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DEVELOPMENT OF A MULTIPURPOSE GEOGRAPHIC DATABASE FOR URBAN INFRASTRUCTURE MANAGEMENT IN HO CHI MINH CITY (VIETNAM)

A Geographic Information System (GIS) is a technology designed to collect, store, analyze, manage, display, and update location-based data, integrating diverse data types from various sources. A critical component of GIS is its database, which organizes and stores data in a structured format, enabling the efficient retrieval and management of primary information. The geographic database plays an important role in various fields, including socio-economic development, national security and defense, natural resource and environmental management, transportation, and the exploitation of natural resources. The urban technical infrastructure database is one of the key databases supporting the development of smart cities.

Purpose. To develop a multipurpose geographic database at a scale of 1:2,000 for Ho Chi Minh City region, Vietnam, from which data layers will be extracted to support the management of urban technical infrastructure in the study area.

Methodology. The research consists of several essential steps, including LiDAR scanning, digital photography, data collection and processing, digital image mapping, standardization of digital elevation models, vectorization of geographic features, and field investigations to gather attribute data for geographic objects. Subsequently, the process involves integrating specialized maps with existing 1:2,000-scale topographic maps to standardize the geographic data. The next phase focuses on building a geographic database and editing the 1:2,000-scale topographic map using ArcGIS. Finally, data layers related to urban technical infrastructure will be extracted from the geographic database.

Findings. The geographic database was developed consisting of seven groups – borders, hydrology, surveying, population, topography, traffic, and surface coverage, and a 1:2,000-scale topographic map of Ho Chi Minh City was created. Additionally, basic urban technical infrastructure data layers were extracted from the geographic database to support urban infrastructure management.

Originality. This study is the first to establish a geographic database at a 1:2,000 scale and extract urban infrastructure data layers from it for the experimental area of Ho Chi Minh City, Vietnam.

Practical value. The research results will enhance the information system supporting urban technical infrastructure management, enabling local authorities to develop appropriate policies and streamline management processes more efficiently and effectively.

Keywords: *geographic database, urban infrastructure, technical infrastructure management, Ho Chi Minh City, Vietnam*

Introduction. Geographic Information Systems (GIS) are essential for modern decision-making, enabling the integration, analysis, and management of georeferenced data [1]. GIS databases, combining spatial and attribute data, ensure efficient storage, retrieval, and manipulation of information [2]. With applications in socio-economic planning, environmental management, transportation, defense, and resource exploitation, GIS effectively addresses complex challenges [3]. In urban infrastructure management, GIS-integrated geographic databases enhance spatial visualization and analytics, optimizing resource allocation, asset monitoring, and maintenance [4]. By consolidating datasets such as road networks, water systems, and energy grids, GIS improves intersectoral coordination, reduces redundancies, and enhances service delivery. Additionally, its scenario modeling and predictive analytics capabilities enable urban planners to anticipate challenges, assess risks, and implement sustainable solutions, fostering resilient urban development.

Ho Chi Minh City, as the largest metropolis in Vietnam [5], faces significant challenges in urban management and sustainable development due to its rapid urbanization and complex infrastructure systems [6]. Establishing a multipurpose geographic database is critically essential to effectively address these challenges. Such a database would provide accurate, up-to-date, and comprehensive geographic information, which is indispensable for urban planning, land use management, environmental monitoring, and disaster risk reduction. Particularly, in terms of developing an urban technical infrastructure database, this geospatial foundation becomes even more crucial. It enables the integration of diverse infrastructure data, such as transportation networks, water supply, drainage systems, and energy grids, into a unified platform. This not only facilitates efficient data sharing and analysis among stakeholders but also supports informed decision-making, enhances infrastructure resilience, and promotes smart city initiatives.

There is a variety of studies on geographic databases worldwide. In 2017, a methodology for database creation has been developed to integrate micro-level geographic context into longitudinal historical demographic analyses. This study offers a significant contribution by establishing a framework in which individuals are linked to micro-level longitudinal geographic data over extended periods [7]. One study presented a method for enhancing the spatial consistency of geographic data sets in vector format. The approach is based on error surveying and classification, identifying three types of errors that result in three types of consistency: structural, geometric, and topological. Each type requires its own specific checking and correction processes [8].

Fitch, et al. developed the National Historical Geographic Information System (NHGIS) with the aim of creating a large volume of aggregated census data that can be accessed through a geographic information system for historical population studies [9]. Baglioni et al. presented a method for analyzing geospatial terminology from geographic data stored in spatial databases and identified key geospatial terms that can form the foundation for advanced user query systems [10]. Another study adopted a simulation approach to examine the impact of urban geometry on the urban climate, presenting this climatic understanding from a quantitative perspective. A geographical building database was used to analyze two key aspects: the urban heat island effect (UHI) and wind dynamics. Urban climate maps were explored using the geographic database, with Hong Kong serving as a case study in the research conducted by Chen, et al. (2011) [11].

