RESEARCH ON APPLICATION OF GIS TECHNOLOGY IN INDUSTRIAL ZONE PLANNING MANAGEMENT

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Abstract

GIS technology (Geographic Information System) is a useful tool in integrating geographic database systems with maps to manage construction planning and has been widely applied in many developed countries. In construction planning in general, the management of industrial zone planning is a very important component, but the application of GIS technology in this field is not yet common in Vietnam. This study proposes a process for making a geographic database to support the planning management of Dinh Vu Industrial Zone (DEEP C1) - Hai Phong city, contributing to supporting synchronous analysis and management solutions of the City planning, industrial zones, coastal infrastructure and marine spatial development. The results indicate that the proposed GIS-based process enhances data consistency, improves planning management efficiency, and provides a more effective solution compared with traditional data management methods.

Keywords: *GIS, Planning, Industrial Zone.*

1. Introduction

Dinh Vu Industrial Zone (IZ) is a large-scale industrial complex characterized by a diversified industrial structure, encompassing light industry, heavy industry, chemical and petrochemical sectors, as well as public logistics services. The industrial zone is supported by a comprehensive infrastructure system, including port facilities, fire-fighting water reservoirs, power supply and water distribution networks, telecommunication infrastructure, transportation systems, and liquid pipeline networks [1].

Currently, the planning, management, and operation of industrial zones are primarily based on map and drawing systems stored in AutoCAD software, which entails significant limitations [2], [3] due to the large, diverse, and complex datasets, as well as the considerable time and effort required. Moreover, AutoCAD-based mapping systems do not allow the integration of spatial and attribute data. Geographic Information Systems (GIS) can effectively overcome these constraints. As a powerful tool for managing both spatial and non-spatial data, GIS is designed as a unified database management system and has been widely applied across various fields, including natural resource and environmental management, urban planning and administration, water resource management, as well as military and defense applications [3], [4], [6].

To apply GIS technology in the management and planning of the Dinh Vu Industrial Zone, this study employed software such as ArcGIS in combination with detailed planning maps of the industrial zone that had been officially approved by the competent authorities. ArcGIS was selected for its robust capabilities in ensuring data accuracy, standardization, and efficiency in spatial analysis, making it well suited for the objectives of this study.

2. Development of GIS Database for Planning Management of Dinh Vu IZ

2.1. Procedure for Developing the Geospatial Database

Based on studies related to GIS, along with planning data and relevant industrial zone data, a procedure was developed for the geospatial database of the Dinh Vu Industrial Zone to support management and planning, consisting of the following steps:

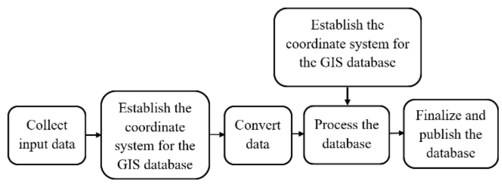

Figure 1. Procedure for developing the geospatial database of the Dinh Vu IZ

2.2. Development of the GIS Database for Dinh Vu IZ - Hai Phong

+ Data collection and related documents:

Within the scope of this study, relevant documents and datasets of the Dinh Vu Industrial Zone were

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collected, including AutoCAD drawings, maps, and other information obtained from the official website of the Dinh Vu Industrial Zone Joint Stock Company.

