CLIMATE CHANGE AND DISASTER MITIGATIONINNOVATION MEASURES FOR EARTH, MINING AND ENVIRONMENTAL SCIENCES (innovative measures for earth, mining and environment sciences to meet sustainable development goals)

APPLYING 3D GEOSPATIAL DATA AND PROPOSED SOLUTIONS TO SUPPORT THE ADMINISTRATION, MANAGEMENT, AND MONITORING OF COASTAL SMART CITIES ADAPTING TO CLIMATE CHANGE IN VIETNAM

L T T Ha[1,2], N V Trung[1,2], N Q Long[1]
[1] Faculty of Geomatics and Land Administration, Hanoi University of Mining and Geology, No. 18 Pho Vien, Duc Thang Ward, North-TuLiem District, Ha Noi city, Vietnam.
[2] Geomatics in Earth Sciences Research Group, Hanoi University of Mining and Geology, No. 18 Pho Vien, Duc Thang Ward, North-TuLiem District, Ha Noi city, Vietnam.
Email: lethithuha@humg.edu.vn

Abstract: The development of smart cities in Vietnam's coastal urban areas faces unique challenges in addressing issues such as the consequences of climate change, rising sea levels, urban floods, storms, marine pollution, and other related factors. To meet this demand, in addition to developing urban infrastructure systems, there needs to be an information infrastructure and data system that allows policymakers, administrators, and residents to connect and formulate preparedness and response plans, minimizing risks during extreme events. The most crucial information resource for a smart coastal city is the 3D geospatial data of the city. The 3D geospatial data of Halong city was established based on the geospatial technologies with popular software such as Excel, ArcMap, Sketchup, FME. Based on the results we have developed for the Ha Long coastal area, we will make recommendations on using 3D geospatial data to enhance governance, management, manage and monitor coastal smart cities as they adapt to climate change in Vietnam.

1. INTRODUCTION

3D geospatial data is a geographic information system (GIS) database system where each geographical entity is treated as a presence situated in a three-dimensional (3D) space. These databases are designed for efficient storage and retrieval of information pertaining to objects within a geospatial model. Numerous 3D database models exist, and one of the exemplary models is characterized by having just two primary components: spatial data and attribute data. Spatial data represents an assembly of objects within 3D space, consisting of points defined by a three-dimensional coordinate system (x, y, z), accompanied by 3D geographical entities and their associated property information.

In the development of smart cities in coastal urban areas, there are distinctive features that address challenges like the impacts of climate change, elevated sea levels, urban flooding, storms, hurricanes, and marine environmental pollution. Coastal cities, characterized by significant population density, face the crucial objective of constructing smart urban environments to safeguard residential communities from the consequences of extreme events. To fulfill this need, beyond constructing urban infrastructure, establishing information and data systems is crucial. These systems assist policymakers, managers, and residents in collaborating to devise strategies for readiness and response, reducing risks during extreme events. The primary information system in a smart coastal city is its 3D geospatial data (Anilkumar, 2014).

In developed nations, the use of 3D geospatial information and geospatial technologies in constructing intelligent coastal cities to tackle climate change and rising sea levels has been put into practice. Meanwhile, the utilization of LiDAR data to generate 3D geospatial information has offered solutions in crafting flood geospatial data for a city in Honduras (Haile and Rientjes, 2005). UAV data was utilized to develop a 3D coastal map for Pusan, Korea, aiding its adaptation to climate change (Yoo, Oh, and Choi, 2018). Additionally, (Papakonstantinou et al., 2015) delineated coastal regions and crafted 3D maps using UAV data for the advancement of smart city initiatives in Lesvos Island and the Eressos coast, Greece. These studies highlight the capability of geospatial data in constructing 3D geospatial information for smart cities, specifically in adapting to coastal regions within developed nations.

Presently, our country is advancing towards smart city development, with approximately 30 cities already in the process. Among these cities are Hanoi, Ho Chi Minh City, Ha Long, Hai Phong, Thai Nguyen, Da Nang, Hue, Da Lat, Binh Duong, Can Tho, and more…Vietnam is currently adopting a fresh strategy for organizing and overseeing marine areas through a geospatial database system. This system aims to detail the positions and spatial boundaries of marine entities while directing oceanic courses. It assists in coastal and marine area planning, shaping legal frameworks, and offers a foundation for users and stakeholders to depict, visualize, and recognize spatial data pertaining to the sea and coastal regions, presented as 3D geospatial information. Creating 3D geospatial data demands consideration of Vietnam's coastal city features amid climate change. This involves using existing data and incorporating new, location-specific data tailored to each area within the country's localities.

