trained primarily on college students'cognition, while also including (younger and older) adults' attitudes towards cognition as they study and practice towards the ultimate end of becoming expert in their fields.

Ethnographers trying to understand the culture in a given settingcan look at phenomena like language, customs, norms, assumptions, rituals, and expectations characteristic of the setting. In a school of architecture, one-on-one discussion of creative work or public reviews of creative workwould qualify as norms; they are characteristic modes of interaction between faculty and students. Expectations about curricular sequences typical of schools of architecture might also help characterize the educational culture of schools in a region or nation. For some years now,I have come to think of myself, at leastsometimes,as being simultaneously a teacher andan ethnographer in my role as an educator. I certainly participate in the culture as a teacher and, from time to time, I try to stand back from the situation in order to try to understand it, and my work with students in it, better.

Psychologists can look for modes of thinking and feeling within groups as well as within individuals. Some developmental and cognitive psychologistshave examinedadults' and young peoples'self-theories regarding their own intelligence (Carol Dweck is one). Others have researched college students' and adults' beliefs, and the stages of development of those beliefs, concerning the nature of knowing (William Perry and Robert Kegan, respectively, for example). Some have explored the notion of multiple intelligences (sometimes referred to as MI) rather than a singular intelligence (sometimes referred to as G) to better explain the diverse ways of, and aptitudes for, learning among the individuals in a classroom (Howard Gardner is the founding researcher behind the multiple intelligence theory). Still others have looked in detail at the social scaffolding and constructing of new learning (Lev Vygotsky pioneered this way of thinking). Encouraging exploring, and not relying on telling,are concepts central to the mode of teaching and learning called Critical Exploration (Eleanor Duckworth's approach).Joining these approaches as building blocks leads towards the ultimate goal of forming expertise is my interest (K. Anders Ericsson is one of the most prominent of the expertise researchers, whose work I have consulted).

Exposure to these frameworks hasprovidednew reference points within my field of vision when I look at students and teachers at work (my own included)on learning and teaching in architecture schools. These frameworks sometimes seem to allow me to "go meta," as Howard Gardner used to sometimes say in his lectures; they seem to allow me, from time to time, to "stand back" from the world I am immersed in, a mental re-positioning Robert Kegan used to discuss in the context of his developmental theory. These frameworks might comprise ladders towards achieving critical distance.

This might be as good a point as any for me to apologize for the hubris of seeming to represent myself as a social scientist in the studio in the title of this paper.

Perhaps it is better thought of as half aspiration and half truth. I try to look at the world in these ways, sometimes, but I really have modest formal exposure to these fields, primarily through my degree studies in education, and several years thereafter, when I continued researching these areas independently. Since then I have continued to research and think about my work in ways that are influenced and inflected by these perspectives from the social sciences.

There are of course elements of the architect's work that overlap the social sciences deeply (assessing client needs for example, can be very much like an ethnographer's work). An architectural educator's practice joins professional topic field knowledge with an educator's perspective on learning and teaching (Lee Shulman's framing of Pedagogical Content Knowledge). This last part is the most extensive 'socially scientific' element of my resume, although most design professors (as well as most college professors, for that matter) have not beenschooled specifically in education, or in applying the related social sciences to learning and teaching.[1]

In the fall of 2007 I made my first trip to Viet Nam. I returned a number of times in 2008 and 2009 and moved to Hai Phong in the summer of 2010. I began to teach at Ha Noi Architectural University (HAU) in the fall of that year. Teaching at HAU adds cultural layers I only partially understand to the familiarpractice of teachingarchitecture.While I was introduced to some of the cultural currents of East Asia decades ago, through an early interest in Japan, a couple of architectural tours there, and some modest coursework in the area, I am still very much a novice student of the culture of Viet Nam. Inevitably I find myself exploring comparisons with my past experiences, Western and Eastern, while reflecting from time to time onthe worthiness of mypreconceptionsas well as my evolving new understandings.

Colleagues and friends in Viet Nam and America have, from time to time, asked me to compare my experience of architectural education in the two nations. That is part of the subject I would like to treat here, both indirectly and directly. I would like to treat the subject indirectly by talking about how I am looking at and thinking about the comparison, informed by perspectives from the social sciences, along the lines I introduced above, weaving these in with my longer experience as a design educator. I would like to convey more directly the comparative East / West impressions forming in my mind as a result of these perspectives.

1. An anthropologist steps into the room

While culture is the domain of anthropologists, design studio culture is an explicit subject for self-examination in every accredited school of architecture in North America – to engage self-study on studio culture is oneof the requirements for collegiate architectural accreditation.

The anthropologist can study a cultural issue or situation in many ways. One way is through being a participant-observer, immersed in the culture you are studying. For schools of architecture in North America, this is really the 'default' method, as the people doing accreditation-related self-study of studio culture are typically the students and faculty learning and teaching in the studios and the administrators that help coordinate the faculty's work. These "anthropologists in the studio"are living in the cultural "world"they want to analyze; they get to know the people in that place very well. They would need, if they applied an anthropologist's rigor to these matters, to examine the assumptions they themselves may hold as well as their own predilections and preconceptions. They would want to try to stand back enough from the situation they live in, in order to develop analytical understanding of it.

One very thoughtful example of participant observer research form isElliot Liebow's study of women in homeless shelters called Tell Them Who I Am.Liebow is absolutely immersed in the world he is studying, and develops strong feelings about the people he studied at these homeless shelters. Arguably this biases the work, but, at the same time, through empathy and personal contact, he develops deeper understanding. The 1996 report on architectural education prepared by Ernest Boyer and Lee Mitgang, Building Community: A New Future for Architecture Education and Practice, was a rare instance of educational experts from outside the design disciplines doing a thorough study of schooling in architecture. Their focus on studio culture, among many other focal areas, may have helped place a subject that was taken for granted onto the radar screen of accreditation leaders, and by extension, on the radar of architectural educators across north America.[2], [3]

When I think of myself as an anthropologist in the studio I find it productive to vary the scale of my studying. I can zero in on what I think of as the culture of an individual student or professor caught up in a particular, situated moment. For me this highlights the importance of getting to know students as individuals – an approach impressively well documented in Michael Armstrong's Closely Observed Children. It can scale up from there to the culture of groups and cliques that can form within a studio during a semester. The school itself, overall, can exemplify a culture (I think of the Cooper Union, when it was led by John Hejduk, based on its reputation, its publications and on discussions I have had with a graduate from that time).Further,the school can exemplify currents, traditions and standards within regional, national and international educational practices. [4]

In moving from the northeastern coast of the USA to the northeastern coast of Viet Nam, the cultural shift has been from a specific locale within'Western Culture' to an equally specific locale that I understand as both East Asian and Southeast Asian. The histories of cultural development and exchange in each setting exert strong influences on each place's presence. Architecture students learn how important it is to shift scale in order to understand a building's design. It can help the educator as well. Shifting one's point of view culturally by moving to the other side of the planet provokes growth of understanding (and, inevitably, misunderstanding) as well.

2. Pedagogical, physical and social cultural history

Indigenous architecture in Viet Nam can be seen in different ways. Travelling to farming and craft-oriented villages may provide a helpful window on early unselfconscious architecture, some of which is still active and extant. The Ethnology Museum in Ha Noi provides a collection of built examples from villages around the country. Archeological museums here take the history further back. Ho Chi Minh's house in Ha Noi is an exquisitely refined version of one indigenous type.Looking for the roots of Native American architecture can be more of an archeological exercise, since relatively little remains of the indigenous ways of living. Overlaid on Native American roots are the indigenous architectures of the generations of immigrants that people America.Overlaid on native Vietnamese roots are the cultures

of China, the more South Asian Cham people, the French, via the colonial period and then the cultures of the Soviet nations. Clearly the architectural cultures, from a historical perspective, are quite distinct, yet they speak to one another through the confluence of Vietnam's historical periods, as well as through contemporary, internationally modern, ways of working.

19th through 21st century modern technologies and cultural currents havecertainly flowed internationally around the world. Wrestling with reconciling these situated and international complexities of local rootedness and international modernity may be aided through Kenneth Frampton's well-published notions concerning critical regionalism – notions equally appropriate to the struggles of students (and practitioners) in Viet Nam and the USA.[5]

Interestingly, France casts a long pedagogical shadow in the USA as well as in Ha Noi. Students in the USA learn about researching precedents, developing a parti and charetting when they work all night to meet a deadline. In these respects, and others, they often learn in an atelier mode that has some of its roots in the Ecole de Beaux Arts' norms and expectations. In Ha Noi students still make watercolor renderings of classical Western architectural elements. They make drawings of historical examples just as students in the Ecole did. The curriculum of Hanoi Architectural University has beenstrongly influenced by Soviet models, along with contemporary international currents.

Architectural culture in a place is formed in significant part by the environment of the place. Students in each city and region learn from living in and on the streets and spaces around them. Boston's Commonwealth Avenue or Bulfinch Triangle become sites where students design their projects. Traces of Dutch, British, French and International Style architectures are found in Boston's historic fabric. Ha Noi has its Old Quarter, as well as many other traces of architectural, civic and planning forms which have become part of itsmix of legacies. In each school's landscape, urban or rural, these legacies and traces teach subsequent generations by experiential example. Globally, climatically and regionally, distinct local architectural histories help differentiate learning at one school from another, and one region from another.