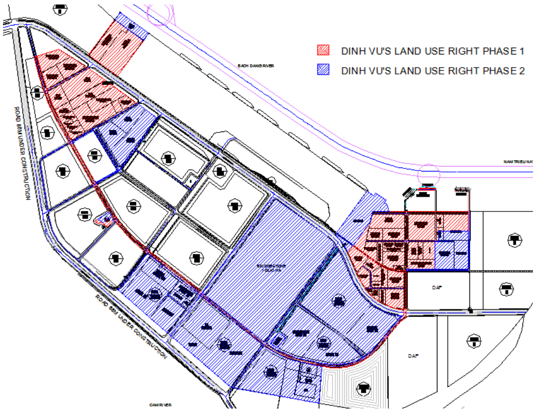

Figure 2. Planning Map of Dinh Vu IZ

The master planning map designates specific land-use functions within the Dinh Vu Industrial Zone, including: Light industry and agro-supporting industries; integrated facilities and warehouses; heavy industry; chemical, petrochemical, and liquid-port-related industries; public service and commercial centers; rental apartment complexes; infrastructure connection facilities; seaport services; national defense land; green buffer zones; and transportation networks.

The land-use map illustrates two construction phases (Phase 1 and Phase 2) and the allocation of land to clients, based on the master planning map and the contracts signed with customers.

In addition, AutoCAD drawings provide detailed representations of technical infrastructure components within the industrial zone, such as stormwater drainage, water supply, wastewater drainage, transportation networks, and the power supply and lighting system.

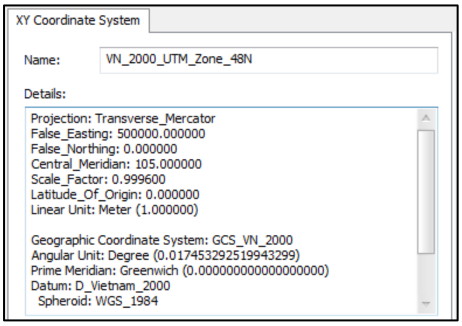

Figure 3. Detailed information on the coordinate system established in ArcGIS

+ Establishing the Coordinate System for Data

Before digitizing, editing, and storing the geospatial database in ArcGIS, it is necessary to establish a coordinate system for the data. This ensures spatial consistency and positional accuracy, so that in cases where updates or modifications to the industrial zone's planning are required, all geographic objects remain correctly aligned with their spatial coordinates.

+ Database Conversion

The data model stored and represented in AutoCAD differs in several respects from that in ArcGIS. Therefore, it is necessary to perform database conversion steps to standardize the data format within the GIS system, enabling effective storage as well as advanced data integration and analysis [2], [3]. To accomplish this conversion, the specialized tool *"Feature Class to Shapefile"* was employed. The results are illustrated in Figures 4 and 5, respectively.

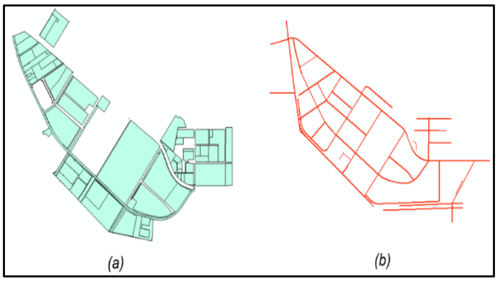

Figure 4. The Land-use planning layer (a) and Internal transportation network layer (b) in ArcGIS

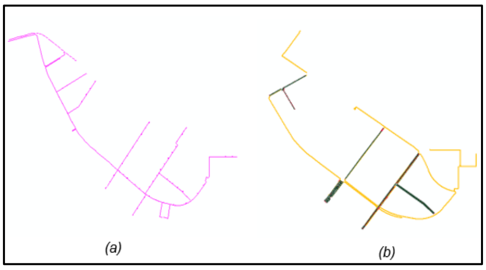

Figure 5. The Water supply system layer (a) and Power supply system layer (b) in ArcGIS

In addition, other AutoCAD drawings of industrial zone infrastructure—such as the wastewater drainage system, stormwater drainage system, green areas, and landscape—were also converted into GIS data formats to enable storage and support advanced management and analytical tasks.

+ Database Processing

After being converted into storage formats compatible with ArcGIS, the geospatial database layers of the industrial zone were further processed, edited, and supplemented with attribute information to ensure data consistency for updates and cross-referencing in planning management. This represents a major advantage of GIS technology, as software built on this platform is capable of storing large volumes of attribute data, whereas most conventional design and drafting software cannot achieve this.