In our study, we have used a technique to integrate the different data acquisition techniques, including terrestrial laser scanner, terrestrial photogrammetry, and unmanned aerial system. The project has built a 3D geospatial data set for the coastal smart city of Ha Long city, Quang Ninh province. This study focuses on recommendations on using 3D geospatial data to enhance governance, management, manage and monitor coastal smart cities as they adapt to climate change in Vietnam.

2. CREATING THREE-DIMENSIONAL GEOSPATIAL INFORMATION FOR HA LONG CITY'S COASTAL REGION

2.1. Study Area

Figure 1: *The study site*

2.2. Data and research methods

Data acquisition techniques DJI Phantom 4 Pro V2.0, FARO FOCUS^{3D} X130 TLS, and Sony DSCF828

Figure 2: *Data collection by using the UAV, FARO FOCUS^{3D} X130 TLS, and Sony DSCF828*

The methodology of this study can be categorized into three phases: data acquisition, data processing, and the results (fig.3).

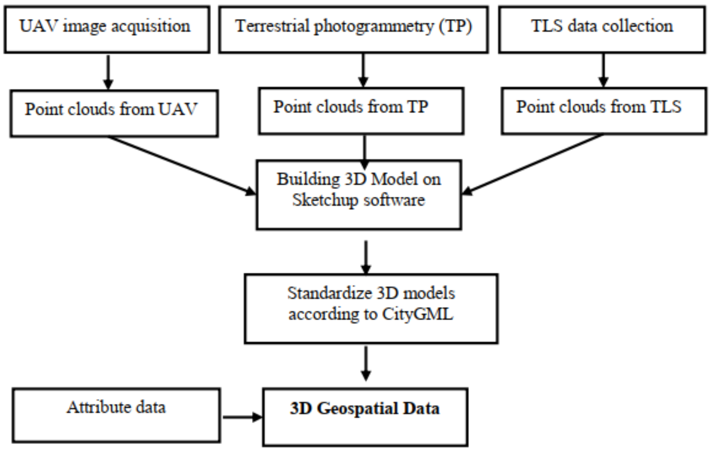

Figure 3: *Flowchart in data processing phase*

2.3. The results

After being satisfied with the integration result obtained, the integrated data is utilized to generate a 3D model as a final product of this study. Figure 4,5 shows the 3D model as a final product of integration points cloud process.

Figure 4: *The 3D Lod-2 point cloud in the experimental area*

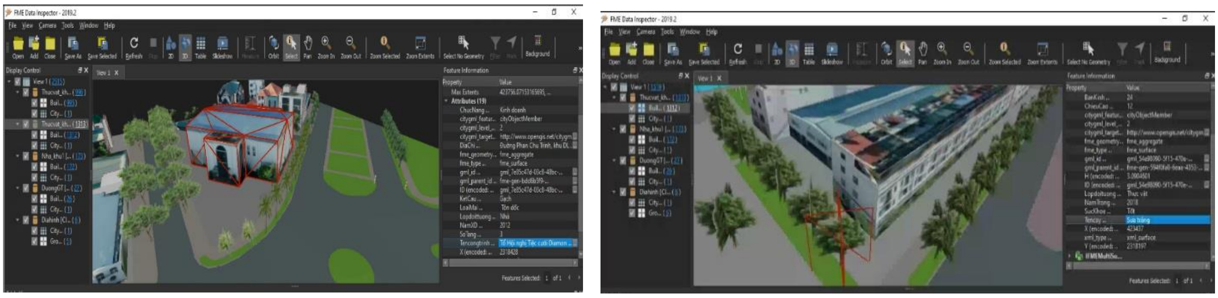

Figure 5: *The 3D geospatial data of buildings and trees*

3. PROPOSE SOME SOLUTIONS APPLYING 3D GEOSPATIAL DATA TO SUPPORT THE ADMINISTRATION, MANAGEMENT, AND MONITORING OF COASTAL SMART CITIES ADAPTING TO CLIMATE CHANGE IN VIETNAM

3.1. Solutions for Applying 3D Geographic Spatial Data in Smart Coastal Urban Space Management

To plan and manage smart cities, a variety of modern technologies must be employed, with a critical element being geospatial data. It is estimated that nearly 80% of decisions in urban planning and management rely on the analysis of geospatial data and information. When we talk about smart cities, we're referring to electronic service systems based on various modern technologies, with information and communication technologies (ICT) being a prime example. Geospatial data plays a vital role and serves as the foundation for developing different types of ICT systems.

