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APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN DEVELOPING A SOIL MAP OF AN GIANG PROVINCE FOR GEOGRAPHY EDUCATION

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Abstract:
This study applied Geographic Information Systems (GIS) to develop a soil map of An Giang Province following the administrative merger of An Giang and Kien Giang provinces, with the aim of supporting geography teaching and learning. The research utilized soil maps, administrative boundary data, and relevant thematic documents, combined with data standardization, field surveys, GIS data processing, and cartographic editing using MapInfo software. The resulting product is a 1:1,000,000-scale soil map integrated with a unified spatial and attribute database that accurately represents the distribution of soil types within the newly established administrative boundary. The completed map provides an up-to-date and reliable educational resource for local geography education and can be effectively integrated into geography teaching and learning activities.

Keywords: Geographic Information Systems (GIS), soil map, An Giang Province, local geography

1. Introduction

Geographic Information Systems (GIS) have become an effective tool for developing and managing maps owing to their capabilities for integrating, analyzing, and visualizing spatial data (Dinh, 2025). The application of GIS to thematic mapping not only improves mapping accuracy and facilitates data updating but also contributes to the development of educational resources that support teaching and learning.

Following the administrative merger of An Giang and Kien Giang provinces into the newly established An Giang Province, updating thematic maps to reflect the new

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administrative boundaries has become an urgent requirement. However, existing soil maps were primarily developed based on the pre-merger administrative boundaries and therefore no longer satisfy the need for local geographic information in teaching and learning.

Within general education and teacher education programs, soil maps constitute an important instructional resource that enables learners to understand soil characteristics, examine the relationships between soil resources, natural environmental conditions, and human production activities, and develop competencies in interpreting and analyzing geographic information. Consequently, developing a GIS-based soil map of An Giang Province not only fulfills the need for updated geographic data following the administrative reorganization but also enriches instructional materials for local geography education.

2. Literature Review

2.1 Soil Maps and the Role of GIS in Soil Mapping

A soil map is a thematic map that depicts the spatial distribution of soil groups or soil types within a given territory according to a specified classification system. It presents the characteristics, boundaries, and spatial extent of individual soil types and is developed through soil survey, classification, and cartographic compilation based on soil data integrated with topographic or administrative base maps (Salisev, 2006).

Soil maps play a vital role in natural resource management, land-use planning, agricultural development, and environmental protection. In geography education, they serve as effective visual learning resources that enable students to identify the spatial distribution of soil groups, analyze the relationships between soils, topography, climate, hydrology, and production activities, and thereby develop spatial thinking and geographic information interpretation skills.

The advancement of Geographic Information Systems (GIS) has significantly transformed soil mapping. Compared with conventional cartographic methods, GIS enables the integrated management of spatial and attribute databases, facilitates efficient overlay analysis, spatial analysis, and data updating, and enhances mapping accuracy, data consistency, and reusability. Consequently, GIS has become a widely adopted tool for producing soil maps that support resource management, scientific research, and education.

2.2 Review of Related Studies

Internationally, the application of GIS to soil mapping has been extensively investigated and implemented for several decades. Early studies primarily focused on digitizing conventional soil maps and developing standardized soil databases. A landmark example is the FAO–UNESCO Soil Map of the World project (FAO–UNESCO, 1961), which established the foundation for global soil data standardization. Subsequent studies by Scull (2003), McBratney et al. (2003), Behrens and Scholten (2006), and many other

researchers have consistently demonstrated that GIS provides an essential platform for developing soil databases, conducting spatial analyses, and updating soil maps to support natural resource management, land-use planning, and sustainable agricultural development.

In Vietnam, numerous studies have employed GIS to produce land-use maps, soil maps, land unit maps, and land suitability maps for agricultural planning and natural resource management at various spatial scales. Representative examples include the studies of Nguyen Hieu Trung et al. (2006), Nguyen Huu Long and Pham The Hung (2014), and Tran Van Ty et al. (2015). Nevertheless, most of these studies have primarily focused on governmental management, land-use planning, or land resource assessment. Research specifically devoted to developing soil maps as instructional resources for local geography teaching and learning remains relatively limited.

Moreover, following the administrative merger of An Giang and Kien Giang provinces into the newly established An Giang Province, the existing soil maps continue to reflect the former administrative boundaries. As a result, they no longer accurately represent the spatial distribution of soil types across the new administrative unit, nor do they adequately meet the demand for updated instructional materials in local geography education.

Against this background, the present study applies GIS to develop an updated soil map of An Giang Province. The resulting map is intended to provide an accurate, up-to-date, and visually effective geographic learning resource that supports both teaching and learning in local geography education.