3. Socially familial life

There is a socially familial quality to life in design studios that stands out as quite unusual in the US. While generations of students (like generations of, for example, medical students) have comparedthe rigors of their education to a military'boot camp' (since the physical and emotional demands can be extreme), at the same time the social support system among architectural students is extremely strong. Many students in the US end up 'living in studio' for long periods of time, only going home to 'crash' – to catch up on their sleep. Students who work side-by-side all night to complete their work form strong bonds that can last a lifetime.Students alsodigest theirlessons and struggles collaboratively, helping each other process and progress, giving advice to one another, while observing one another's ways of thinking and working – it is common for graduates in the US to say that they learned more from their fellow students than they did from their teachers.

Viet Nam enjoys a socially familial quality of life as a norm - this stands out for mevery strongly as quite extraordinary, especially when I compare it with life in the USA.Some anthropologists tie this East Asian characteristicof communality to traditional life in rice-farming villages. Viet Nam also has a relatively homogeneous population when compared to the cultural diversity of the population of the USA. As a result, more can be inferred when conversations and exchanges take place among Vietnamese students and teachers; less may need to be said explicitly. In contrast, the well-known reputation for 'frankness' in the USA – of people saying what they mean in more explicit terms – is perhaps, in part, a cultural response to the diversity of norms within the population and the resultant impracticality of leaving things unsaid.

Teachers and students trying to cross the cultural boundary between Viet Nam and the USA need to be aware of these 'cultures of communication' and try to be mindful of them, as best they can, in all of their complexity.

4. The developmental psychologist's sympathetic accompaniment

a) Self-theories

Carol Dweck, in her book Self-Theories, explains her research findings regarding students' self-theories about their own intelligence. I believe her findings can be extended and applied to students' theories about their own 'design intelligence' - what is often termed 'talent,'(however I know of no specific study of self-theories related to 'talent'). Dweck's studies showed that most students fall into one of two categories in terms of how they view their own intelligence. They either believe intelligence is something fixed – a quality you are born with - or they believe that intelligence is malleable and can be improved every time you learn something new. [6]

Her findings indicate as well that those with a malleable self-theory of their intelligence are more resilient in the face of difficulty (more willing to try again after mistakes or perceived failures). For those with a fixed theory, failures can be emotionally crushing;failure becomes like an indictment of lack of intelligence. Dweck explored trying to change people's self-theories from fixed to malleable by explaining the research to them. She discovered that many can be swayed to change their self-theory when they understand the research-based evidence. For me, these findings are as profoundly relevant in the Vietnamese studio as they are in the USA, and relevant to majors in any subject, for that matter.

Design studio culture in the USA and in Ha Noi often includes public reviews of student work. These critiques can be delivered with empathic care but they can also be delivered harshly, even cruelly. Over the years I have seen a number of students publicly break down in tears during such situations, and my experience is not unusual. Some students become cynical about design education as a defense against the feared or actual public humiliation. Others who keep their stress hidden may still feel like they are being crushed orfeel that they are losing face. Some of these student responses may have an East / West cultural component. On the other hand, the position of the teacher in East Asian cultural hierarchy is very high, compared to the west. That can strongly influence the dynamics of teacher and student interactions too.

In architecture school the value of Dweck's research might even be magnified: until more architecture faculty exercise empathetic care in their remarks, the ability to be resilient in the face of what may feel like public failure and humiliation is crucial for students of architecture. Students

who learn about Dweck's work may be better prepared for this. Faculty who know about Dweck's work may think twice before subjecting their students to potentially devastating criticism (or, in some cases, high praise).Dweck also indicts blanket positive feedback (like, "you are a very smart person") because, similar to blanket negative criticism, it reinforces a fixed view of intelligence. She advises being as specific as possible about evaluation of work; identifying the strengths and the weaknesses, not characterizing the person. To me, these are principles that can help teachers achieve more positive, sympathetic accompaniment of their students.[6]

b) College student development and adult development

William Perry studied the development of college students' ways thinking about knowing. Through longitudinal interview-based research with hundreds of college students, Perry developed his 'scheme' of stages of development. In Robert Kloss's review of Perry's scheme, he outlines 4 major steps along Perry's way: "dualism, multiplicity, relativism, and commitment in relativism." [Kloss, Robert J. (1994). "A Nudge is Best: Helping Students Through the Perry Scheme of Intellectual Development." in College Teaching. Volume: 42. Issue: 4]. According to this framework a 1st year college student, at the dualism stage, might be expected to think of learning as "received truth." Many first-year architecture students wish that their instructors would simply tell them 'the right way' to proceed – they want the received truth. It takes many of them a good bit of time to come to understand that they are learning a process (the design process) for finding their own valid ways to proceed.[7], [8]

Robert Kegan's work on adult development looks beyond the framework provided by Perry and, more fundamentally, by Piaget's pioneering work on childhood stages of development. Kegan's stage theory moves from birth through advanced stages of adulthood that can occur in old age. As such it is relevant to thinking about both students' and teachers' development. In Jennifer Garvey Berger's "Key Concepts for Understanding the Work of Robert Kegan," she notes that "older adolescents and the majority of adults" are at what Kegan calls the "Third Order." She goes on to explain, [9], [10]

"Those at the Third Order don't have an independently-constructed self to feel good about; their esteem is entirely reliant on others because they are, in many ways, made up of those around them. A villager at this Order is a model citizen and follows the laws out of loyalty to the others in the village (or his religion or his place of business or his family). He tries hard not to break the rules because he wouldn't want to feel he had let others down."

Many college professors, in Vietnamese and American architecture school, wring their hands over students who want others to tell them what to do. If they are familiar with Perry's scheme and Kegan's work,they can look at this as a common developmental phenomenon; an expected stage in students' development. This research is as relevant in Boston as it is in Ha Noi.

c) Cognition, multiple intelligences, critical exploration and expertise

Howard Gardner's multiple intelligence theory has been very influential in the K-12 educational community in the USA, perhaps because it conforms well to the world as educators' experience it in the classroom. Gardner's theory, and the researchit is based upon, indicates that intelligence is not singular but rather composed of multiple capacities: " 'I feel that what we call 'intelligence' is almost always 'scholastic skill' -- what it takes to do well on a certain kind of short-answer instrument in a certain kind of Western school,' he writes in an e-mail (to Joel Garreau, Washington Post Staff Writer, Washington Post, Sunday, June 11, 2006; Page D01). 'Other uses of intellect -- musical competence, facility in the use of one's hands, understanding of other people, sensitivity to distinctions in the natural world, alertness to one's own and others' emotional states etc. -- are not included in our definitions of intelligence, though I think that they should be.' " Gardner's research indicates a spatial intelligence which, for me as an architect and architectural educator, conforms well to the world of students in design school, where developing the ability to pre-visualize, 'solve' and manipulate spatial conditions is crucial. Gardner counsels for providing many ways in to subjects of study, so that the student favoring spatial intelligence can approach the problem that way, while the student who manifests musical intelligence, for example, is equally able to apply that perspective. This research is of value to any school of architecture in any locale or cultural context. Gardner's many invited lectures in China on this subject indicates the ideas can travel well to this side of the planet… [11]

The work of the Soviet psychologist Lev Vygotsky was 'discovered' in the West many years after Vygotsky's early death in 1934, when English translations of his writings became available. His notion of a "zone of proximal development"for learning has been quite influential and is very relevant to design pedagogy. When a student can solve a problem with some assistance from another person (let us say help from a teacher) there is a particular profile to the boundary between the student's knowing and unknowing that forms one edge, we might say, of the region of proximal development. By attempting to tailor assistance to the particularity of each individual studio student's profile – sometimes called "scaffolding in the zone of proximal development" – the student can be helped to move from being partially knowing to more fully knowing. This principle can, like Gardner's research, be applied in Ha Noi as readily as in Boston.[12]

In approaching this boundary and in considering the student / teacher relationship in scaffolding, the teacher must choose how much scaffolding to provide. One of my professors at Harvard's Graduate School of Education, Eleanor Duckworth, chose to minimize the amount of scaffolding and strived to eliminatethetelling ofanswers to students. Her work, which she calls critical exploration, relies on the student to do much more and the teacher to do less. The teacher is recast more in the role of the inventor's assistant, in some respects, providing some tools that might be useful to the principal inventor / studentto solve what might not otherwise be understood. The less telling the teacher did, the more discovering the student did. Professor Duckworth made the case that we deeply underestimate the capacity of students to discover. Her endless refrain, in modeling her teaching method, was, "tell me more." The spotlight of her attention was clearly a part of the power of the method. [13]

The aim of the preparation of an architect is to help the student towardssomeday becoming expert in the field – to wield the medium fully and fluently at a high level of facility and quality. Expertise has become its own field of study, with its own literature, and one renowned leader of research on expertise is K. Anders Ericsson. His 2007 publication in

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Factors influencing blended learning adoption in higher education

Bui Thi Ngoc Thuy

Abstract

The article presents an overview of the results of various studies on factors influencing Blended Learning (BL) adoption in higher education and refers to the current implementation of blended learning in Vietnamese universities. The research results indicate that the adoption of blended learning in higher education depends on factors such as institutional and technological readiness, as well as the attitudes of both instructors and students toward this type of training. In Vietnam, many universities are making a strong transition from traditional learning to blended learning; however, this process faces certain limitations that hinder its adoption in practice. The article also provides some recommendations to enhance the adoption of this approach and highlights gaps and areas for future research.