3D geographic spatial data can be utilized for urban planning. Using the X, Y coordinates of the data and the descriptive information, leaders at various levels can combine 3D visualization to gain a comprehensive overview of the current urban planning zones and anticipated future development areas for the city. 3D geographic spatial data facilitates visual and vivid urban planning, enabling managers, investors, and residents to envision the new layout of functional planning areas.

Figure 6: *Application of 3D Geographic Spatial Data in Urban Planning and Management*

The planning can include:

- Opening new roadways for the city;

- Expanding existing road networks;

- Establishing economic zones such as coastal and inland economic zones.

Furthermore, 3D geographic spatial data of the city provides the capability to display visuals with precise geographic coordinates and dimensions relative to reality. This allows designers and planners to efficiently develop and integrate their design proposals directly onto models for evaluation (Figure 3). When designing transportation routes through an area, 3D urban spatial data also serves as crucial documentation for assessing impact levels, calculating information, estimating relocation and compensation costs, and determining traffic density. It also provides the optimal conditions for planning amusement parks, greenery planting, and landscape design for research areas.

3D geographic spatial data of the city provides information to support urban real estate management. A 3D spatial information system is an essential foundation for the management of real estate, including land and buildings. In addition to traditional documents like land records and cadastral maps, which show the ground layout of land and buildings, today, 3D geographic spatial data with different levels of detail (LoD) offers more specific and visually detailed technical drawings of urban real estate objects (Figure 7).

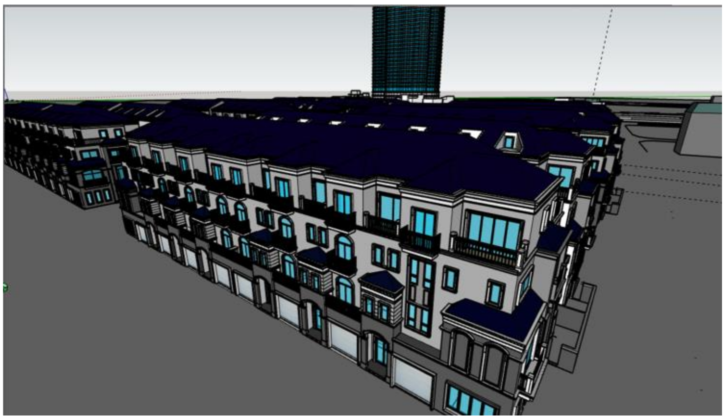

Figure 7: *Application of 3D Geographic Spatial Data in Real Estate Management*

3D geographic spatial data provides information for managing incidents, emergencies, and urgent responses. In densely populated urban areas, incidents related to traffic, medical emergencies, fires, and crimes occur frequently, necessitating swift and timely interventions. Thanks to spatial information about street networks, addresses, buildings, traffic routes, and both industrial and residential structures, experts can quickly identify and access the locations of incidents.

Furthermore, through spatial data analysis, it is possible to determine the shortest or most sensible route to make decisions regarding the most advantageous approach to an object or incident. Spatial information about housing density, infrastructure systems, the likelihood of crime occurrence serves as a foundation for urban authorities to devise preventive measures against fires, traffic incidents, and criminal activities.

3.2. Solution applying 3D geographic spatial data in smart risk alert management for coastal cities ensures adaptation to climate change

The integration of information technology facilitates the real-time connection of data between monitoring locations and the center. Data from specialized automated monitoring stations are continuously updated online and shared with 3D geographic spatial data. With applications on mobile devices, technical staff can extract all the needed information, and some criteria are even automatically alerted by the system. In addition to automatic updates from monitoring stations, risk information data can also be contributed by the community in real-time to the relevant authorities.

By combining 3D geographic spatial data with real-time models and figures, the analysis, calculation, and statistical assessment of damages (if any) during risks or natural disasters are conducted. Real-time updates of parameters and the construction of models are performed using 3D geographic spatial data, which includes the positions of real-time monitoring stations. This is combined with expert knowledge to provide forecasts for the monitored areas in the near future. Based on actual data and forecasts, leaders can make quick decisions to minimize damages as much as possible.

3D geographic spatial data of the city provides information about buildings in the form of visual 3D data with real dimensions. In addition to calculating damages and assessing risks from natural disasters such as earthquakes, tsunamis, etc., it also aids in developing preventive measures, such as evacuation and rescue plans during disasters. The 3D geographic spatial data is constructed on a terrain with real photo overlays, assisting in choosing optimal evacuation locations in the event of flooding. In densely populated urban areas, incidents such as traffic accidents, emergency medical responses, fires, crimes, etc., occur frequently and require prompt and timely handling.