3. Materials and Methods

3.1 Research Methods

3.1.1 Data Collection and Standardization

This study utilized secondary data from three primary sources: (1) soil maps of An Giang and Kien Giang provinces prior to the administrative merger; (2) the administrative boundary map of An Giang Province; and (3) the national soil classification system and relevant soil-related documents published by governmental agencies.

All datasets were standardized in terms of coordinate reference system, data format, and attribute structure to ensure consistency within the GIS environment. The standardization process included transforming all spatial data into the VN-2000 coordinate reference system, detecting and correcting topological errors, harmonizing soil classification schemes, and standardizing attribute tables.

3.1.2 Field Survey

Field surveys were conducted in representative areas of the major soil groups to validate the map database. At each survey location, geographic coordinates were recorded using GPS, current land-use conditions were documented, photographs were taken, and field observations were compared with the corresponding map information. The survey

results were subsequently used to refine both the spatial and attribute data in the GIS database.

In addition, after the soil map had been compiled, further field verification was undertaken by comparing the mapped information with actual field conditions, thereby enabling appropriate revisions and improvements to the completed map.

3.1.3 GIS Data Processing, Map Compilation, and Editing

This stage constituted the core component of the study. It involved integrating the soil maps of An Giang and Kien Giang provinces prior to the administrative merger, updating the administrative boundaries of the newly established An Giang Province, constructing a geodatabase, editing and refining soil data layers, and designing map symbols, color schemes, legends, and layouts in accordance with current cartographic standards. The outcome of this stage was a unified soil map covering the entire province.

The completed map was evaluated in terms of geometric accuracy, completeness, and consistency of attribute information through comparison with original source documents and field survey results. In addition, its effectiveness in information retrieval, visual presentation, and suitability for geography teaching and learning was assessed

3.2 Soil Map Development Workflow

MapInfo software was employed to develop the soil map of An Giang Province. The workflow comprised the following stages:

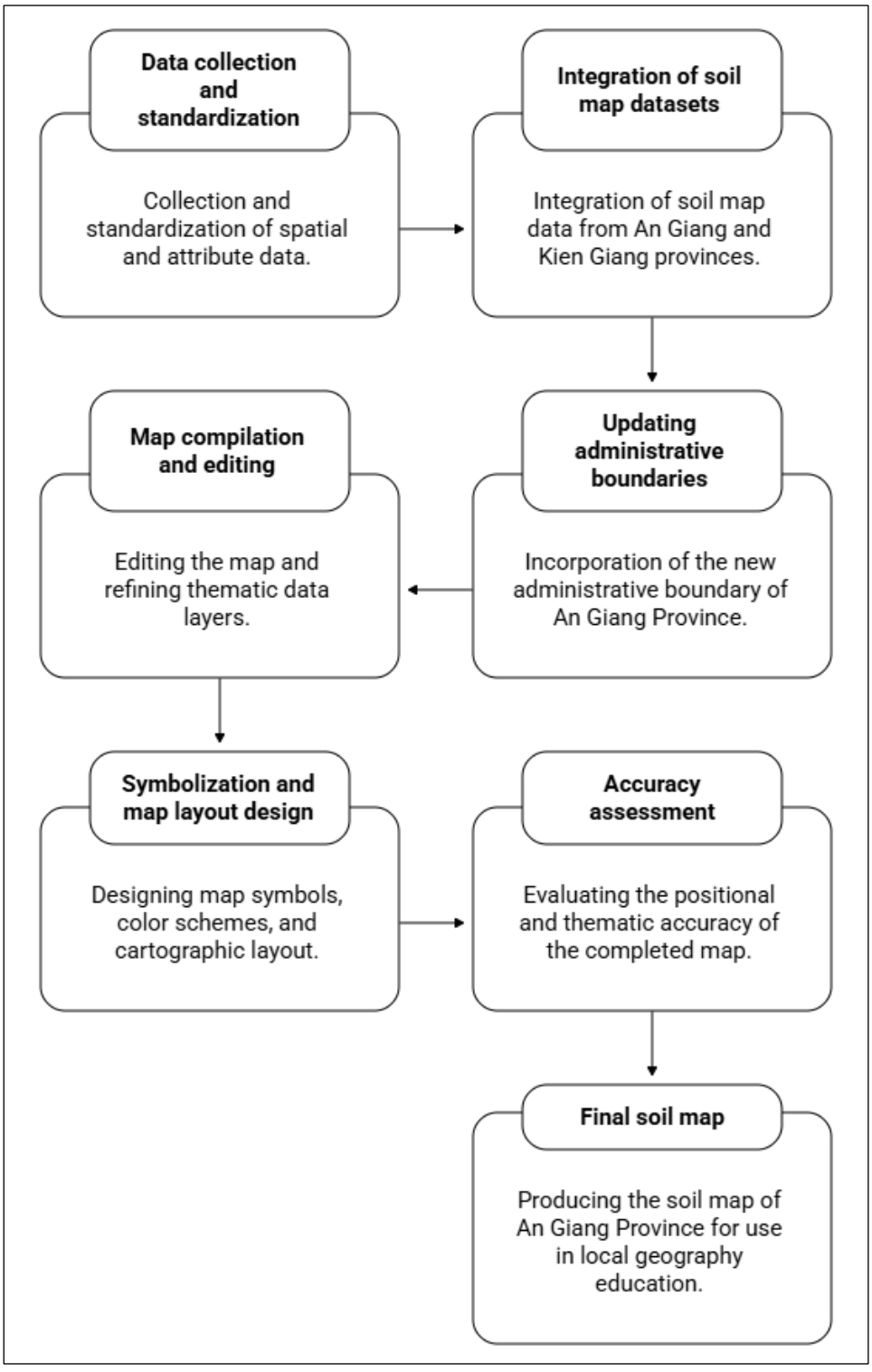

Figure 1: Workflow for Developing the Soil Map of An Giang Province

4. Results

4.1. Design of the Soil Map of An Giang Province

4.1.1 Mathematical Framework

- **Reference system and coordinate system**: The map was developed using the Vietnam National Reference System (VN-2000) for a map scale of 1:1,000,000. The technical specifications include:
  - UTM projection based on the WGS84 ellipsoid, with a semi-major axis of 6,378,137.0 m and a flattening factor of 1:298.257223563.
  - 6° UTM projection zone with a scale factor of $k_0 = 0.9996$.
- **Map scale:** The map scale was determined according to the study area's size, shape, spatial extent, required level of detail, and intended application. To ensure that the map could be clearly presented on A4 paper and conveniently used for teaching and learning, a scale of 1:1,000,000 was selected for the soil map of An Giang Province.
- **Geographic graticule:** The map employs a geographic graticule consisting of latitude and longitude lines expressed in decimal degrees.
- **Map frame:** The map frame defines the spatial extent of the mapped features and consists of both an inner and an outer frame. The geographic coordinate system is displayed in the space between these two frames.

4.1.2 Map Content

- **Base map layers**
  - Administrative boundaries: provincial boundary layer (*AG_Tinh.Tab*).
  - Hydrography: major river network layer (*AG_TV2.Tab*).
  - Topography: elevation point layer (*Diem_docao.Tab*).
  - Mathematical framework: map frame, projection grid, coordinate grid, north arrow, and scale bar (*Khung.Tab*, *luoi.Tab*, *luoi_ten.Tab*, *thuoc_ti_le.Tab*, *muiten_chihuong.Tab*).
  - Place names: layer containing geographic names, mountains, and islands (*AG_diadanh.Tab*).
- **Thematic layer**
  - Soil type layer (*AG_dat.Tab*).
- **Supporting data:** Statistical information on the area of each soil type was calculated from the AG_DAT Browser attribute table using the Column Statistics function in MapInfo.

4.1.3 Cartographic Design

The cartographic design generally followed the technical specifications stipulated in Circular No. 10/2017/TT-BTNMT, which regulates the production of thematic maps at scales of 1:5,000, 1:10,000, 1:500,000, and 1:1,000,000, and Circular No. 47/2014/TT-BTNMT, which prescribes technical standards for administrative mapping in Vietnam.

To better support educational use, however, several modifications were made to map symbols, color schemes, and the size of selected map elements, thereby improving readability and facilitating classroom teaching and learning

4.2 Development of the Soil Database and Map Compilation

4.2.1 Spatial Data

The spatial database was developed from the digitization of the administrative maps of An Giang and Kien Giang provinces prior to the administrative merger, at a scale of 1:100,000.

4.2.2 Attribute Data

The soil attribute database was compiled from several authoritative sources, including the *Explanatory Report on the Soil Map of An Giang and Kien Giang Provinces (2003)* prepared by the Sub-Institute of Agricultural Planning and Projection for Southern Vietnam, and the *Comprehensive Report on the Supplementary Soil Degradation Survey of An Giang Province (2016)* published by the Departments of Natural Resources and Environment of An Giang and Kien Giang provinces.

The area of each soil polygon, soil type, and soil group was calculated after digitizing the original soil maps using the **Area(obj, "sq km")** function and the **Statistics** tool in MapInfo.