Key words: *adoption, blended learning, e-learning, factors, higher education*

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1. Introduction

Higher education is closely associated with specialized knowledge and academia, which is often perceived as difficult to access, requiring a significant investment of time and effort from both instructors and learners, as well as from the entire education system. Consequently, for a long time, it has been confined to the traditional form of direct education. It is for this reason that those seeking advanced education had to leave their homeland or study abroad. This incurred substantial costs and hindered people's access to higher education.

However, with the development of information technology and communications, especially the widespread use of the Internet, various new forms of education have emerged, such as distance education, online education, and blended learning (collectively referred to as technology-imbedded education). Distance education and online education in higher education are often criticized for their educational quality. The primary reason for this criticism is the lack of direct interaction between instructors and students, as well as among students themselves in their learning activities.

To address these limitations, many universities have shifted from exclusively using either traditional education or entirely online or distance education to adopting a combined approach, known as blended learning. Blended learning is expected to leverage the strengths and mitigate the weaknesses of both traditional and modern forms of education. In other words, blended learning not only maintains direct communication and ensures educational quality in a traditional setting but also allows universities to harness modern educational technology to enhance teaching effectiveness, increase student engagement, and keep pace with the trends of the fourth industrial revolution.

In response to the demand for modernizing higher education with the application of advanced technology, and amidst the ongoing debate about online higher education, the adoption of such blended learning approach is a reasonable solution. It represents a necessary transition from traditional education to technology-enhanced education. Implementing blended learning has become a popular trend, drawing the interest of many universities in Vietnam and around the world. Particularly, after the Covid-19 pandemic, this trend has gained even more momentum, compelling institutions to swiftly and decisively shift towards blended higher education.

However, the rapid transition can lead to a sense of compulsion among all parties involved in this approach, including instructors, students, and educational administrators. Implementing blended learning also demands changes in how instructors teach, how students learn, how educational programs are managed, and the integration of 2 modes of higher education training named as traditional education and e-learning within a common framework. According to a study by Taylor & Newton (2013), blended learning in higher education requires a shared vision, perspective, and systemic approach throughout all aspects of the educational institution. Conversely, a feeling of coercion can result in a lack of voluntary effort from all parties to make the necessary adjustments to fit the new learning modality. This leads to the moderate effectiveness of blended learning in higher education. Hence, as the benefits of blended learning in higher education have been recognized and this has become an irreversible trend, addressing the barriers to voluntary adoption of this learning approach becomes a critical issue.

In theoretical terms, many studies have demonstrated the benefits and factors influencing the quality of blended learning in higher education. However, only a few have focused on the factors influencing the adoption of this type of learning. In Vietnam, domestic research on this topic primarily concentrates on the advantages of this approach, as well as the content and methods of its implementation in some universities in Vietnam, rather than delving deeply into the factors influencing the adoption of this learning format. Such an in-depth exploration can encourage individuals to voluntarily adapt and change their perspectives and skills to align

with the new learning modality. In summary, there is a limited amount of research on the factors affecting the adoption of blended learning in higher education. Therefore, researching this topic is essential to help fill the theoretical research gap.

In the following section of the article, the author will present the following aspects: Theoretical Framework, Current Situation and Some Proposals for the Development of Blended Learning in Higher Education in Vietnam, and Conclusion.

2. Theoretical Framework

2.1. Concepts and theories

2.1.1 Concept of Blended Learning

There are various definitions of blended learning. In the Cambridge Dictionary (managed by the University of Cambridge, often considered one of the first organizations to introduce this concept), blended learning is the combination of traditional classroom lectures with computer technology-based lectures that can be delivered over the Internet. Graham (2013) defines blended learning as a combination of face-to-face instruction and computer-based instruction. Garrison and Kanuka (2004) describe blended learning as the merging of in-person classroom learning experiences with online learning experiences. In simple terms, blended learning can be defined as the combination of traditional face-to-face learning and e-learning. Different educational institutions and countries may choose various combinations based on their perspective on the necessity of each form and the appropriateness of the combination, often expressed in percentages such as 50-50, 40-60, 30-70, and so on.

2.1.2 Theory of Technology Adoption

To investigate the barriers to accepting blended learning, the Theory of Planned Behavior (TPB) proposed by Ajzen in 1991 can be based on. According to TPB, the adoption of blended learning is driven by the intention to engage in this behavior. However, this intention is influenced by three fundamental factors: (i) the individual's attitude towards blended learning, (ii) the subjective norm or the attitude of people surrounding the individual towards blended learning, and (iii) the awareness of behavioral control, which refers to the individual's perception of the advantages and disadvantages when carrying out the behavior.

In addition to the TPB theory, the Technology Adoption Model (TAM) with its three versions: TAM 1, TAM 2, and TAM 3, a unified theory of adoption and use of technology by Venkatesh (2003), is often used in research on factors influencing the adoption of new technology. In this context, blended learning can be considered as the application of modern technology in education. Therefore, using this theory to examine and explain the factors influencing the adoption of blended learning in higher education is logical.

According to TAM, the adoption of new technology is typically influenced by two fundamental factors: perceived usefulness and perceived ease of use. Additionally, certain individual characteristics such as age, experience, and culture also influence technology adoption.

Basically, the two theories mentioned above are in agreement with each other. Therefore, it is possible to combine both of these theories in research on the factors influencing the adoption of blended learning in higher education. Specifically, the adoption of blended learning depends on the subject's intention to accept it, with the intention of adoption being contingent upon: perception of roles and benefits of blended learning, attitudes of relevant parties towards blended learning, and the perception of the feasibility of blended learning.

Based on these theories, the next section of the article will summarize specific factors that have been examined in experimental research on this topic.

2.2 Factors Influencing the Adoption of Blended Learning in Higher Education

2.2.1 Factors Related to Instructors

- Instructors' Attitudes Toward Blended Learning:

Instructors' attitudes, whether supportive or oppositional, toward blended learning stem from several factors:

(i) Instructors' Perception of the Importance and Benefits of Blended Learning in Higher Education:

When instructors have a full understanding of the importance and benefits of blended learning, they are more likely to have confidence in the future and quality of this learning approach. This motivates them to actively and willingly accept blended learning. In other words, they will make efforts to engage with the system and implement necessary changes to adapt and support students in adapting to this learning format [9].

(ii) Instructors' Confidence in the Quality of Blended Learning in Higher Education: Instructors often believe that lack of communication in blended learning at the university level may hinder the quality of this learning format. This belief leads to unsupportive attitudes or a refusal to accept blended learning if they have the choice.

- Instructors' Perceived Behavioral Control or Instructors' Perception of the Feasibility of Blended Learning:

Perceived feasibility of blended learning in higher education essentially pertains to instructors' perception of the ease of using educational technology. Instructors often doubt their ability to work with new technology, lack confidence in the value of technology, worry about their own ability to incorporate technology into their teaching, and feel pressured by the dual responsibilities of teaching and having to guide students in becoming familiar with educational technology platforms. These concerns may stem from their limited experience and past interactions with technology [9], [10].

Additionally, blended learning also demands different pedagogical skills compared to traditional teaching. This necessitates instructors to update, refine, and enhance their teaching skills to align with this new learning format. This challenge can lead to instructors' resistance to change and hinder their adoption of this learning approach.

Furthermore, instructors' awareness of the challenges they commonly encounter when implementing blended education also affects their adoption of blended learning in higher education. Instructors often complain about the lack of time for preparation, reduced face-to-face interaction with students, work pressures, lack of motivation, and financial support [11]. These challenges can impede instructors' adoption of blended learning in higher education.

- The attitudes of related parties:

The attitudes of related parties toward blended learning in higher education also influence the attitudes of instructors towards this format, subsequently affecting their intention and adoption behaviors. Those parties in this case include students, educational administrators, and other instructors.

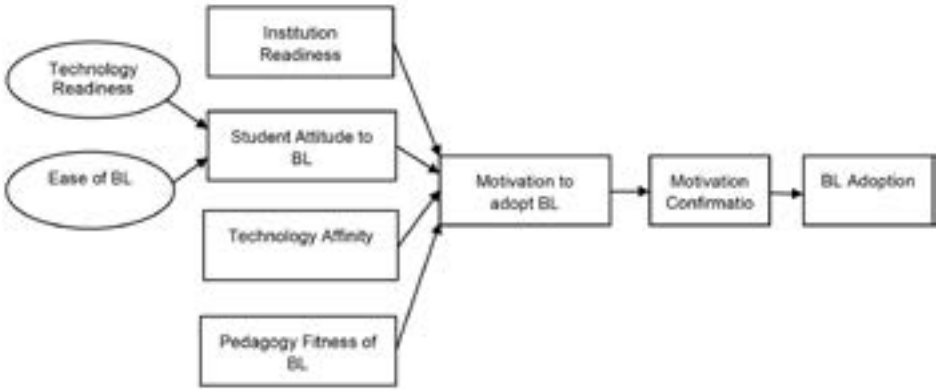

Figure 1. Determinants of Blended Learning adoption [10]

Instructors will assess the attitudes of these related parties during their interactions with them before and during the implementation of blended learning.