Author Tran Anh Tuan and his research team introduced GIS programming techniques using the ArcObject library to develop a tool for checking the conformity of data with the national basic geographic database framework at scales of 1:2,000, 1:5,000, and 1:10,000. The tool functions as a plug-in within ArcMap software and was tested on the geographic dataset of the Nam Dinh area at a scale of 1:10,000. The software's error detection results were compared with manual testing, and it was found that the errors in class names, aliases, field types, and value domains were entirely accurate [12].

Another article by Vietnamese authors presented a process for updating the 1:10,000 scale geographic database using stereoscopic SPOT 6 and 7 satellite images. This process was developed based on the findings of experimental research on updating the 1:10,000 scale geographic database [13]. Author Dong Thi Bich Phuong and her team highlighted the importance of and proposed a solution for creating a technical database to support the development of geographic databases and topographic maps at various scales. The solution is based on the principles of data augmentation, data generalization, automatic mapping, and restructuring the national geographic database and topographic map system [14].

A number of papers on the development of urban infrastructure databases have also been explored. Balasubramani et al. introduced GUIDES, a new data management and transformation framework for urban underground infrastructure systems. This framework enables city managers, workers, contractors, and other users to query digitized and integrated data, facilitating smarter decision-making [15]. Another study combined material flow analysis (MFA) with GIS data to examine the spatial and temporal dynamics of material stocks and flows associated with infrastructure development in Shanghai, China, at a high level of spatial detail. Efforts to make the city more compact are expected to improve the functional efficiency of existing stocks, though they may also lead to greater use of energy-intensive and emissions-heavy construction materials. Additionally, the study highlights that extending the service life of infrastructure through effective management, along with enhancing the recycling and reuse of demolition waste, are considered highly effective strategies for sustainable development [16].

Chen and colleagues focused on creating versatile urban analytics tools that can accommodate various data formats, a challenge that remains largely unresolved in practice. Their work presents an innovative system called the Urban Data Analytics Infrastructure (UADI), designed to address these challenges by utilizing technological advancements. The proposed approach employs a two-level mapping strategy to integrate diverse datasets into a cohesive structure [17]. One study developed a 3D geospatial dataset for the urban green tree system in the coastal area of Ha Long City, Vietnam, by integrating modern geospatial technologies. The dataset for the urban green tree system in the experimental area was created using a combination of low-cost drone technology and widely used software, including Excel, ArcMap, SketchUp, and FME [18].

Nguyen Bich Ngoc and colleagues developed a 3D-GIS map for both current and future scenarios of Hai Chau District in Da Nang City, Vietnam. The study integrates GIS, GPS, and RS technologies with advancements in 3D-GIS to manage urban areas in three dimensions, providing enhanced visual effects and management capabilities. The system allows for flexible information sharing, marking a significant breakthrough in spatial management and urban planning. As a result, managers can visually explore each area in detail from various perspectives [19]. The next group of authors employed GIS to develop a spatial database in the ESRI Personal Geodatabase format, incorporating a raster dataset (DigitalGlobe image) and dividing it into 34 vector data layers related to the water supply infrastructure system in the inner city districts of Can Tho, Vietnam [20].

Although numerous studies have been conducted on geographic databases and urban technical infrastructure databases, no research has been carried out on the construction of these two types of databases in Ho Chi Minh City. The geographic database in this research encompasses seven aspects, which collectively generalize nearly all real objects. Various databases, including urban infrastructure databases, can be developed from geographic databases. Therefore, this paper aims to prioritize the establishment of a multipurpose geospatial database, from which a basic urban infrastructure database can be extracted. The development of a multipurpose geographic database and a basic urban infrastructure database is a strategic step toward sustainable urban development in Ho Chi Minh City.

Study area. Ho Chi Minh City is located in southern Vietnam (Fig. 1). The city spans a natural area of 2,095.6 km^2 and had a population of 8.9 million as of 2023 [19]. It is home to a diverse population, including various ethnic groups and foreigners. The Kinh people form the majority, while other ethnic groups include the Chinese, Khmer, Cham, Tay, and Muong.

Geographically, Ho Chi Minh City is located between 10°10'–10°38' North latitude and 106°22'–106°54' East longitude. It shares borders with Binh Duong province to the north, Tay Ninh province to the northwest, Dong Nai province to the east and northeast, Ba Ria-Vung Tau province to the southeast, and Long An and Tien Giang provinces to the west and southwest. With its favorable geographical location – once known as the "Pearl of the Far East" – the city has consistently affirmed its role as Vietnam's economic, financial, commercial, and service hub, serving as the nucleus of the Southern Key Economic Region. Ho Chi Minh City plays a leading role in the Vietnamese economy, contributing 15.5 % of the country's total GDP and more than 20 % of its total budget revenue. The city has a relatively high density of architectural structures, interspersed with residential and civil constructions.