Figure 8: *Application of 3D Geographic Spatial Data to identify and timely access the locations of incidents*

Furthermore, 3D geographic spatial data provides information about the street network, buildings, roads, infrastructure, enabling experts to quickly identify and timely access the locations of incidents (Figure 8). Moreover, it helps determine the shortest or most reasonable route for approaching objects or incidents in the most advantageous way. In the case of fires, the 3D model serves as a basis for pre-selecting the location to place firefighting ladders while the firefighting team is en route to the scene.

3.3. The solution applying 3D geographic spatial data in smart water management for coastal cities involves several aspects

The 3D geographic spatial data helps city managers have an overview of the city's water supply and drainage system, enabling them to plan renovations, upgrades, and new installations in a synchronized manner, while meeting the requirements of a smart city.

3D geographic spatial data in smart cities is used for storing, managing, manipulating, and analyzing spatial information. This data can be used to create specialized maps, enabling the design and operation of a unified water supply and drainage system for the entire city (Figure 9).

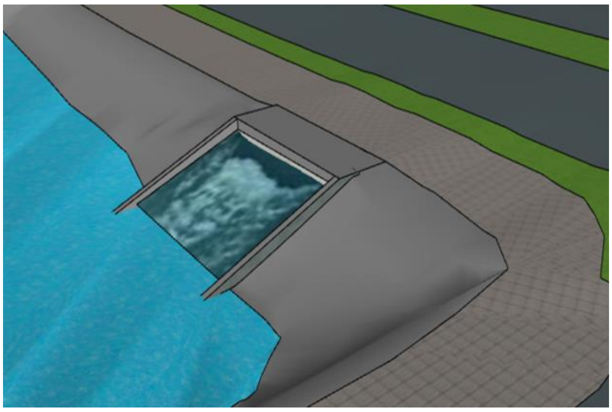

Figure 9:*3D spatial data of the urban drainage system*

Smart cities around the world have successfully implemented water supply and drainage models. However, applying these models, managing operations, adopting new technologies, and developing smart coastal cities in Vietnam face many challenges and difficulties during implementation. Smart drainage systems in coastal cities provide real-time water level results on the 3D spatial data model accurately and instantly. This real-time model helps operators and managers know precisely when to control the system for optimal operation. Combined with e-governance in providing new clean water services, operators can use the existing 3D spatial data of the city to make the most optimal choices during real-world deployments based on operational requirements.

3.4. Solution for applying 3D geographic spatial data in smart transportation management for coastal cities for economic and social development

Detailed 3D geographic spatial data on traffic, this data serves as a convenient and fast management foundation (Figure 10). It includes:

- Smart camera data: Supports the city's smart traffic management system in monitoring and handling violations of traffic safety regulations.

- Smart streetlight data: Involves automatic lights that adjust according to ambient light or pedestrian movement, contributing to the city's illumination.

Figure 10: *3D geographic spatial data in smart transportation management for coastal cities*

- Data for lane management: Covers traffic lane management, parking lot management, non-stop toll booth management, smart load weigh station management, road management, and road quality.

- Sensor and traffic alert system data: Assists managers in monitoring and alerting for traffic hazards involving different vehicles.

- Detailed navigation map data: Includes road classifications, road types, speed limits for road segments, aiding vehicles during transit.

- Intelligent signage and warning system data: Covers data related to intelligent traffic signs and warnings.

- Road infrastructure data: Supports monitoring, analyzing situations, maintenance, and managing road infrastructure for various activities.

This comprehensive 3D geographic spatial data facilitates the implementation of a smart road transportation system, contributing to the economic and social development of coastal cities.

3.5. Solution for Applying 3D Geographic Spatial Data in Smart Waste Collection and Management for Urban Environmental Protection

Identifying environmental issues and managing the urban environment, one significant concern in large cities is urban waste. The results of spatial data analysis from 3D geographic spatial data enable the determination of landfill locations, assessing their volume and optimizing waste collection routes for cost efficiency and increased effectiveness. The landfill location depends on various criteria, such as the distance to the city center, residential areas, locations of water wells, and groundwater sources.

Analyzing multiple criteria allows identifying the optimal landfill location. Spatial data analysis helps determine the optimal collection routes for waste transportation within the urban area. Optimized collection routes contribute to cost savings in transportation, fuel efficiency, and time.