Additionally, instructors assess the attitudes of those related through the necessary support they receive from them in implementing blended learning. This support can include technical assistance, training in educational technology usage and that in adaption to new technologies, policies that encourage instructors to implement blended learning, clear and comprehensive implementation strategies and plans, etc. The supportive or oppositional attitudes of those related directly influence instructors' intention to accept blended learning in higher education.

2.2.2 Factors Related to Students

Students' attitudes toward blended learning influence the adoption of this learning format at the university level. On one hand, a supportive attitude will encourage them to participate and make efforts to overcome challenges in adapting to this learning format. On the other hand, their supportive attitude also impacts the attitudes and behaviors of others, especially instructors. This, in turn, helps instructors have more confidence in blended learning and promotes their voluntary and positive adoption of this format.

Students' supportive or opposing attitudes are influenced by their technological readiness and their perception of the ease of use of this learning format. Specifically, these factors can be reworded as the ease of using educational technology in blended learning and adapting to learning methods in blended learning, and more [10].

2.2.3 Factors Related to Educational Administrators

Educational administrators bear the responsibility for institutional readiness regarding blended learning in higher education. Institutional readiness is primarily reflected in the availability of strategies, plans, policies for designing and developing blended learning [10], [11]. Institutional readiness has several effects, including:

(i) Establishing a blended learning management system to facilitate coordination among various parties and departments to achieve the goals set out in blended learning. This system also aids in handling and addressing issues that may arise during implementation, ensuring the continuous quality of this learning format.

(ii) Institutional readiness for blended learning in higher education also contributes to building confidence among instructors and students regarding this learning format, as well as reducing difficulties in implementation due to a lack of direction, policies, and related procedures. This helps foster a supportive attitude and enhances the adoption capacity of those related toward blended learning.

In summary, the factors influencing the adoption of blended learning in higher education can be summarized in the framework proposed by Antwi-Boampong as Figure 1.

2.3 Strategies to Enhance the Adoption of Blended Learning in Higher Education

In essence, strategies to enhance the adoption of blended learning in higher education stem from the factors influencing the adoption of this learning format, as discussed in the previous sections. This means that to promote the adoption of blended learning, the factors influencing its adoption are to be addressed. In this section, the author will present strategies based on a systemic approach viewed from the management perspective of educational institutions towards the practices of different parties within the system, including instructors and students.

2.3.1 Establishing and Improving the Framework for Blended Learning in Higher Education

The process of establishing and improving the framework for blended learning in higher education generally follows two fundamental stages [11]:

- Stage 1: Raising Awareness of Blended Learning

During this stage, there is no formal framework on blended learning yet. However, educational administrators recognize the role and importance of this format. They provide initial support to academic departments to encourage them to explore ways to integrate blended learning into traditional classroom settings.

- Stage 2: Establishing and Enacting Preliminary Frameworks for Blended Learning

In this stage, a formal framework has been adopted, which includes strategies, plans, and policies to support the implementation of blended learning in practice.

- Stage 3: Refining Frameworks Linked to Enhanced Implementation of Blended Learning in Practice

In this stage, educational administrators need to complete and fully integrate the framework related to blended learning, including strategies, structures, and the necessary support for implementing blended learning effectively in practice.

2.3.2 Enhancing Accessibility and Technological Familiarity for Both Instructors and Students

Blended learning often requires basic hardware devices such as computers and internet-connected smartphones, as well as supportive educational software. These devices are typically expected to be self-provided by individual instructors and students. In some cases, educational institutions invest in building computer labs on their campuses, which students and instructors can use for blended learning purposes using the institution's equipment.

Additionally, in blended learning, instructors often need to play a supportive role in helping students become familiar with the educational technology used in blended learning. However, many instructors may not be proficient

in technology, especially information technology. Therefore, to support instructors, educational institutions are often recommended to provide training and workshops for instructors in dedicated labs to help them understand and troubleshoot basic technical and technological issues that may arise during blended learning.

Simultaneously, alongside instructor training, guiding and training students to become familiar with and practice using the educational technology is also encouraged. Furthermore, educational institutions are advised to keep their educational technology up to date and upgrade new software functions to help both students and instructors effectively implement blended learning [9].

These solutions related to guiding and training students and instructors to use technology in blended learning also help improve the perceptions of both students and instructors regarding the ease of technology use and the feasibility of blended education. This, in turn, makes them more comfortable with this learning format and increases their adoption capacity.

2.3.3 Enhancing Pedagogical Skills Relevant to Blended Learning in Higher Education for Instructors

According to Nelson et al. (2005), pedagogy, rather than technology, is the decisive factor for the success of online higher education [12]. Therefore, while applying information technology is a prerequisite, improving pedagogical skills is a sufficient condition for developing blended learning in higher education. Enhancing pedagogical skills is primarily the responsibility of instructors, but educational institutions should also support instructors through measures such as providing pedagogical training suitable for blended learning, encouraging instructors to share their experiences and pedagogical skills in blended learning, and having policies that incentivize instructors to propose and successfully apply new pedagogical skills to blended learning.

3. The Current Situation and Some Proposals for the Development of Blended Learning in Higher Education in Vietnam

3.1 Institutional Readiness

First and foremost, regarding the institutional aspects related to blended learning in higher education in Vietnam, a common issue in the implementation of blended learning is inadequate pre-planning. Vietnamese universities appear to be fairly dynamic in adopting new technologies, but the execution is often not well-prepared. Consequently, instructors often complain that they are not adequately informed or briefed about the significance and expected effectiveness of new technologies before their adoption by the institutions. Tight deadlines for completion of tasks further exacerbate this situation. This lack of readiness and the rushed nature of implementation can lead to instructors being less willing to accept blended learning.

This reality often results in many instructors lacking adequate preparation when transitioning to blended learning, both in terms of content delivery and suitable pedagogical styles and methods for this format. In other words, many instructors simply digitize traditional lecture materials into e-learning formats, while their teaching styles and pedagogical approaches remain largely unchanged as they transfer from traditional to blended learning. Challenges related to limited interaction between instructors and students, as well as among students themselves in the blended learning format, require instructors to research and employ strategies for improvement. However, due to factors such as time constraints and work pressure, instructors often complain that they lack adequate preparation and investment, leading to these limitations in blended learning not being well-addressed.

Furthermore, the issue of institutional regulations is also linked to the requirements imposed on all participants in blended learning. A common issue is that learners often feel that they do not receive timely feedback and support from instructors during the blended learning process. This issue primarily falls under the responsibility of instructors. Many instructors may not fully realize the seriousness of this matter in terms of the quality of online higher education, and most importantly, they may not feel compelled to address it.

Therefore, in the author’s opinion, this issue, in addition to instructors' responsibilities, is also related to the fact that institutions currently lack regulations and sanctions to compel instructors to provide timely feedback to students. In practice, according to the author's survey, some universities, beside developing blended learning programs, have also enacted regulations with penalties that require instructors to provide timely feedback to students. Additionally, in the initial stages, there are staff members in educational support departments who remind instructors to adhere to these regulations. These are positive signals showing that these universities are showing greater interest in coordinating relevant departments to enhance the effectiveness of blended learning in higher education in Vietnam.

Finally, the issue of assessing the quality of blended learning is also a limitation of this training mode in universities in Vietnam. Many students have provided feedback that they feel the assessment methods in blended learning are not adequate and do not accurately reflect their performance. This situation primarily arises from the fact that curriculum designers and program managers often simply copy criteria and assessment methods from traditional programs into blended learning programs. Adjustments are made, but they are often insufficient and not suitable. Therefore, program managers and curriculum designers need to address this issue to promote the adoption of blended learning in higher education in Vietnam.

3.2 Technology Readiness

Concerning the issue of technology in blended learning in higher education in Vietnam, even though Vietnamese universities have made certain investments in technology infrastructure, educational support software, and training for both faculty and students to become familiar with and proficient in using technology in blended learning, the reality is that faculty members' comfort and proficiency with technology varies with age. Older faculty members often feel reluctant to stay updated and change, especially when it comes to technology. Engagement in blended learning also requires faculty members to take on a supportive role and explain technological aspects to students, which can further discourage some faculty members from embracing this learning format.

Besides, despite continuous improvements, in many places, students still complain about the inadequacy of physical facilities and information and communication technology infrastructure to meet the requirements of blended learning. Students also often lack timely technical support from the support departments, and the responsibilities of

providing timely feedback to students and faculty members are not clearly defined among these departments. This leaves students feeling that blended learning is challenging, hindering their adoption of this learning format.