The "Land-use planning" layer for each land parcel was updated with attribute information, as illustrated in Figure 6 including attributes such as land-use type, parcel area, customer name, and construction density.

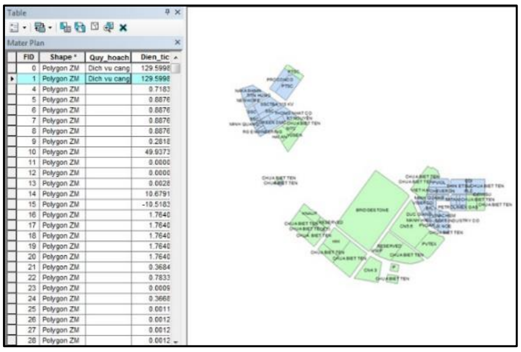

Figure 6. Update of land parcel attributes and client information in the Dinh Vu IZ

The "Internal road network" data layer of the Dinh Vu Industrial Zone was updated and supplemented with attribute information, as shown in Figure 7, including attributes such as road name, length, right-of-way, road classification, and carriageway cross-section.

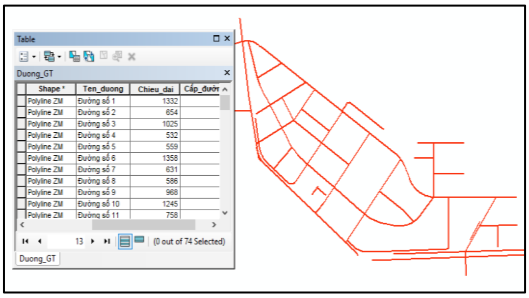

Figure 7. Attribute updates of the internal road network system

The data layers of the industrial zone's technical infrastructure systems—such as power supply, water supply and fire protection, stormwater drainage, and wastewater drainage—were also supplemented with complete attribute information based on the detailed planning maps, similar to Figures 6 and 7.

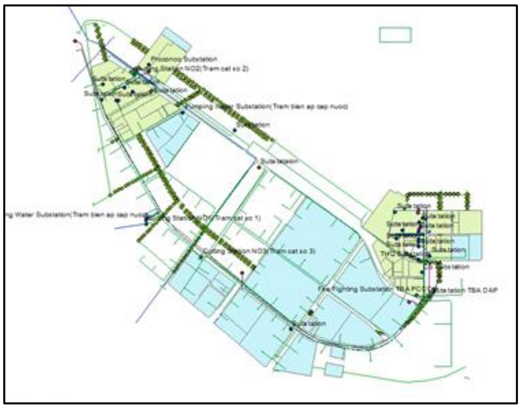

Figure 8. IZ Geospatial database after digitization and completion

2.3. Database Quality Assessment

To ensure the reliability and applicability of the GIS database for industrial zone planning management, this study developed a quality assessment workflow using ArcGIS Data Reviewer. The workflow enables evaluation based on four key criteria: geometric accuracy, spatial consistency, data completeness, and attribute accuracy. The Geometric accuracy was checked by comparing coordinates with reference maps, spatial consistency was verified using topology rules such *as "Must Not Overlap and Must Not Have Gaps…"*, data completeness was assessed through record counts and coverage checks, and attribute accuracy was ensured by cross-checking field values and code formats in accordance with planning standards. The results are consolidated in the Reviewer Table, providing quantitative reports that support data correction and standardization [5].