The general terrain of Ho Chi Minh City gradually slopes downward from north to south and from east to west. The city's terrain can be categorized into three sub-regions: high terrain area: located in the north-northeast and part of the northwest, this region features undulating terrain with an average elevation of 10–25 meters, interspersed with hills and mounds reaching up to 32 meters; low-lying area: found in the south-southwest and southeast, this region has an average elevation of just over 1 meter, with the highest point at 2 meters and the lowest at 0.5 meters; medium terrain area: located in the central part of the city, this region has an average elevation of 5–10 meters. Overall, while the terrain of Ho Chi Minh City is not particularly complex, it is diverse and offers favorable conditions for development in various aspects.

Ho Chi Minh City is situated in the equatorial tropical monsoon zone, characterized by high temperatures year-round and two distinct seasons: rainy and dry. The rainy season lasts from May to November, while the dry season runs from December to April. The city receives an average of 160–270 hours of sunshine per month, with an average air temperature of 27 °C. The annual rainfall is high, averaging 1,979 mm, and the average relative humidity throughout the year is 79.5 %.

Because of its favorable natural conditions, Ho Chi Minh City has become a major traffic hub in Vietnam and Southeast Asia, encompassing roads, railways, waterways, and airways. The city has a dense road network, with the longest total length of roads among urban areas in Vietnam. However, the transportation system has not kept pace with the city's rapid development. In addition to the existing routes that pass through the city center, Ho Chi Minh City is undertaking national railway and inter-urban railway projects. The city is traversed by a dense system of rivers and canals and boasts around 320 ports and wharves. The four major ports are Saigon, Tan Cang, Ben Nghe, and Nha Be. Tan Son Nhat International Airport, the largest airport in Vietnam in terms of area and capacity, serves as the international gateway to the city.

Methodology and data. The research was conducted through several stages. The methodological workflow is presented in Fig. 2. First, the preparation phase involved tasks such as designing the scanning flight plan, testing and inspecting equipment, installing the system, and establishing connections to the GNSS base station. Next, the installation, inspection, and calibration of the LiDAR scanning equipment and digital camera on the aircraft took place, followed by LiDAR scanning flights, digital photography, GNSS signal collection at the base station during flights, and the checking and storage of raw data.

Subsequently, the data processing phase began, which included calculating flight trajectories, generating point clouds along flight strips, and merging them into blocks. The point cloud data was then converted to the VN-2000 coordinate system, UTM projection grid, 3-degree projection zone, and the axial meridian at 105°45'00" for Vietnam. This step also involved verifying and correcting point cloud data using measurement data from point classification and calibration sites.

The next phase focused on creating the Digital Elevation Model (DEM) and ortho-images. This included establishing a Digital Surface Model (DSM), generating intensity response images based on terrain map fragments, and tasks like format conversion, image quality enhancement, image rectification, and the standardization of the DEM and ortho-images.