To address this limitation, universities in Vietnam should continue upgrading and improving their information and communication technology infrastructure to meet the growing demand for blended learning by students in the future. Additionally, university administrators need to establish and strictly implement clear sanctions that specify the responsibilities for providing timely technical support and feedback for students' technical and technological requirements within the functional departments of the university.

3.3 Pedagogical Skills Relevant to Blended Learning in Higher Education for Instructors

In terms of the issue of pedagogical skills that are suitable for blended learning in higher education in Vietnam, it is important to note that the extensive adoption of blended learning in Vietnam only became more pronounced after the prolonged Covid-19 pandemic from 2020 to 2022. This has meant that the preparation of pedagogical skills among instructors to adapt to this form of learning is still not sufficient. As a result, instructors tend to apply traditional pedagogical skills mechanically when implementing blended learning. The outcome of this approach includes various issues in blended learning such as limited communication, reduced interaction between instructors and students, as well as among students themselves, decreased student interest and motivation, and a decline in academic performance compared to traditional learning.

It is safe to say that, compared to the technological and institutional issues, the matter of pedagogical skills for instructors in implementing blended learning is equally crucial. The duty of resolving this issue is to be firstly born by instructors themselves. Instructors should proactively enhance their pedagogical skills to meet the teaching requirements in this new format and ensure they don't fall behind as blended learning has become more widespread in higher education in Vietnam. Beside the instructors' responsibility, academic departments and educational institutions should also support instructors in improving their pedagogical skills by organizing training programs and workshops on pedagogical skills in blended learning. Additionally, they can encourage instructors to participate in relevant courses by offering financial incentives or other forms of support.

4. Conclusion

Firstly, the article has summarized the factors influencing the adoption of blended learning in higher education. These factors can be divided into three groups, corresponding to the three participants in blended learning in higher education: administrators, instructors, and students. Corresponding to these factor groups are solutions aimed at promoting the adoption of blended learning in higher education. The specific research results are as follows:

(i) Factors related to institutional structure under the responsibility of educational administrators: This group includes elements such as development strategies, implementation plans, procedures, regulations for blended learning, and management policies that support and promote blended learning in higher education.

The studies also highlight that the process of building and perfecting blended learning should follow a series of steps, starting from awareness, moving towards implementation, and ultimately advancing to blended learning in practice. This process is to be accompanied by the fact that administrators should effectively communicate the benefits, importance, and strategic direction of blended learning to instructors and students. They should also guide them on how to effectively engage in blended learning. These efforts help strengthen the supportive attitudes and adoption of blended learning among instructors and students.

(ii) Factors related to instructors' attitudes and perceptions regarding their roles, how to overcome challenges when implementing blended learning, and the pedagogical skills that align with this learning format: to promote the adoption of blended learning in higher education, appropriate solutions are needed to enhance instructors' awareness of these issues. This, in turn, fosters supportive attitudes and adoption behaviors among instructors.

Specific solutions to be proposed is the comprehensive communication from educational institutions to instructors about the role of blended learning, the future trends of this format, thus supporting them to overcome barriers related to technology usage through training. Institutions should also encourage instructors to proactively research and update the necessary pedagogical skills for this new learning format. Additionally, they may have policies that alleviate job pressure, incentivize instructors to apply new pedagogical skills, and offer appropriate rewards.

In addition to the support policies, educational institutions should also establish regulations to compel instructors to provide timely feedback to students. Moreover, institutions should listen more attentively to instructors' opinions when designing.

(iii) Factors related to students' attitudes toward blended learning in higher education: This group of factors includes two elements. The first is the availability of technological devices and students' ability to use technology to engage in blended learning. The second element is students' perception of the ease of participating in blended learning. If students have high levels of access to and a perception of ease regarding technology use, their adoption of blended learning is higher. Furthermore, students' supportive attitudes toward blended learning positively influence instructors' attitudes toward this mode of learning, thus enhancing instructors' adoption of blended learning.

Solutions to influence students' attitudes include investing in physical infrastructure and information technology facilities to meet the technological needs of students who are not technologically ready, providing training and encouraging students to use technology proficiently in their learning, and offering timely technical support for any technical issues that may arise. Additionally, designing blended learning programs that ensure quality while aligning students' capabilities is crucial, preventing students from feeling overwhelmed by

Secondly, based on the theoretical foundation of the influential factors and solutions to enhance the adoption of blended learning in higher education, the article reviewed the current state of blended learning implementation in Vietnamese universities. The review revealed several noteworthy points, including:

(i) Regarding technology: Blended learning is becoming a trend and is being implemented by many universities.

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Solutions for cooperating bussinesses with interior design department at Hanoi Architectural University

Trần Ngọc Thanh Trang

Abstract

Education 4.0 represents a smart education model with tight interconnections between multiple organizations, including educational institutions, management bodies, and businesses. This collaboration creates an optimal learning environment, enabling students to develop their skills and adapt to the labor market's dynamics in the context of the 4.0 technological revolution. In recent years, the Interior Design department of Hanoi Architectural University has maintained a cooperative relationship with businesses in the interior design sector through various activities, such as seminars, workshops, and competitions. This study aimed to evaluate the current state of these collaborative efforts. Subsequently, it proposed solutions to enhance the effectiveness of integrating business practices into university education. The study relies primarily on data collected from surveys of 50 businesses involved in interior design linked with the Interior Design department of Hanoi Architectural University. The proposed solutions were tailored to the specific nature of the educational sector and addressed practical business requirements, focusing on achieving university autonomy.

Key words: *4.0 technological revolution, education 4.0, businesses, interior design, corporate*

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1. Introduction

The idea of collaboration between universities and businesses is not a new concept, and was proposed over 100 years ago by Wilhelm Humboldt, a German philosopher. According to him, universities, in addition to their educational roles, should engage in research and collaborate with various industries. In 1810, he founded the University of Berlin, which stood out from the other universities by shifting its focus towards research to support training activities. It particularly emphasized the development of technological fields for both civilian and military purposes, contributing to making Germany the most powerful nation in the world. [6]

The Bayh-Dole Act was passed in December 1980, marking a significant revolution in higher education. The Bayh-Dole Act addresses two critical issues that enhance the relationship between universities and the industry: i) it allowed universities and nonprofit organizations to obtain patents and commercialize the results of their research in government-funded research programs; and ii) it enabled federal agencies to grant licenses for their technologies' commercial and industrial applications. By creating a uniform copyright policy for all federally funded research agencies and allowing universities to hold legal rights to inventions, this act established a national policy that encouraged universities and nonprofit organizations to collaborate with the business and service sectors in knowledge and technology transfer. [7]

In Vietnam in 2018, the Ministry of Education and Training advised the National Assembly on amendments to the Higher Education Law, which included several provisions aimed at promoting collaboration between universities and businesses. These provisions emphasized "aligning education with the labor market's demand" and "conducting scientific research and technological applications." In 2021, the Ministry of Education and Training conducted a survey on the state of cooperation between universities and businesses, and the results indicated that more than 90% of the educational institutions collaborated with businesses. Institutions that did not primarily belong to artistic fields. These results demonstrate that educational institutions recognize the necessity of enhancing this relationship, and businesses understand their responsibility in participating in the process of training the workforce in conjunction with educational institutions. [8]

In recent years, the Interior Design Department at Hanoi Architectural University has maintained a symbiotic relationship with the furniture industry. This relationship ensures connectivity, competitiveness, and delivery of training programs that align with the ever-evolving needs of the furniture industry. After nearly a decade, the number of businesses engaged in collaboration with the Interior Design Department at Hanoi Architectural University has grown to 60 companies with collaborative activities that have been carried out include:

• Internship Visits: Providing students with internship opportunities in real-world settings without financial obligations.

• Sponsoring/Scholarships: Supporting students by sponsoring scholarships to alleviate their financial burden during their studies.

• Equipment/Facility Support: Supplying equipment, tools, or infrastructure to enhance the teaching and learning environments.

• Organizing Seminars/Workshops: Collaborating to host academic events such as seminars and workshops to share knowledge and foster community connections.

• Research Collaboration: Engaging in joint research projects to ensure research meets real-world needs and promotes innovation in the field.

• Student Entrepreneurship Support: Offering financial assistance and guidance to help students embark on entrepreneurial ventures within the Interior Design industry.

Among these activities, the highest level of participation from businesses is in

Figure 1. Talkshow by Businesses with Interior Design Students

the "internship visits" activity, accounting for 38%. Following that is "sponsorship/scholarships" with a share of 27%. The "equipment/facility support" activity makes up 11%, while organizing seminars and workshops comprises 8% of participation...

Although a variety of collaborative activities have been explored, they have mostly remained experimental and lack a well-defined cooperative framework and strategy for optimizing the potential of both businesses and educational institutions, enabling them to progress toward academic and financial autonomy. This research aims to elucidate the shortcomings of connecting Interior Design education with businesses and concurrently proposes a set of solutions to enhance the cohesion between the involved parties, ultimately elevating the effectiveness of this model.