Table 1. Summary of quality assessment criteria and tools used in ArcGIS

Criteria & Tools	Purpose
Geometric accuracy - Define Projection, Check Geometry	Standardize coordinates, detect geometry errors
Spatial consistency - Topology Rules	Verify spatial logic (e.g., no overlap, no gaps)
Data completeness - Completeness Check	Identify missing features/records
Attribute accuracy - Field Calculator	Detect missing, invalid, or out-of-range values
Statistical comparison - Statistics/Summary	Compare indicators with planning records

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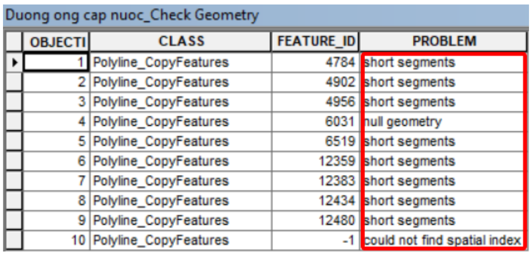
The first step focused on geometric accuracy, where the coordinate system was standardized using the Define Projection tool and geometry errors were identified with the Check Geometry tool [5].



Duong ong cap nuoc_Check Geometry

OBJECTI	CLASS	FEATURE_ID	PROBLEM
1	Polyline_CopyFeatures	4784	short segments
2	Polyline_CopyFeatures	4902	short segments
3	Polyline_CopyFeatures	4956	short segments
4	Polyline_CopyFeatures	6031	null geometry
5	Polyline_CopyFeatures	6519	short segments
6	Polyline_CopyFeatures	12359	short segments
7	Polyline_CopyFeatures	12383	short segments
8	Polyline_CopyFeatures	12434	short segments
9	Polyline_CopyFeatures	12480	short segments
10	Polyline_CopyFeatures	-1	could not find spatial index

Figure 9. Check Geometry results showing pipeline errors

Next, spatial consistency was evaluated through topology rules (e.g., Must Not Overlap, Must Not Have Gaps). This step enabled the detection of logical errors in land-use polygons and infrastructure networks, as illustrated in Figures 10 and 11 [5].

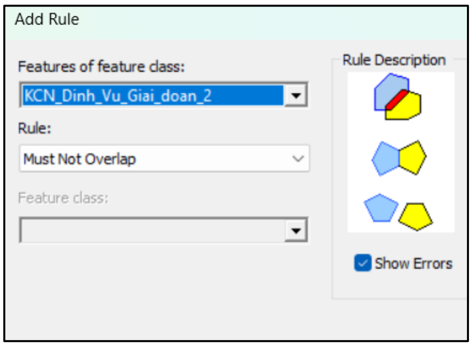


Figure 10. Example of applying topology rules in ArcGIS to check spatial consistency

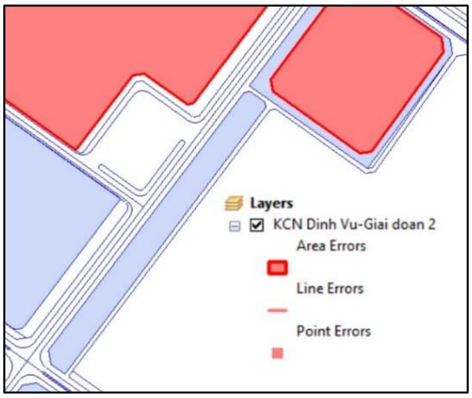


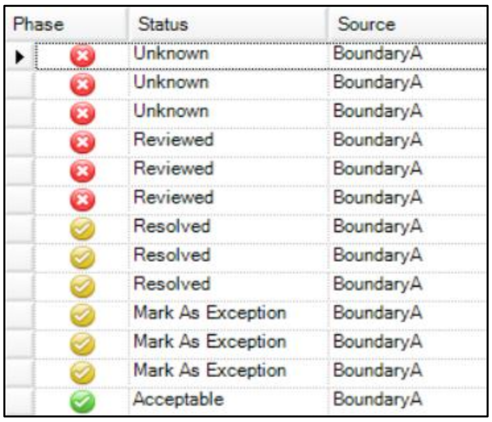
Figure 11. Visualization of topology errors detected in the planning database

In addition, attribute validation can also be implemented through the "Field Calculator" with logical expressions. This enables the detection of errors such as missing codes, invalid land-use values, or incorrect area ratios [5].