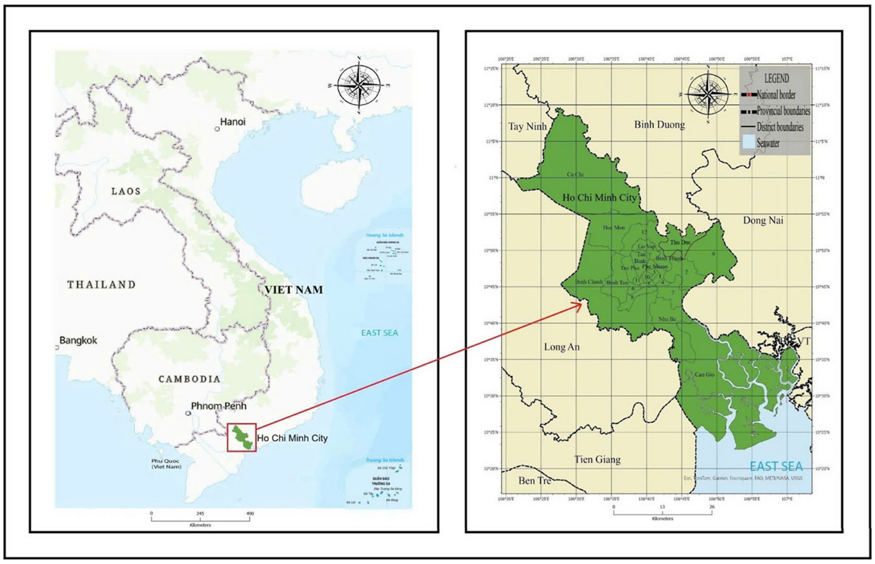

Fig. 1. Study area of Ho Chi Minh City, Vietnam

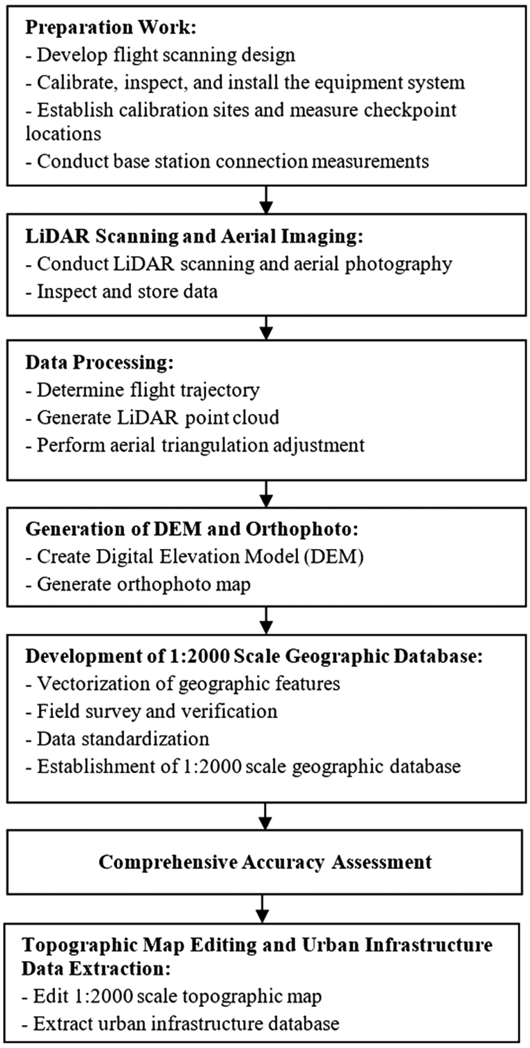

Fig. 2. Process of establishing a geographic database and extraction of urban infrastructure database

The fourth stage involved vectorising geographic objects, conducting field investigations, standardizing raw geographic data, and building a geographic database at a 1:2,000 scale. After editing and correcting the data, the standardized GIS data was stored in a GeoDatabase, which included database groups such as boundary, hydrology, measurement points, population, terrain, traffic, and surface cover. Following this, a 1:2,000 scale topographic map was created. Finally, data layers related to urban technical infrastructure were extracted from the 1:2,000 scale geographic database to support urban infrastructure management in the experimental area.

The materials utilized in this study were quite varied. For coordinates and elevations, the area includes a comprehensive network of coordinate grids and elevation benchmarks across all levels in Ho Chi Minh City.

In terms of map resources, the study makes use of digital cadastral maps at scales ranging from 1:200 to 1:5,000, created between 1997 and 2009. These maps serve as critical references, integrating measurement data from aerial photography, vectorized data, and field measurements to effectively standardize spatial data. The topographic map of Ho Chi Minh City was developed between 2003 and 2005 using the VN2000 coordinate system, with a 3-degree projection zone and a central meridian of 105°45'00", at scales of 1:2,000 and 1:5,000. These maps are valuable for referencing stable geographic features during the measurement of geographic objects on digital photo stations and for consulting associated attribute information.

The study also utilizes LiDAR and digital photo data, which include: Digital Terrain Models (DTM): Featuring laser points reflected from the terrain surface in ASCII text format; Image Products: In GeoTIFF format, corrected for registration and coordinates, including grayscale intensity images, True-Ortho images with a resolution of 25 cm, and digital terrain and surface model (Embossing) images with a resolution of 1 m; 3D Building Models: Generated at varying levels of detail (LOD1 to LOD3) and provided in shapefile and DGN formats.

Specifically, the processing of LiDAR point clouds involves systematic filtering and classification to ensure high-quality digital elevation models (DEMs). Using the TerraScan module, noise is removed from the point cloud, ground points are classified, and above-ground points are categorized for further analysis. While automated filtering software facilitates initial classification, it lacks the ability to subjectively remove unwanted objects, necessitating manual inspection and refinement. In TerraScan, ground points are carefully reviewed and refined to enhance accuracy, particularly in noise-affected and occluded areas, before interpolating the DEM. The final DEM is generated in Scan Binary 8-bit format to support orthorectification in TerraPhoto, where orthoimages are created through mosaicking based on map sheets. Standardization of the DEM dataset is conducted using various geospatial software, including Terrasolid, ArcGIS, and Global Mapper, alongside supporting tools such as MicroStation, Mapping Office, and specialized macros, ensuring consistency and accuracy in geospatial applications.

