

GIS in Smart urban planning and management: Lessons learned for Vietnam

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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

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 infrastructure and 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, potential and challenges, so managing smart urban planning in each sector, each location and 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, practices and 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

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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, information and elements in the city to create a green, sustainable city with a competitive economy, innovation and 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 life and 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, innovative and innovative information and communication technologies and other methods to enhance the effectiveness, efficiency, analysis, forecasting, provision of services and management of urban resources involving people; improve the quality of life and workforce; and enhance the economy and society.

Smart city is knowledge based city that develops extraordinary capabilities to be self-aware; functions 24 hours and 7 days a week; communicates, selectively, knowledge in real-time to citizen and 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



Figure 1. The smart city components [10]



Figure 2. Characteristics of Smart City [14]

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 infrastructure and 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 development and 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, sustainable and 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

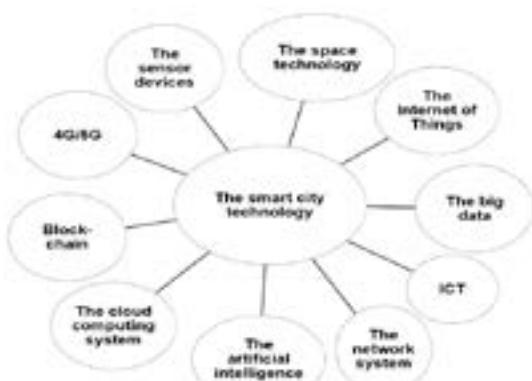


Figure 3. Technology makes smart cities

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 movement and 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, economic and 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



Figure 4. Components of GIS

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 process and generate spatial information (through cartographic and photogrammetric 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 measurement and 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 available and (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, sectors and 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, visualisation and 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 change and staffing.

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 conditioning and high-tech waste collection systems. Cars will remain outside and 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

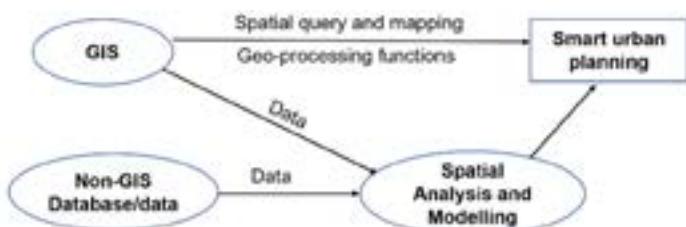


Figure 5. GIS and Smart urban planning

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].

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 lot-based 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, sustainable and 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 control and 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

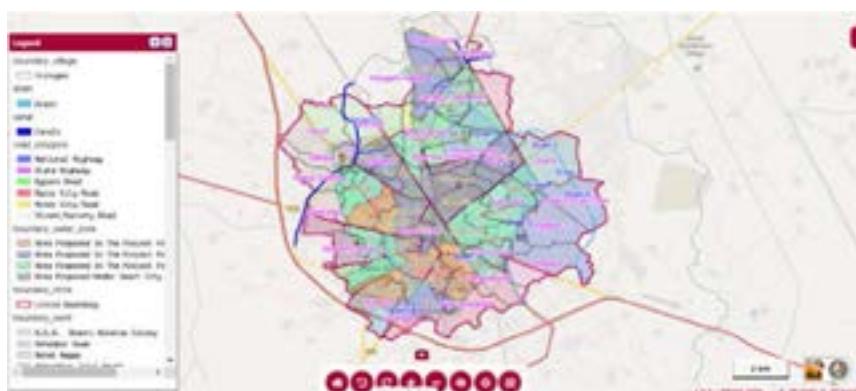


Figure 6. Using GIS for city planning in Aligarh smart city [13]

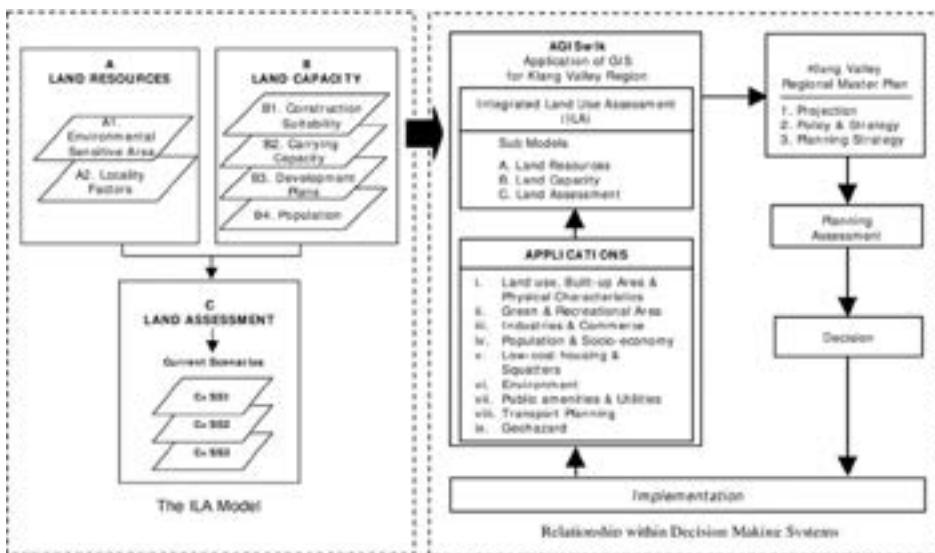


Figure 7. Model developed and implemented for Integrated Land Use Assessment of Klang Valley [19]

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, utilities and 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, objectively and 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 management and education). Japan has applied GIS in construction management and planning through the government, related ministries and planning training in universities.

In France, in urban development planning, GIS is successfully applied in national territorial planning, regional planning and urban planning due to its rich national data base and national standards in terrain, geography, non-picture maps, statistics and 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 development and 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 country and 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

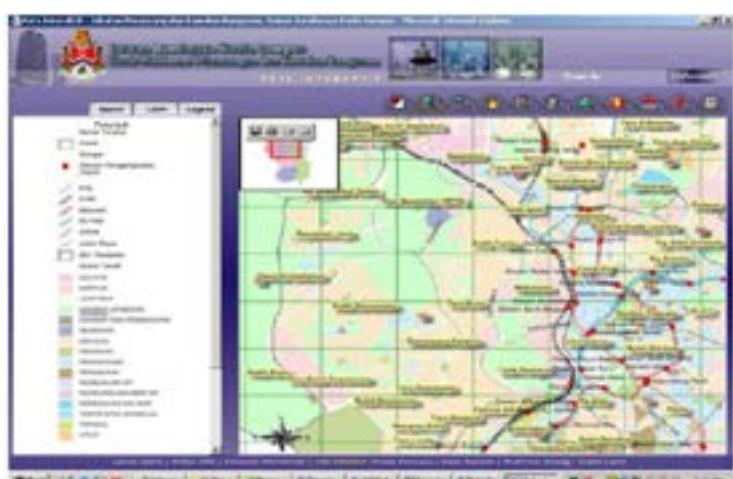


Figure 8. Interface for Interactive Maps Application through the information kiosk [19]

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, energy and the environment. Smart urban planning management is, in essence, a digital transformation of scope, urban scale and people-centricity. This is a constant, long-term process and 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, efficiency and quality of urban systems. The analytic environment includes engineering, management and 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, videos and 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./.

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A social scientist in the studio

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.

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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 about perspectives 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./.