The curricula for Hanoi Architecture University in general and the Interior Design program in particular were developed following a CDIO approach. This aims to equip students with not only strong foundational knowledge in science, technical principles, and analytical skills but also a fundamental understanding of business processes and technical economic management. Students are also encouraged to enhance their awareness of their social roles and responsibilities towards the sustainable development of the country.

Although it originated as a system for engineering education, the essence of CDIO lies in an outcome-based education process, which necessitates the design of corresponding input standards. Building this process requires a rigorous balance between science and practice. CDIO is essentially a solution for enhancing the quality of education and meeting societal demands. It can be applied to the design and standardization of training processes in various fields. Graduates who undergo CDIO-based training will possess the necessary knowledge and skills to meet the evolving demands of society and adapt to the rapidly changing times. To achieve this, business involvement in vocational training is indispensable.

Furthermore, Education 4.0 is, at its core an intelligent education model with a strong interconnection between multiple entities, including educational institutions, management bodies, and businesses. This interconnectedness provides each student with the opportunity to independently develop their skills and capacities. Simultaneously, it leveraged the application of technology in economic and societal development in the era of Industry 4.0.

The relationship between CDIO (Conceive-Design-Implement-Operate) output standards in the furniture industry and connection activities with businesses in furniture industry training is vital in ensuring that educational programs align with industry needs and standards. Here, how are these two elements interrelated?

• Curriculum Alignment: CDIO output standards often define the key skills and knowledge required of graduates in the furniture industry. By connecting with businesses, educational institutions can ensure that their training programmes align with these standards. This alignment means that graduates are better prepared to meet industry expectations and excel in the field.

• Real-world Application: CDIO principles emphasize the importance of practical applications. Connection activities with businesses can provide students with real-world projects and challenges that allow them to apply concepts learned in their coursework. This practical experience is invaluable in reinforcing CDIO standards and preparing students for the workforce.

• Industry Feedback: Collaboration with businesses often involves obtaining feedback from industry professionals. Their input can help educational institutions refine their training programs to meet the CDIO standards. The feedback loop allows for continuous improvements in curriculum design and implementation.

• Internships and Work-Integrated Learning: Businesses often play a role in offering internships or work-integrated learning opportunities to students. These experiences give students the opportunity to implement their knowledge and skills, as emphasized in the CDIO standards, in a real work environment. This can serve as a direct bridge between academic training and operational implementation.

• Networking and Professional Relationships: Connection activities with businesses help students build professional relationships and networks in the furniture industry. This aspect aligns with the CDIO principle of "operate," as it fosters connections within the industry and exposes students to professionals and mentors.

• Innovation and Problem Solving: CDIO encourages graduates to be innovative and effective problem solvers. Collaboration with businesses often exposes students to real-world problems and encourages them to conceive creative solutions, which aligns with the "conceive" and "implement" phases of CDIO.

• Quality Assurance: Businesses can be a source of quality assurance for educational programmes. They can assess whether graduates meet the CDIO standards and provide input on how to improve training to ensure that students are adequately prepared for the industry.

In summary, the relationship between CDIO output standards and connection activities with businesses in the

furniture industry training is symbiotic. CDIO provides a framework for the development of skills and knowledge, while connection with businesses ensures that these standards are implemented in a real-world context, students are well prepared for the industry, and programs remain aligned with industry expectations and advancements. This interconnection is essential for producing graduates who meet the furniture industry's needs.

2. Literature review

Research on "Connecting Businesses with Interior Design Industry Training" explores the critical relationship between businesses and educational institutions in the field of interior design. This study focuses on how collaboration between these two entities benefits both parties and contributes to the growth and development of the interior design industry. Here is an overview of the key themes and findings from the existing research in this field.

• Enhancing Industry-Relevant Education: Research highlights the importance of industry-academic partnerships in ensuring that interior design students receive education that aligns with current industry needs. By connecting businesses with training programs, universities can adapt their curricula to include practical up-to-date knowledge and skills.

• Internships and Work-Integrated Learning: Studies often emphasize the significance of internships and work-integrated learning opportunities for interior design students. Collaboration with businesses provides students with real-world experiences and insights, helping them bridge the gap between theory and practice.

• Fostering Innovation: Research suggests that these collaborations lead to innovation within the interior design industry. Joint projects and research initiatives between academia and business can result in the development of new design concepts, materials, and technologies.

• Career Development: Many studies have explored the positive impact on students' career development. Graduates who engage in industry-connected training are often better prepared to secure employment and have a competitive advantage when entering the job market.

Networking and Professional Relationships: Establishing professional relationships and networks is a common topic in this area of research. Collaboration between businesses and educational institutions provides students with opportunities to connect with industry professionals, which can lead to future employment and mentorship opportunities.

• Curriculum Development: Research often delves into how the input of industry experts can shape the curriculum of interior design programs. This ensured that graduates were equipped with the practical skills and knowledge required by the industry.

• Knowledge Transfer and Best Practices: Studies may explore how businesses can transfer industry-specific knowledge and best practices to educational institutions. Knowledge transfer enhances the quality of education and promotes industrial standards.

• Measuring Impact: Researchers often seek to quantify the impact of these collaborations. This includes assessing how partnerships with businesses affect student learning outcomes, industry growth, and the overall program quality.

Several notable studies have been conducted on connecting businesses in Interior Design education at universities. Here are some examples: connecting businesses with interior design industry training can be achieved through various approaches. One approach is to incorporate design education into the day-to-day advice provided by professionals such as lawyers, accountants, bankers, and marketing specialists [1]. This requires continuing education regarding the design of these non-design consultants. Another approach is to provide business education specifically tailored to interior designers, covering topics such as planning and launching an interior design business as well as strategies for growth and success [2]. Additionally, it has been found that graduates who have received preparation in business and communication skills through accredited programs are more likely to find employment in the interior design profession [3]. These skills, such as public speaking and oral presentations, are transferable and valuable to the workplace. Overall, connecting businesses with interior design industry training involves integrating design education into various professional settings and providing the necessary business skills for success [4] [5].

The following is a summary of studies related to this topic:

• "Industry-Academia Collaboration in Interior Design Education: A Case Study": This study focuses on specific cases of collaboration between businesses and universities in Interior Design education. It analyzes the benefits and challenges of this model, and evaluates the effectiveness of such connections in the learning process.

• "Enhancing Interior Design Education through Industry Partnerships": This study delves into how the relationship between universities and businesses can enhance the quality of education in the field of Interior Design. It addresses specific details of how such collaborations can improve students' practical skills and meet market demands.

The Role of Business in Interior Design Education: A Comparative Study This study compares the role of businesses in Interior Design education at various universities. It discusses different methods and models of business-school collaboration and evaluates their effectiveness.

Evaluating the Impact of Industry Collaboration on the Interior Design Curriculum": This study focuses on assessing the impact of collaboration with businesses on the Interior Design curriculum. This includes measuring improvements in students' skills and knowledge after participating in business-related activities.

In summary, research on connecting businesses with interior design industry training underscores the mutually beneficial relationship between academia and the industry. Such collaborations play a pivotal role in enhancing interior design students' education, fostering innovation, and promoting career opportunities. These findings emphasize the importance of continued collaboration between educational institutions and businesses in interior design.

3. Methods

The study was conducted to carry out a sociological investigation involving a total of 60 participants. Among them, 30 businesses operating in the field of Interior Design have established collaborative partnerships with the Department of Interior Design at Hanoi Architecture University, while the remaining 30 businesses are not currently linked with the mentioned department. Half of the business group operates in the field of consulting/design/construction, and the remaining half belongs to commercial and manufacturing groups.

The survey was conducted between August and October

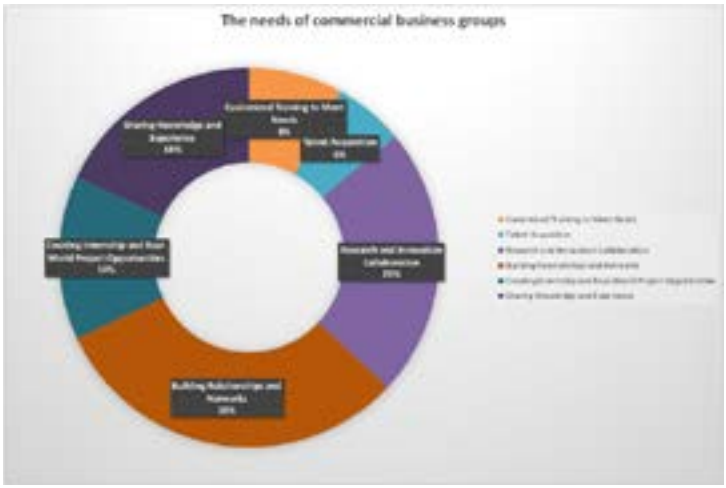

Figure 2. The neess of commercial businesses groups when collaborating with the Interior Department

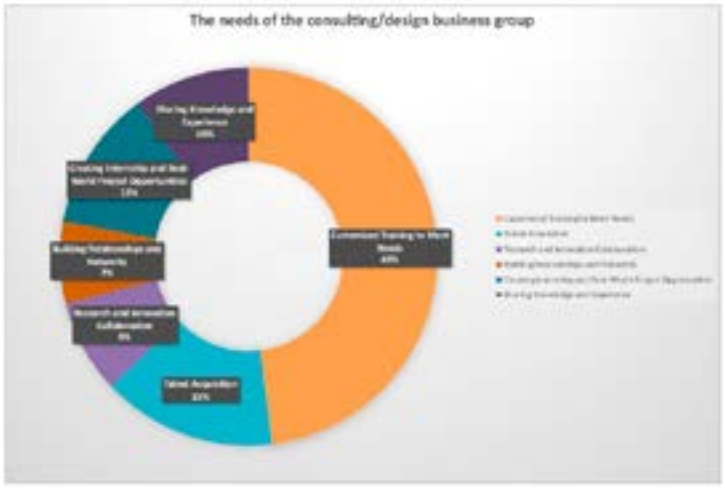

Figure 3. The neess of commercial businesses groups when collaborating with the Interior Department

2023. The research team from the Department of Interior Design at Hanoi Architecture University executed the study utilizing both direct and indirect interviews through an online questionnaire via the Google Form platform. The primary objective of this research is to identify the requirements, preferences, and perspectives of businesses seeking and establishing collaborative partnerships with the Department of Interior Design at Hanoi Architecture University.