The presentation of 1:2,000 scale maps in ArcGIS software was done using a set of digital symbols for 1:2,000 scale topographic maps. These symbols are based on the topographic map symbols issued by the General Department of Land Administration (now the Ministry of Natural Resources and Environment) in 1994 for scales of 1:500, 1:1,000, 1:2,000, and 1:5,000, as well as a set of digital symbols for administrative base maps at different scales from the administrative map collection of the Map Publishing House, Vietnam.

The accuracy of the DEM must meet strict quality standards to ensure reliability in geospatial applications. The maximum allowable elevation error is set at 0.3 m under normal conditions. However, in areas with significant elevation variations or occlusions – such as dense vegetation or architectural structures – this threshold may be increased by a factor of 1.5 to account for data inconsistencies. The proportion of errors exceeding the tolerance but remaining within the maximum allowable error must not exceed 5 % in open areas and 10 % in complex or unstable terrains. Additionally, the root mean square error (RMSE) and mean error must not surpass twice their predefined thresholds. To maintain dataset integrity, the proportion of errors reaching or approaching 70–100 % of the maximum allowable error must be limited to 10 % of all validated points. These criteria ensure that the DEM maintains high accuracy and consistency for analytical and mapping applications.

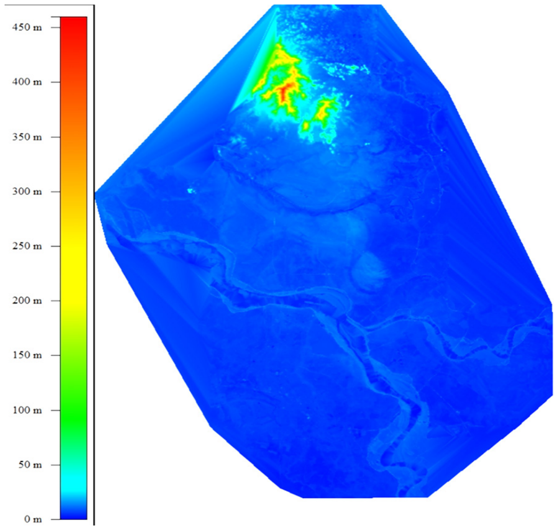

Fig. 3. Digital Elevation Model of the case study area

The 1:2,000 scale geospatial database for Ho Chi Minh City is developed based on LiDAR scanning combined with aerial imagery, producing both a DEM and an orthophoto map. The positional accuracy of geographic features within the geographic database and topographic maps at this scale is directly linked to the accuracy of these LiDAR-derived products, as established during the LiDAR survey. As a rule, at a scale of 1:2,000, the RMSE error of horizontal position should not exceed 1m under standard conditions and can increase to 1.5 m in complex terrain. For elevation, the RMSE error of contour lines, terrain features and elevation points should be less than 1/4 of the uniform elevation interval in open areas, but can increase by 1.5 times in obscured environments.

Results and discussion. The Digital Elevation Model (DEM) is constructed to support digital editing and image correction (Fig. 3).

The next result is a 1:2,000 scale geodatabase of Ho Chi Minh City (Fig. 4) consisting of seven main data