Table 1: Statistics of Soil Types in An Giang Province

No.	Soil Type	Symbol	Area (ha)	Proportion(%)
1	Alluvial soil	P	744.16	7.62
2	Alluvial soil with mottled horizon	Pb	208.32	2.13
3	Acid alluvial soil	Pc	6.86	0.07
4	Gleyed alluvial soil	Pg	1,651.44	16.91
5	Active acid sulfate soil	Sj	4,772.33	48.85
6	Potential acid sulfate soil	Sp	350.78	3.59
7	Peaty potential acid sulfate soil	Ts	118.20	1.21
8	Strongly saline soil	Mn	200.26	2.05
9	Moderately saline soil	M	368.38	3.77
10	Mangrove saline soil	Mm	104.78	1.07
11	Grey soil with mottled horizon	Xl	335.17	3.43
12	Ferralic grey soil	Xf	508.33	5.20
13	Gleyed grey soil	Xg	90.40	0.93
14	Eroded rocky soil	E	63.30	0.65
15	Sand	C	54.05	0.55
16	Rivers, Lakes	Ho	191.94	1.96
Total			**9,768.70**	**100.00**

Source: Calculated from the soil map database.

4.3 Map Compilation

The soil map database comprises six thematic layers represented using different cartographic methods (Table 2).

- **Qualitative area method** was used to represent soil types. Each soil type is displayed using a distinct color, with clearly defined polygon boundaries.
- **Linear symbol method** was employed to depict administrative boundaries, transportation networks, rivers, and canals. Different line colors, styles, and widths were used to distinguish individual feature classes.
- **Point symbol method** was adopted for elevation points and administrative centers.

Table 2: Data Structure and Cartographic Representation of the Soil Map

No.	Data Layer	Data Structure	Representation Method
1	**Thematic data**		
1.1	Soil groups	Polygon	Qualitative area method
2	**Base data**		
2.1	Hydrography	Line	Linear symbols
2.2	Elevation points	Point	Point symbols
2.3	Administrative boundaries	Line	Linear symbols
2.4	Mathematical framework	Line, text	Combination of cartographic methods
3	**Supporting data**		
3.1	Place names and symbols	Text	Point symbols