4. Results & discussion

4.1. Survey Results

When businesses collaborate with the field of Interior Design education, they have several expectations and primary objectives, including

• Talent Acquisition: One of the primary objectives of businesses collaborating with Interior Design education is to seek and recruit new talent. They aim to have the opportunity to discover and hire outstanding and talented students through these educational programs.

• Customized Training to Meet Needs: Businesses want Interior Design training programs to reflect actual needs and industry standards. They hope that these programs will equip students with the practical knowledge and skills required to work in real-world Interior Design.

• Research and Innovation Collaboration: Companies wish to collaborate with universities in research and development projects. This helps them drive innovation in the industry, develop new products and technologies, and maintain market competitiveness.

• Building Relationships and Networks: Businesses aim to build relationships and networks with universities and students. This can lead to business opportunities, long-term relationships, and the identification of potential partners.

• Creating Internship and Real-World Project Opportunities: Companies want to provide internship and real-world project opportunities for students. This helps them to train and evaluate young talent in a real-world environment and find a high-quality workforce upon graduation.

• Sharing Knowledge and Experience: Businesses may wish to share their knowledge and experience with students and universities. This could involve providing lectures, mentoring, and reference materials to support the learning process.

The biggest need for businesses when connecting with the IT industry isCustomized Training to Meet Needs," followed by communication.

Using analytical and statistical methods, it can be seen that the highest demand for the group of interior design consulting businesses when cooperating with the interior design department of the University of Architecture is: "Customized Training to Meet Needs" with a billion 48% rate, followed by "Talent Acquisition" demand at 15%, "Creating Internship and Real-World Project Opportunities" demand at 10%. Meanwhile, for the commercial business group, their biggest wish is "Building Relationships and Networks" with a proportion of 31%, followed by "Research and Innovation Collaboration" with 23% and "Sharing Knowledge and Experience" with 18%.

In summary, businesses desire to collaborate with Interior Design education to discover talent, ensure that training programs meet their needs, drive innovation, build relationships, and share knowledge to support industry development and improve the quality of education. This requires connection and cooperative activities to be diverse, differentiated, and in-depth.

Solutions

Develop interdisciplinary interior training programs adapted to the labor needs of businesses

Interdisciplinary interior training programs combine knowledge and skills from various fields to prepare students for careers in interior design, architecture, or related fields. These programs emphasize the importance of cross-disciplinary learning in creating well-rounded professionals. There are a few examples of interdisciplinary interior training programs.

• Interior Design and Architecture: These programs integrate interior design knowledge with architectural principles. Students learn how to design interior spaces that harmonize with architectural structures.

• Interior Project Management: Focusing on project management and interior design, these programs teach students how to plan, execute, and manage interior design

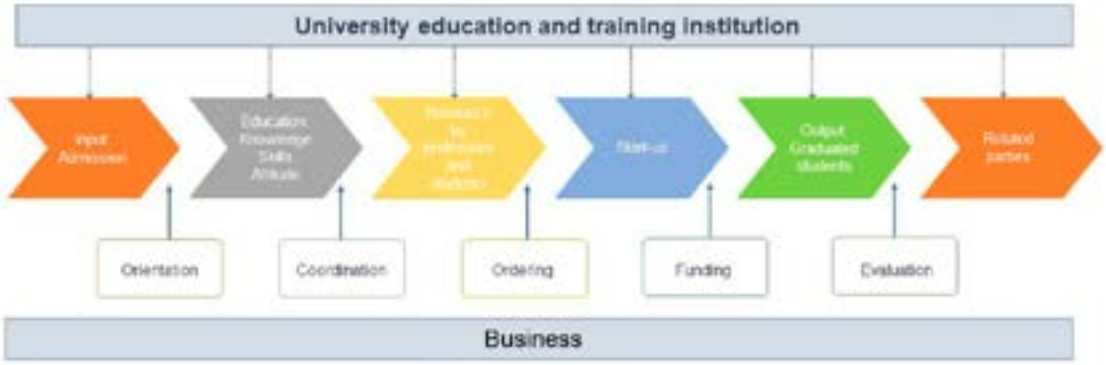

Figure 4. The role of businesses in the Interior Design education process

projects effectively.

• Art and Applied Art in Interior Design: These programs merge art and interior design, encouraging students to be creative and develop a strong aesthetic sense while designing interior spaces.

• Interior Design and Environmental Science: These programs connect environmental science with interior design to teach students how to create sustainable and environmentally friendly interior spaces.

• Interior Design and Business: Focusing on business and interior design, these programs prepare students to manage interior design firms or work in business-related roles in the interior design industry.

• Interior design and marketing: Intersect as they influence brand identity, customer experience, and visual communication. They collaborate in retail and hospitality spaces to optimize layouts and enhance sales. Sustainability is a common concern and both industries engage in collaborative campaigns. Interior designers can provide insights into market research. Synergy between them creates a holistic brand experience.

Interdisciplinary interior training programs offer students a broader skill set and more holistic understanding of interior design and related fields. They encourage creativity, critical thinking, and adaptability, enabling graduates to excel in their career. To develop interdisciplinary training programs, it is necessary to implement the following synchronous solutions:

• Market Research and Analysis: Begins conduct research and analyze the labor market to understand the needs of businesses in the interior design field. This includes identifying job positions, the required skills, and knowledge.

• Establish Collaboration with Businesses: Collaborate with businesses in the interior design sector to identify their specific needs and build cooperative relationships. This may involve the formation of business advisory committees or internship programs for students.

• Training Objectives: Based on the information gathered from research and cooperation with businesses, we set specific training objectives for the interdisciplinary program. Determine the skills and knowledge that must be taught to meet business needs.

• Develop the Curriculum: Build an interdisciplinary curriculum based on established objectives. This includes integrating courses from various fields and providing opportunities for students to learn through internships and projects.

• Ensure Quality: Ensure the quality of the program by regularly evaluating and adjusting its content based on feedback from businesses and students.

• Build a Network: Create a network with businesses and organizations in the interior design field to provide internship opportunities, employment, and other activities for students.

• Continuously Update the Program: The interior design field and businesses can change over time. Therefore, it is essential to continuously update the program to ensure that it reflects current reality.

• Establish a Strategic Partnership Model: Build long-term strategic partnerships between universities and businesses in the furniture industry. This requires commitment from both sides to jointly develop training programs, research projects, and related activities.

• Provide Ongoing Learning Opportunities: Support students with opportunities for continuous learning and knowledge updates after graduation, such as postgraduate courses or related training programmes.

• Promote Long-Term Commitment: Both businesses and universities must show long-term commitment to this relationship. Long-term collaboration ensures stability and continuous improvement in the quality of training.

Developing interdisciplinary interior training programs adapted to the labor market's needs requires close collaboration with businesses and a long-term vision to maintain the program's competitiveness in the labor market.

Proposing education activities for the Interior Design field with business participation.

Connecting businesses in various activities related to Interior Design education, such as research, training, construction, design consultation, and community building, brings about numerous advantages for both universities and enterprises. Here's how the collaboration works within each activity:

Research:

Organizing conferences and scientific seminars: Businesses can sponsor and participate in organizing research events to share knowledge and connect with experts.

Conducting scientific research projects: Companies can collaborate in funding or participating in research projects to ensure that they meet real-world demands.

Support Research and Innovation: Businesses can support research and new developments in the industry. This encourages innovation in furniture design and contributes to industry development.

Training:

Training human resources as per business requirements:

Enterprises can collaborate to determine training needs and even contribute to curriculum development.

Developing short-term and long-term courses: Companies can provide practical knowledge and necessary skills through short-term courses or long-term training programs.

Workforce training for businesses: Collaboration in employee training ensures that new hires are effectively and efficiently trained.