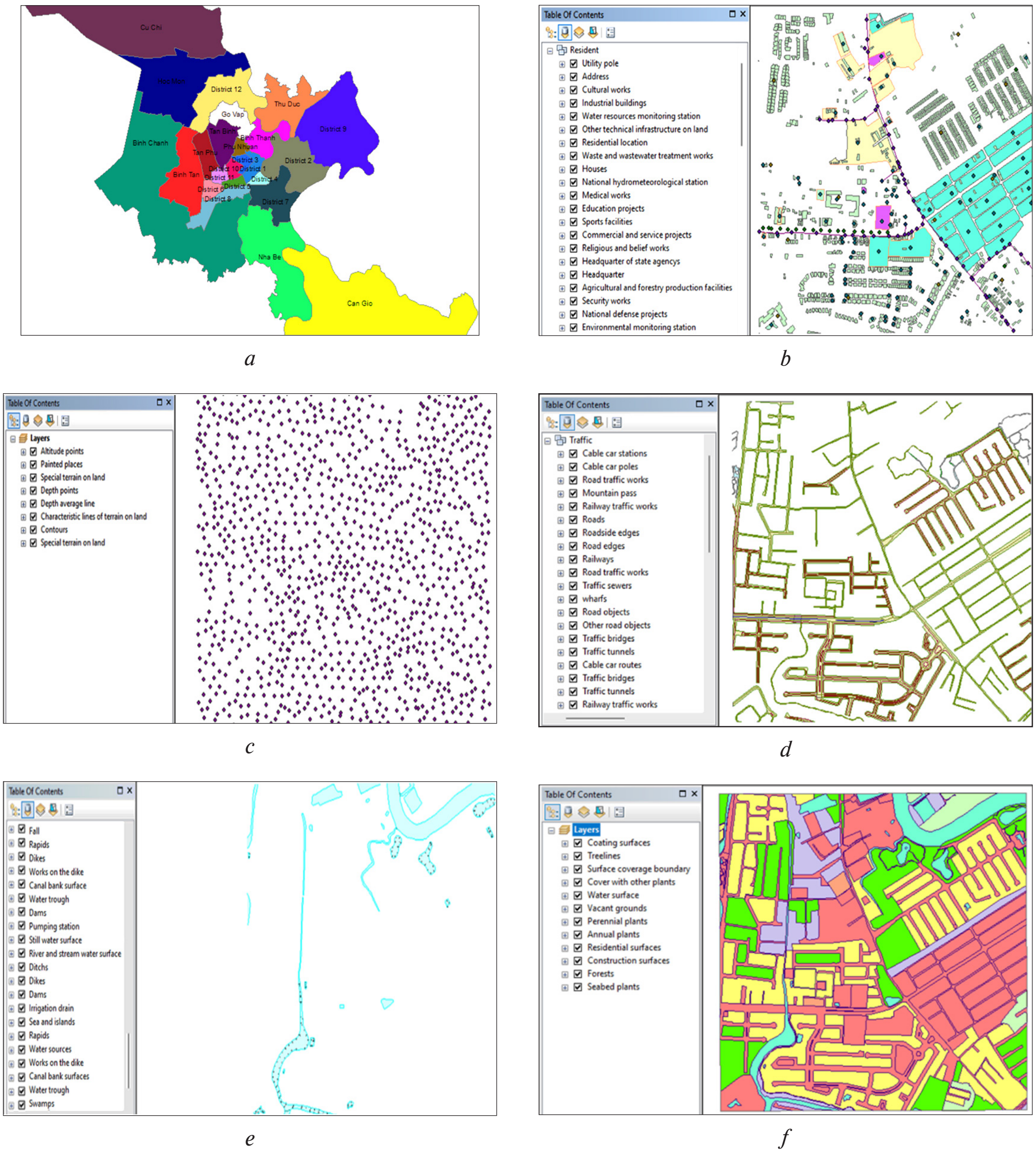

Fig. 4. Geographic database at 1:2,000 scale for Ho Chi Minh City (6/7 layer groups):
a — boundary; b — population; c — terrain; d — transportation; e — hydrology; f — surface cover

layer groups (Fig. 4). Among these, the border boundaries layer provides essential information on administrative divisions, including national borders, provincial boundaries, and other geographic features relevant to territorial representation. Another critical component is the surveying points layer, which includes precise coordinate points and elevation data, serving as the foundation for geodetic and surveying activities. Within this framework, the measurement system relies on key elements such as survey control points, which function as fixed reference positions to ensure consistency and accuracy in spatial measurements. Additionally, satellite positioning stations enhance data reliability by incorporating advanced satellite-based positioning technologies, thereby strengthening the overall geospatial framework.

The remaining layers of the geodatabase offer detailed insights into various aspects of Ho Chi Minh City's geography and infrastructure. The population layer integrates residential and technical infrastructure data, encompassing facilities such as schools, government offices, religious sites, and 22 kV power lines. Terrain data supports topographic mapping through elevation points, contour lines, and 3D terrain models, facilitating the construction of digital elevation models. The transportation layer captures the city's mobility networks, including roads, railways, waterways, and associated infrastructure such as bridges and tunnels. The surface cover layer classifies land use, vegetation, and built-up areas, while the hydrology layer maps the city's water systems, including rivers, lakes, irrigation structures, and coastal features.

A 1:2,000 scale topographic map of the Ho Chi Minh City area has also been created (Fig. 5). Finally, the urban infrastructure database was extracted from the geographic database (Fig. 6). These data layers include green spaces, parks, flower gardens, lighting cables, drainage pipes, rivers, canals, and ditches.

To verify the accuracy after processing LiDAR data, it is necessary to compare the coordinates and elevations of identical points from the LiDAR dataset and the control calibration field (at ground control points measured for planar or height accuracy in the calibration field). After the absolute adjustment of each survey area based on the XYH control field, the absolute adjustment error relative to the number of points in the survey area achieves a standard deviation of 0.180 m for planar accuracy (XY) and 0.077 m for elevation accuracy.