Finally, all detected errors and completeness indicators were recorded in the "Reviewer Table" for analysis and reporting.

Table 2. Examples of attribute validation rules using Field Calculator in ArcGIS

Object/Attribute	Example Formula/Condition
Industrial land plot - Area	`!Shape.area@hectares! < 1` → polygon too small `!Shape.area@hectares! > 1000` → polygon too large
Functional subdivision - Green area ratio	`(!Green_Area! / !Total_Area!) < 0.1` → green area < 10%
Land plot code	`!Land plot_Code! is None or !Land plot_Code! == ''` → missing land plot code
Land use type (LandUse)	`NOT (!LandUse! in ('Industrial','Green','Traffic'))` → invalid land-use value



Phase	Status	Source
	Unknown	BoundaryA
	Unknown	BoundaryA
	Unknown	BoundaryA
	Reviewed	BoundaryA
	Reviewed	BoundaryA
	Reviewed	BoundaryA
	Resolved	BoundaryA
	Resolved	BoundaryA
	Resolved	BoundaryA
	Mark As Exception	BoundaryA
	Mark As Exception	BoundaryA
	Mark As Exception	BoundaryA
	Acceptable	BoundaryA

Figure 12. Summary table of detected errors and data completeness statistics

2.4. Finalizing the planning database of Dinh Vu IZ

After converting, editing, and updating the geospatial database layers, the finalized planning map of Dinh Vu Industrial Zone was compiled using ArcGIS software (Figure 13) [4], [5].

The processed GIS data can be published on ArcGIS Online platform, enabling wider public access and allowing multiple users to view and utilize the information to support planning management of Dinh Vu Industrial Zone [4], [5].

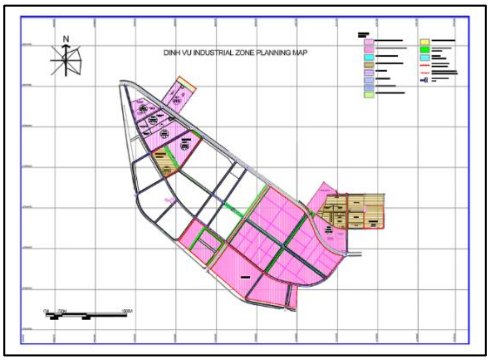


Figure 13. Planning map of Dinh Vu IZ compiled using ArcGIS software

Figure 14. Planning geospatial data of Dinh Vu IZ shared via the ArcGIS Online

3. Conclusion

This paper proposes a procedure for developing a GIS database to support planning management at Dinh Vu Industrial Zone, Hai Phong City. The results highlight key advantages of applying GIS technology, including:

- Ensuring high accuracy in data analysis and editing.

- Developing a comprehensive database that is easy to manage, access, update, and modify; thereby facilitating fast, accurate, and timely information retrieval, improving management efficiency and decision-making.

- Enhancing transparency in planning information dissemination, exploitation, and development of industrial zones; creating favorable conditions for agencies, organizations, individuals, and potential investors both domestically and internationally to access information, identify investment opportunities, and participate in planning supervision.

- Compared with traditional AutoCAD-based planning management, GIS offers clear advantages by integrating spatial and attribute data to ensure consistency and quality. In addition to automatic updating and statistical functions, GIS supports spatial analysis, scenario comparison, visualization, and WebGIS sharing. It thus serves as an effective decision-support tool that improves management efficiency, enhances transparency, and underpins the development of smart industrial zones.

Although the proposed GIS process has demonstrated clear advantages in improving data accuracy and management efficiency, it is still limited by the availability and quality of source data, as well as the need for periodic updates to maintain data validity. Future research could expand this approach to include real-time data integration, WebGIS-based monitoring, and predictive spatial analysis to support broader applications in urban and regional planning.

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