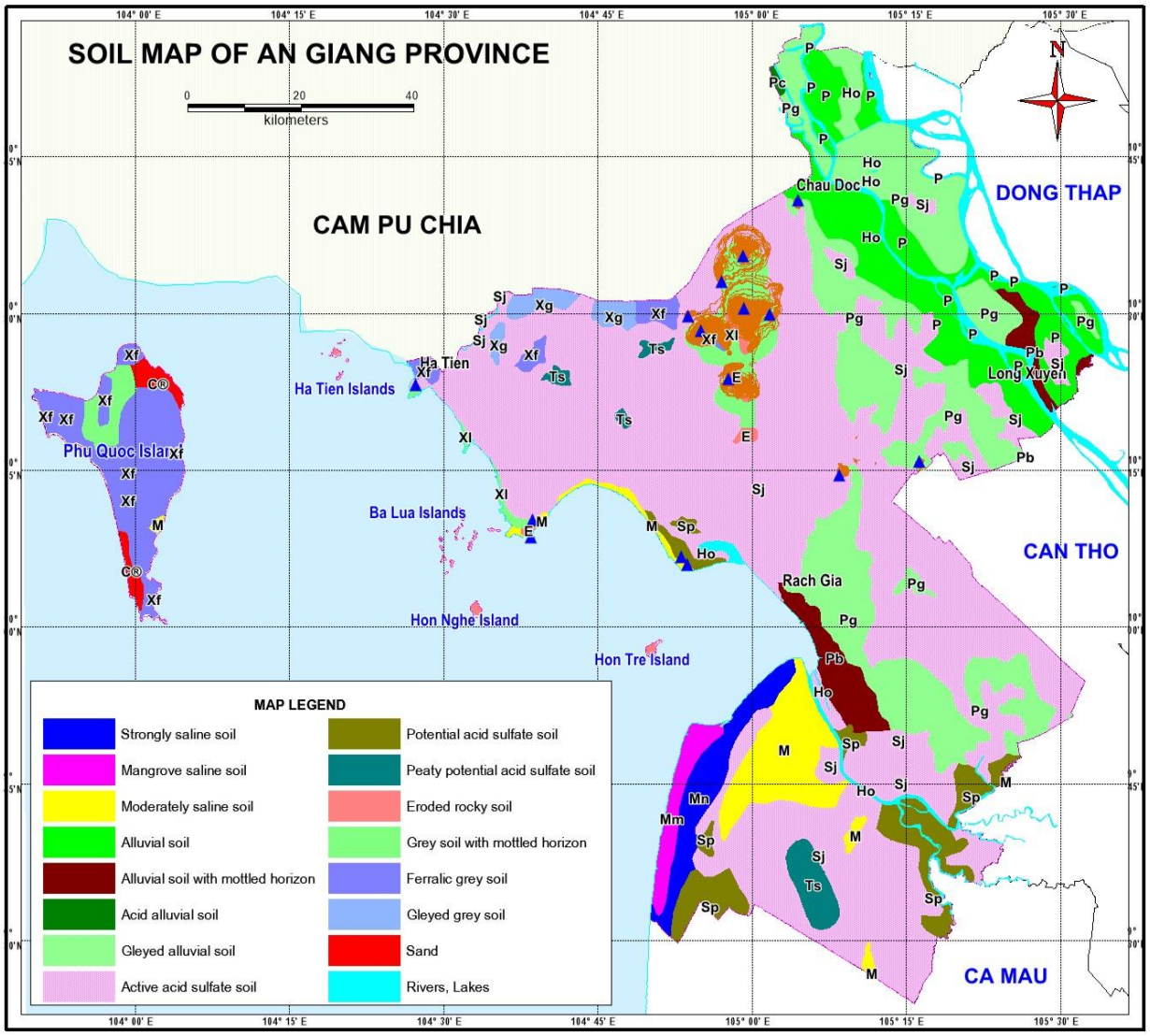

Figure 2: Soil Map of An Giang Province

4.3. Application of the Soil Map of An Giang Province in Local Geography Education

The GIS-based soil map of An Giang Province is not only a cartographic product serving resource management and scientific research but also a valuable visual instructional resource for local geography education. By accurately depicting the spatial distribution of major soil groups across the newly established province following the administrative merger, the map overcomes the limitations of previous geographic materials that were developed according to the former administrative boundaries.

In classroom instruction, teachers can employ the map to organize learning activities aligned with competency-based education. Through map interpretation, students are able to identify the spatial distribution of major soil groups, analyze the relationships among soils, topography, hydrology, and agricultural production, explain the formation of specialized agricultural production zones, and evaluate both the opportunities and constraints associated with local soil resource utilization and conservation. These learning activities contribute to the development of students'

competencies in map interpretation, spatial thinking, geographic analysis, and the application of geographic knowledge to real-world contexts.

The soil map also facilitates the implementation of active learning approaches, including project-based learning, problem-based learning, and place-based education. Teachers can integrate the soil map with other GIS layers—such as topography, river networks, land-use patterns, population distribution, and agricultural production—to design authentic learning scenarios that enable students to analyze the interactions between natural conditions and the socio-economic development of An Giang Province.

Table 3: Examples of Using the Soil Map in Geography Teaching

No.	Learning Content	Teacher Activity	Student Activity	Competency Developed
1	Distribution of soil groups	Guide students in map reading	Identify locations and describe distribution patterns	Map interpretation competency
2	Relationship between soils and topography	Ask guiding questions	Analyze spatial relationships	Geographic thinking
3	Soils and agricultural production	Organize group discussions	Explain crop distribution patterns	Application of geographic knowledge
4	Soils and environmental protection	Assign learning tasks	Propose appropriate land-use and conservation measures	Problem-solving competency

5. Conclusion

This study successfully applied Geographic Information Systems (GIS) to develop a soil map of An Giang Province by integrating the pre-merger soil maps of An Giang and Kien Giang provinces, updating the new administrative boundaries, standardizing the geospatial database, and validating the results through field surveys. The study produced a 1:1,000,000-scale soil map supported by a unified spatial and attribute database that comprehensively represents the distribution of soil types across the entire province.

The resulting map not only satisfies the requirements for positional accuracy, data consistency, and update capability but also demonstrates substantial practical value for local geography teaching and learning. Its integration into instructional activities enhances the visualization of geographic knowledge while fostering students' competencies in map interpretation, spatial thinking, and the application of geographic knowledge to real-world contexts.

Furthermore, the study contributes an updated geographic database for local education and provides a practical GIS-based workflow that can be adapted for the development of other thematic maps, including topographic, climatic, hydrological, vegetation, and land-use maps. Consequently, the soil map of An Giang Province not only fulfills the need to update geographic information following the administrative reorganization but also enriches the collection of modern, visually effective, and user-friendly instructional resources for local geography education.

Conflict of Interest Statement
The author declares no conflicts of interest.

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