The True Orthophoto achieves a pixel resolution of 0.1m (for a scale of 1:2,000). The positional accuracy of image points at the checkpoint after adjustment is 0.35 mm × M (0.7 m), while the positional accuracy of image points relative to the nearest control point is less than 0.5 mm × M (1 m). The results indicate that the geographic database effectively represents spatial objects and their relationships. For geographic objects at a 1:2,000 scale, the root mean square error (RMSE) of planar position relative to the nearest national coordinate point meets the required standards, not exceeding 1 meter in typical areas and 1.5 meters in complex, obscured, or unstable terrain. In terms of elevation accuracy, the RMSE of contour lines, terrain feature eleva-

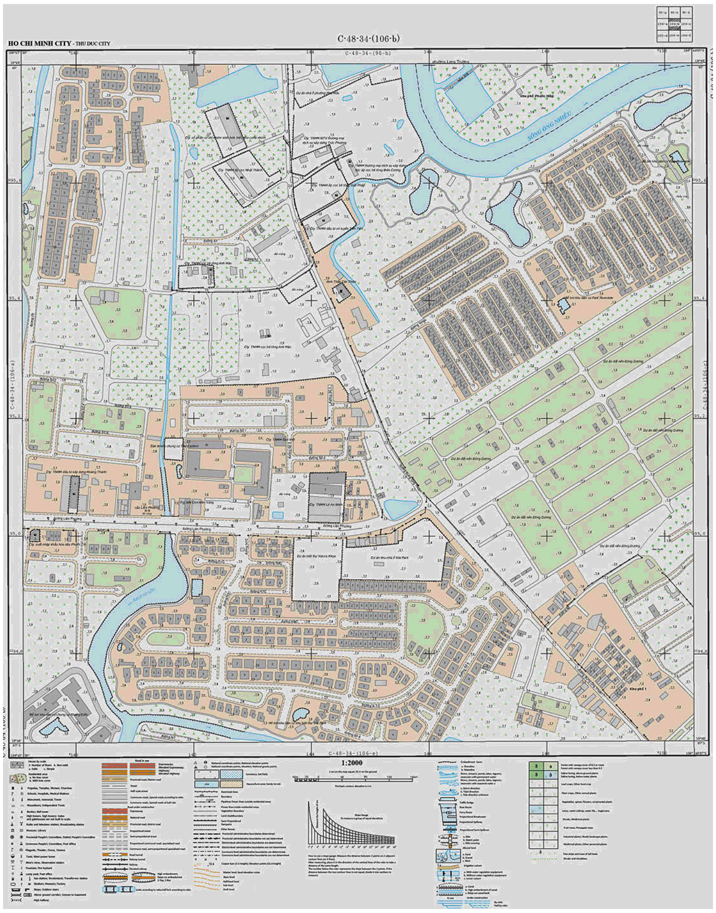

Fig. 5. Topographic map at 1:2,000 scale for the study area

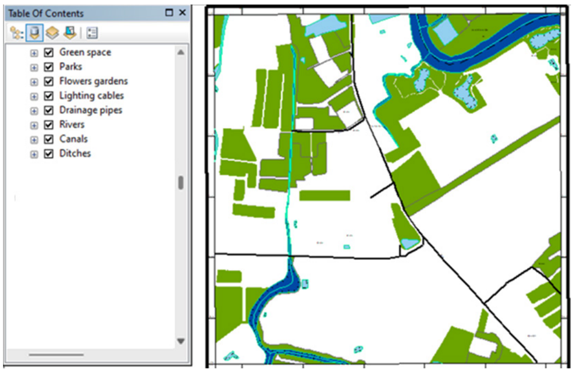

Fig. 6. Urban technical infrastructure database extracted from 1:2,000 scale geographic database of Ho Chi Minh City area

tions, and elevation reference points, when compared to elevation control points, also meets the required standards, remaining within one-fourth of the elevation range (h = 1 and 2.5 m) in open areas. However, in obscured regions, such as those covered by vegetation or architectural structures, these errors may increase by up to 1.5 times.

This approach ensures a comprehensive and scalable solution for managing urban technical infrastructure. Multi-purpose foundational databases can be developed from these topographic map information layers. Partial automation of the map construction process enhances efficiency, improves economic outcomes, and ensures high-quality control of geographic data content.

The data includes complete topological relationships, facilitating the representation and analysis of spatial relationships. Geospatial data can be seamlessly edited, created, and analyzed. Users can explore datasets, highlight relevant features, and generate maps, enabling quick and accurate creation of thematic maps. Additionally, users can integrate their own data into maps, presenting it in an effective and visually impactful way.

Geographic databases organize data based on spatial distribution, allowing users to identify patterns and spatial relationships that are difficult to discern using traditional methods. They feature a compact data structure, saving memory, enabling fast data recovery, and supporting quick calculations and conversions. Users can create high-quality maps and establish interactive connections between map content and reports, graphs, charts, tables, drawings, images, and other related data.

The study proposes various applications of geographic databases for analysis and database development, including: Administrative Management and Planning (land management, urban planning and administration, public service management, and administrative boundary division); Traffic and Transportation (transportation network planning, positioning, and navigation systems); Natural Resource and Environmental Management (monitoring environmental changes, disaster response, early warning systems, evacuation guidance, disaster monitoring, environmental analysis, management of protected and restricted areas, and forecasting environmental impacts); Smart Agriculture (land management, crop forecasting, and pest monitoring); Defense and Security (border management, military planning, and internal security); Socio-economic Development (business and service support, tourism development, and infrastructure management); Scientific Research and Education (development of GIS technology, map and spatial data management, spatial analysis, disaster forecasting, digital map applications, geographic information storage and sharing, real-time updates, and support for interdisciplinary research).