The application of 3D database for managers and government authorities enables the identification and planning of centralized waste treatment areas using modern technology to minimize the impact on the surrounding environment. Around islands and coastlines, sensors can be placed to determine the flow of waste in the sea, allowing for quick remedies. Remote-controlled robots can also be deployed to access areas that are inaccessible to humans.

4. CONCLUSION

Based on the findings of the research into solutions that utilize spatial data to aid in the oversight and administration of smart cities, the article arrives at the subsequent conclusions:

3D geographic spatial data consists of layers of information about buildings, greenery, hydrology, traffic, and topography. It provides 3D objects with spatial information regarding height and attribute. These object attributes serve as input requirements to support the management, administration, and supervision of urban space. The calculations aid in alerting the impacts of natural disasters, smart drainage management, operation and monitoring of intelligent transportation, and waste collection. These are essential tasks in the construction, operation, and management of smart cities.

5. REFERENCE LISTS

[1] Anilkumar, P. P. (2014). Geographic Information System for Smart Cities. India, Copal Publishing Group.

[2] Biljecki, F., J. Stoter, H. Ledoux, S. Zlatanova and A. Çöltekin (2015). "Applications of 3D City Models: State of the Art Review." ISPRS International Journal of Geo-Information 4(4): 2842-2889.

[3] Yalcin, G. and O. Selcuk (2015). "3D City Modelling with Oblique Photogrammetry Method." Procedia Technology 19: 424-431.

[4] Yoo, C. I., Oh, Y. S., and Choi, Y. J. (2018). COASTAL MAPPING OF JINU-DO WITH UAV FOR BUSAN SMART CITY, KOREA, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-4, 725-729, https://doi.org/10.5194/isprs-archives-XLII-4-725-2018, 2018

[5] OGC City Geography Markup Language (CityGML) Encoding Standard," Open Geospatial Consortium: Wayland, USA, 2012.

[6] OGC IndoorGML-with Corrigendum, Open Geospatial Consortium: Wayland, USA, 2018.

[7] OGC CityGML 3.0 Conceptual Model, [Online]. Available: https://github.com/opengeospatial/CityGML-3.0CM. [Accessed 14 June 2020].

[8] T. Kutzner, K. Chaturvedi and T. Kolbe, "CityGML 3.0: New Functions Open Up New Applications," Photogramm. Remote Sens. Geoinf. Sci, vol. 88, p.43-61, 2020.

[9] Góźdź, K., Pachelski, W., Oosterom, P.O., Coors, V. (2014). The possibilities of using CityGML for 3D representation of buildings in the cadastre. In Proceedings of the 4th International Workshop on 3D Cadastres, p.339-362.

[10] Komninos, N., (2021). Developing a policy roadmap for smart cities and the future internet. eChallenges e-2011 Conference Proceedings.

[11] Kozłowski, W., and K. Suwar, (2021). Smart City: Definitions, Dimensions, and Initiatives. European Research Studies Journal. XXIV(3), p.509-520.

PROCEEDINGS OF THE SIXTH INTERNATIONAL SCIENTIFIC CONFERENCE

EARTH AND ENVIRONMENTAL SCIENCES, MINING FOR DIGITAL TRANSFORMATION, GREEN DEVELOPMENT AND RESPONSE TO GLOBAL CHANGE

GREEN EME 2023

Chịu trách nhiệm xuất bản
Giám đốc - Tổng Biên tập
Bùi Minh Cường

Chịu trách nhiệm nội dung: TS. NGUYỄN HUY TIẾN
Biên tập và sửa bản in: TS. NGUYỄN HUY TIẾN
Họa sỹ bìa: NGỌC ANH

NHÀ XUẤT BẢN KHOA HỌC VÀ KỸ THUẬT
70 Trần Hưng Đạo - Hoàn Kiếm - Hà Nội

CHI NHÁNH NHÀ XUẤT BẢN KHOA HỌC VÀ KỸ THUẬT
28 Đồng Khởi - Quận 1 - TP. Hồ Chí Minh

Liên kết xuất bản: Công ty Cổ phần in và dịch vụ văn phòng Tân Đại Việt

---

In 100 bản, khổ 17x24cm, in tại Tại Công ty Cổ phần in và dịch vụ văn phòng Tân Đại Việt

Địa chỉ: 16 Đường Chùa Láng, P. Láng Thượng, Q. Đống Đa, Hà Nội

Số ĐKXB: 4525-2023/CXBIPH/01-253/KHKT

Quyết định xuất bản số: 196/QĐ-NXBKHKT, ngày 11 tháng 12 năm 2023

ISBN: 978-604-67-2826-9

In xong và nộp lưu chiểu năm 2023.