



Design of Shandong Province Coastline Quality Assessment Information System

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Abstract. The Shandong Province Coastline Quality Assessment Information System is an intelligent system that facilitates the coastline refined management by integrating a large amount of data accumulated through actual field works. The system provides various functions, including data management and retrieval function, “one-map” function, statistical analysis function, chart output function, and other functions. In addition, the system employs technologies, including convenient data entry, intelligent analysis, data screening, and visual comparison, as well as coastline quality assessment databases, basic geographic information databases, coastline investigation databases, and marine ecological databases, to comprehensively record and present the results of Shandong Province’s coastline quality assessment from multiple angles, such as geographic distribution, type, development and utilization, quality, etc. The system represents a significant achievement of the “Smart Ocean” in Shandong Province, and provides a comprehensive and scientific technical support for the protection and management of the coastline.

Keywords: Information system · Coastline management · Coastline quality assessment · “One map”

1 Introduction

The coastline is not only a vital aspect of the ocean’s ecology, but also a crucial resource for economic development [1]. The coastal zone supports 43% of the population and contributes to 57% of the domestic gross domestic product [2, 3]. As the interface between land and sea, the coastline plays a critical role in various aspects, such as the approval of maritime rights, territorial and spatial planning, and natural resource surveys and monitoring [4]. Therefore, understanding the various characteristics of the coastline, including its length, type, development and utilization, protection category, and quality status, is important to enhancing the modernization of the ocean governance system, promoting the high-quality development of the ocean economy, and ensuring the well-being of local communities.

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The “Shandong Province Marine Strong Province Construction Action Plan” explicitly proposes to focus on the nearshore waters of Shandong Province, with the support of the ocean big data platform, aims to deeply integrate the advanced information technology in the areas of marine environment, equipment, and activities. This integration will improve the scientific and accurate decision-making related to marine monitoring and management, ecological protection, and public service capabilities through modern information technology. However, the rapid development of the economy and society has resulted in a less than optimistic ecological environment [5, 6] and utilization [7, 8] status of coastal areas. To address issues like natural coastal areas erosion, waste pollution, and low utilization of artificial coastline, a quality assessment project was initiated to evaluate the quality of the coastline in the Shandong Province. Base on a significant amount of basic geographic information, survey data, remote sensing images, and coastline quality data accumulated in the long-term fieldwork, an intelligent and visual coastline quality information system has been developed as a crucial component of the project.

The Shandong Coastline Quality Assessment Information System (SPCQAIS) is designed to provide intelligent analysis and visual presentation of results for coastline quality assessment, utilizing GIS technology, basic geographic information data, coastline quality assessment methods, and statistical analysis models. The system aims to provide comprehensive and accurate data support for coastline protection and management, help marine authorities gain a clear understanding of the coastline quality status and its influencing factors, and provide scientific and intelligent technical support for refined marine management.

2 Method and Database

The design of SPCQAIS is based on field work conducted for coastal quality assessment in Shandong Province, with the aim of providing improved presentation and analysis of the results. The method for evaluating coastal quality includes four key steps: 1) dividing assessment units based on the properties of the coastline; 2) designing assessment factors and scoring standards based on past survey results, in order to accurately reflect the status of the coastline; 3) conducting investigations for each assessment unit and assigning scores to corresponding assessment factors based on the scoring standards; and 4) comprehensively calculating the quality assessment results based on the assigned scores.

The database of the SPCQAIS is based on the coastline quality assessment data and deeply integrates other basic geographic information databases, coastline investigation databases, marine ecological databases, etc. The quality assessment database is divided into natural coastline database and artificial coastline database. The natural coastline database provides corresponding assessment factors scores for the width of the coastal beach, the types of human interference, the extent of natural effects on the coastline, the environmental hygiene conditions on the landward side, the seawater quality near the coast, the invasive species situation, the land use situation, the designation of nature reserves or tourist areas, the coastline restoration situation, and the number of local illegal sea use cases (Table 1). Meanwhile, the artificial coastline database offers corresponding

assessment factors scores for the artificial structure type of the coastline, the integrity of the artificial structure, the facility running situation, the situation of intensive coastal use, the land use situation on the landward side, the seawater quality, the environmental hygiene conditions on the seaward side, and the number of illegal cases (Table 2).

The basic geographic information database includes various types of data, such as coastlines, administrative boundaries, marine functional zones, marine protected areas

Table 1. The table of natural coastline quality assessment factors

Classification	Factors	Definition
Natural Form	the width of the coastal beach	the width from the vegetation line or the first main road to the mean spring low water line
	the human interference type	the situation where the coastline suffering human interference while retaining the main attributes of the natural coastline
	the extent of natural effects on the coastline	the extent to which the coastline is directly affected by natural factors (like currents, winds or waves) on the seaward side
Ecological Health	the environmental hygiene conditions	the distribution of living, building, and industrial waste within the beach
	the seawater quality	the water quality status in the nearshore waters
	the invasive species situation	the distribution of invasive species on the seaward side of the coastline
Management Status	the land use situation	the utilization situation of the land area between the landward side of the coastline and the first main road
	the designation of nature reserves or tourist areas	whether the coastal area has been designated as a nature reserve, scenic spot, or tourist area and thus received better protection and management
	the coastline restoration situation	the amount of funding from financial sources for coastal restoration and improvement projects
	the number of local illegal sea use cases	the number of illegal cases that have been investigated and punished for damaging the natural form and ecological health of the coastline