Additionally, the research proposes solutions to enhance the technical infrastructure management information system in the experimental area. Urban technical infrastructure data requires continuous investment, investigation, supplementation, and updating. This includes data on trees, tree routes, tree management records, control cabinets, electric poles, lighting routes, lighting management records, manholes, discharge gates, wastewater treatment plants, drainage routes, and drainage management records.

Following this, it is essential to invest in and develop application software for effective urban technical infrastructure management. The software must ensure consistency and synchronization across management functions, user services, interfaces, and interactions. It should be organized into subsystems to facilitate maintenance and future upgrades.

Conclusions. In conclusion, the results of this research include a 1:2,000-scale geographic database of the Ho Chi Minh City area and a foundational urban technical infrastructure database derived from it. The geographic database plays a crucial role in creating a multipurpose database in general and an urban technical infrastructure database in particular. ArcGIS software has proven to be an excellent tool, offering powerful features for data analysis, geographic database system development, and the extraction of data layers for the urban technical infrastructure database.

Building a geographic database is essential, as it not only establishes a modern information infrastructure for facility management systems but also provides fast and accurate spatial positioning information. Moreover, it serves as an indispensable tool for improving the reliability of the map information system, addressing errors and data gaps. Developing software that can efficiently handle all stages of geographic database creation is important, ensuring that the process remains simple yet effective while meeting necessary requirements. Further research and updates are required to incorporate additional layers of urban technical infrastructure data and to develop robust management tools for a comprehensive database system.

Future research will focus on developing a complete urban technical infrastructure management information system for the entire research area and its surroundings. This system will support infrastructure management at both macro and micro levels, fully addressing the management and operational needs of local facilities, sectors, towns, and communes.

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Розробка багатофункціональної географічної бази даних для управління інфраструктурою міста Хошимін (В'єтнам)

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Географічна інформаційна система (ГІС) – це технологія, призначена для збору, зберігання, аналізу, управління, відображення й оновлення даних про місцезнаходження, що інтегрує різні типи даних із різних джерел. Найважливішим компонентом ГІС є база даних, яка впорядковує та зберігає дані у структурованому форматі, що дозволяє ефективно знаходити первинну інформацію й керувати нею. Географічна база даних відіграє важливу роль у різних сферах, включаючи соціально-економічний розвиток, національну безпеку й оборону, управління природними ресурсами та охорону навколишнього середовища, транспортування й експлуатацію природних ресурсів. База даних міської технічної інфраструктури є однією із ключових баз даних, що підтримують розвиток «розумних» міст.

Мета. Розробка багатофункціональної географічної бази даних масштабу 1:2 000 для регіону міста Хошимін, В'єтнам, з якої будуть вилучені данні різних рівнів для підтримки управління міською технічною інфраструктурою в досліджуваному регіоні.

Методика. Дослідження складається з декількох основних етапів, зокрема сканування за допомогою LiDAR, цифрова фотозйомка, збір й обробка даних, цифрове картографування зображень, стандартизація цифрових моделей рельєфу, векторизація географічних об'єктів і польові дослідження зі збору атрибутивних даних для географічних об'єктів. У подальшому процес включає інтеграцію спеціалізованих карт з існуючими топографічними картами масштабу 1:2 000 з метою стандартизації географічних даних. На наступному етапі створюється географічна база даних і редагується топографічна карта масштабу

1:2 000 за допомогою програмного забезпечення ArcGIS. На завершення з географічної бази даних будуть вилучені рівні даних, пов'язані з міською технічною інфраструктурою.

Результати. Розроблена географічна база даних, що складається із семи блоків: кордони, гідрологія, геодезія, населення, топографія, дорожній рух і покриття, а також створена топографічна карта міста Хошимін масштабу 1:2 000. Крім того, із географічної бази даних були вилучені базові рівні даних міської технічної інфраструктури з метою підтримки управління міською інфраструктурою.

Наукова новизна. Це дослідження є першим, у межах якого створена географічна база даних масштабу 1:2 000 та вилучені з неї данні різних рівнів міської інфраструктури для експериментального району міста Хошимін, В'єтнам.

Практична значимість. Результати дослідження сприятимуть удосконаленню інформаційної системи управління міською технічною інфраструктурою, що дозволить місцевій владі розробляти відповідну політику та оптимізувати управлінські процеси більш ефективно та результативно.

Ключові слова: *географічна база даних, міська інфраструктура, управління технічною інфраструктурою, Хошимін, В'єтнам*

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