Collaborate in Curriculum Design: Businesses can participate in the design of training programs. By providing input from the industry, universities can ensure that their educational programs reflect the real needs of the furniture industry.

Construction and Building:

Implementing new technologies/materials in education: Collaboration between universities and businesses ensures that students are introduced to the latest technologies and materials during their studies.

Involving students in real construction/production: Companies can provide practical experience opportunities for students, allowing them to apply their knowledge in real-world settings.

Design Consultation:

Involving students in consultation/design activities: Businesses can collaborate with universities to allow students to participate in real consulting and design projects.

Create Internship and Real-World Projects: Businesses can offer internship and real-world project opportunities for students. This helps students apply knowledge in real-world environments and develop practical skills.

Community Building:

Professional knowledge exchange: Enterprises can engage in knowledge-sharing and networking activities with educational communities and students.

Domestic and international connections: Collaboration with businesses can expand networking opportunities for students and provide them with learning and working experiences in various locations.

Communication: Companies can partner in communication efforts to share knowledge and information about industry events, projects, and achievements.

Cooperation in these various activities ensures that the Interior Design field produces high-quality talent and meets market demands while driving industry development and innovation.

Develop Communication Strategies: Develop communication strategies to promote and market activities related to this connection. This can attract interest from other businesses and enhance existing relationships.

Develop Relationships and Networks: Collaborating with businesses helps students build relationships and networks in the furniture industry. Businesses can help students connect with experts and create employment opportunities after graduation

Build Shared Resources:

Create platforms or databases for sharing educational materials, information, and resources. This helps businesses and universities efficiently share knowledge and study materials.

5. Disscussion

While the solutions mentioned above have numerous benefits in creating a better learning and working environment for students and businesses, there are also some limitations and challenges to consider.

• Cost: Developing interdisciplinary training programs and building infrastructure to support teaching and learning requires significant financial investment. This can be a barrier, particularly for smaller universities and businesses.

• Consensus and Management: Effective implementation of these solutions requires consensus and effective management between universities and businesses. Creating an effective consensus and management can be challenging, especially when there are differences in objectives and priorities.

• Competition: Universities and businesses may compete to attract and retain talented individuals, especially in fields with ample job opportunities. Competition can create an environment that may not be optimal for collaboration.

• Time and Resources: Developing new training programs and maintaining collaborative activities requires substantial time and resources from both parties. If not well managed, investment in time and resources can become a burden.

• Changes in the Industry: The Business and industrial environments can change rapidly. Established training programs and relationships may become less effective if they are not regularly updated and adjusted to reflect these changes.

• Sustaining Long-term Relationships: Effective collaboration requires long-term commitment from both parties, universities, and businesses. However, this can be challenging to manage.

Despite these limitations and challenges, the development of interdisciplinary training programs and the promotion of collaboration between universities and businesses still have the potential to improve the quality of education and meet the needs of the labor market.

Additionally, in the context of building a curriculum closely tied to the labor market's needs, it is essential to align with the current conditions and circumstances of the educational institution to make it easily applicable at the present moment. Specific suggestions that can be implemented immediately include enhancing elective courses so that students can construct their own customized curriculum according to their abilities and diverse business needs.

6. Conclusions

In conclusion, with the onset of the 4.0 technology revolution, the landscape of education is undergoing a significant transformation. Traditional education institutions, such as universities, are no longer the sole proprietors of knowledge creation and dissemination. Instead, a more equitable and integrated "school - business" model is emerging, one that places theoretical knowledge and practical application on an equal footing. The success of higher education institutions, particularly universities, hinges on their ability to align their offerings with the real-world needs of society and businesses, rather than adhering to a one-size-fits-all approach. Education must pivot towards a learner-centric paradigm, where the quality of educational outcomes takes precedence.

These proposed solutions serve as a compass for fostering effective collaboration between businesses and universities in the context of furniture industry training. They

are designed to ensure that educational standards and curricula align with the specific requirements and industry standards of the furniture sector.

In practice, the adoption of a business-academia partnership model necessitates flexibility. The progression can begin with individual partnership arrangements and evolve into more comprehensive collaborative efforts. Ultimately, the objective is to transform universities into institutions dedicated to "technology transfer training," eventually evolving into "research and implementation universities." This progressive approach is vital for shaping the future of education and the symbiotic relationship between academia and industry./.

References

1. *Seungpok, Choi. (2010). Effective shared process and application of knowledge management (KM) in interior design service industry. International Journal of Contents, 6(3):65-70. doi: 10.5392/IJOC.2010.6.3.065*
2. *Anne, E., Creigh, Tyte. (2010). Design Training in the Professions: A Policy Proposal for the UNITED KINGDOM. 7(3):61-66. doi: 10.1111/J.1948-7169.1996.TB00497.X*
3. *Terri, L., Maurer., Katie, Weeks. (2010). Interior design in practice: case studies of successful business models.*
4. *Shannon, Tew. (1991). The Role of Business and Communication Skill Preparation for Interior Design Graduates. Journal of Interior Design, 17(2):51-58. doi: 10.1111/J.1939-1668.1991.TB00038.X*
5. *Christopher, Budd. (2011). Valuing the Intuitive: Reintroducing Design Into Interior Design Education. Journal of Interior Design, 36(3) doi: 10.1111/J.1939-1668.2011.01059.X*
6. *Pham Van Quan (2019). Building a school-enterprise linkage model in training and scientific research at training establishments. Education and training website gdnn.edu.vn, Thursday, October 19, 2023, 11:44*
7. *The Bayh-Dole Act, signed into law in 1980, gives universities rights to intellectual property (IP) generated from federal funding. It was never intended to be used to control drug prices.*
8. *Center for Educational Communication (2022). Propose policies to support and promote university-enterprise cooperation. https://moet.gov.vn/. Thursday, October 19, 2023, 11:44*

Factors influencing blended learning adoption...

(continued on page 109)

Therefore, universities recognize the importance of investing in technological infrastructure, such as computer labs, network connectivity, and educational support software. They also provide guidance and training for both instructors and students to familiarize them with and master the use of technology for blended learning. However, during the implementation of blended learning, various technical issues arise, causing difficulties for students who then blame instructors for not supporting them timely.

(ii) In terms of institutional structure: Implementing blended learning in higher education is not a new concept in Vietnam, especially after the COVID-19 pandemic. Universities have established relevant institutional structures; however, due to the rapid expansion of blended learning, the institutional quality of blended learning remains limited. Specifically, the implementation is often inadequately prepared, leading to rushed plans. Policies and mechanisms to support instructors and students are lacking, and regulations and procedures for blended learning are not yet complete. Communication aimed at enhancing awareness of blended learning for both instructors and students is still insufficient. This results in apprehension and hinders the adoption of this form of learning.

Thirdly, there are research gaps and potential future research directions. In general, to enhance the adoption of blended learning in higher education, four factors need to be considered: technology, institutional structure, the role of instructors, and student participation. Technology and institutional structure have been extensively researched, while the roles of instructors and students have received less attention. However, instructors and students are directly involved in blended learning and play a crucial role in its adoption. In particular, domestic research on this topic has primarily focused on improving technological and institutional factors. Therefore, future research could delve deeper into the pedagogical skills of instructors and the needs of students in blended learning. This can lead to more comprehensive proposals to improve the adoption of these participants towards blended learning in higher education in the future./.

References

1. *Taylor, Janet A., and Diane Newton, "Beyond blended learning: A case study of institutional change at an Australian regional university", The Internet and Higher Education 18 (2013): 54-60*
2. *Graham, Charles R. "Emerging practice and research in blended learning." Handbook of distance education 3 (2013): 333-350.*
3. *Garrison, D. Randy, and Heather Kanuka, "Blended learning: Uncovering its transformative potential in higher education", The internet and higher education 7.2 (2004): 95-105.*
4. *Venkatesh, V. and Davis, F.D., "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies", Management Science, (2), 2000, 186-204.*
5. *Venkatesh, V. and Bala, H., "Technology Acceptance Model 3 and a Research Agenda on Interventions", Decision Science, (2), 2008, 273-312.*
6. *Thabet, R., Christopher, H., and Eman G., "Perceptions and barriers to the adoption of blended learning at a research-based University in the United Arab Emirates", Recent advances in intelligent systems and smart applications, 2021, 277-294.*
7. *Antwi-Boampong, A., "Towards a faculty blended learning adoption model for higher education", Education and Information Technologies, 25(3), 2020, 1639-1662.*
8. *Porter, W., et al. "A qualitative analysis of institutional drivers and barriers to blended learning adoption in higher education", The internet and Higher education, 28, 2016, 17-27.*
9. *Hồ Ngọc Khương, "Mô hình Blended Learning trong giáo dục đại học và thực tiễn áp dụng ở các trường đại học", Tạp chí Khoa học Giáo dục Việt Nam, 45(9), 2021, 6-11.*
10. *Trần Thị Huệ, Nguyễn Kim Oanh, "Các nguyên tắc cơ bản để thiết kế khoá học ở đại học theo mô hình Blended Learning hiệu quả", Tạp chí Giáo dục, 477, 2020, 18-22.*