Table 2. The table of artificial coastline quality assessment factors

Classification	Factors	Definition
Artificial Structure	the artificial structure type	the material and structural situation of the alongshore artificial structures
	the integrity of the artificial structure	the integrity level of alongshore artificial structures
Development and Utilization	the facility running situation	the running status of various production, living, and service facilities that are attached to the coastal area
	the intensive coastal use situation	the level of coastal development and utilization
	the land use situation	the utilization situation of production, living, environment, and services within the areas adjacent to the coastline
Ecological Health	seawater quality	seawater quality status in the nearshore region
	the environmental hygiene conditions	the distribution of residential, construction, and industrial waste near the seaward side of the coastline
Management Status	the number of illegal sea use cases	the number of illegal cases that have been investigated and punished for damaging the shape or position of the coastline

and marine parks, ecological red lines, remote sensing images, digital vector maps, and geographic annotations.

The coastline investigation database includes types of coastlines, development and utilization status, and natural coastline retention rate (the proportion of the natural coastline).

The marine ecological database includes seawater quality near the coast, the marine ecological and restoration projects, and more.

3 System Architecture

The SPCQAIS follows a hierarchical design approach, with four main components: software and hardware layer, data layer, service layer, and application function layer. These components form a unified operation platform to provide efficient and integrated services (Fig. 1).

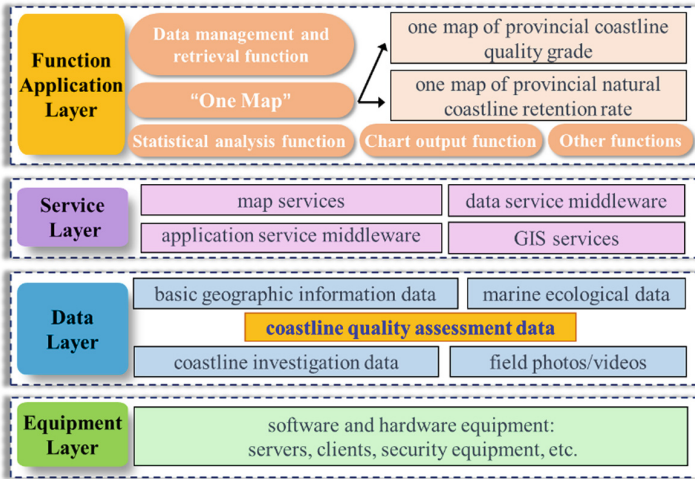


Fig. 1. The Architecture diagram of Shandong Province Coastal Quality Assessment System

The software and hardware equipment layer includes servers, clients, and security equipment. The data layer contains a range of information, including the system’s database mentioned in the last chapter and field photos/videos. The service layer provides map services, data service middleware, application service middleware, and GIS services.

The application function layer provides user-facing functions that are directly embedded into the user interface for operation. It includes data management and retrieval function, “one map” function, statistical analysis function, chart output function, and other functions. The data management and retrieval function enable users to enter and modify single or batch data via the open ports, filter and display data based on multiple conditions, and create standard forms. The “one map” function includes “one map of provincial coastline quality grade” and “one map of provincial natural coastline retention rate”. The “one map of provincial coastline quality grade” displays an overview of the scores and grades for the quality of the entire coastline in the province, as well as corresponding on-site photos/videos. The “one map of provincial natural coastline retention rate” displays the natural coastline retention rates of the different administrative regions. The statistical analysis function calculates and ranks the coastline quality scores of the different administrative regions and types of assessment units. The chart output function can generate various types of statistical charts based on user screening conditions. Other functions, such as layer zooming, translation, switching, basic measurements, auxiliary functions, are designed to facilitate the operations.

4 System Requirements

The SPCQAIS is designed to serve the comprehensive management of the coastline and adapt to the increasing use of digital technologies in marine management. It has applied information technologies such as Java language, Wicket framework, and Web

Service interface, combined with a large amount of data accumulated in actual business work, to achieve intelligent and digitalized management of the coastline. As such, the establishment of the system should meet the following requirements.

4.1 Integrability

The system has integrated a large amount of basic coastline survey data and various functional modules to present a comprehensive and scientific platform for coastline management and protection. Thanks to the effective linkage between the application functions and the database, the system can offer a comprehensive display of the coastline quality from various angles.

4.2 Practicality

The system is highly practical. For example, it allows for easy updating of changed data, either individually or in batches, through open ports, ensuring the timeliness of the data. In addition, the statistical and analysis models embedded in the system enable automatic calculation of statistical results and generation of charts. Furthermore, the system can be improved by adding new functional modules based on feedback from practical use.

4.3 Security

To ensure the security of the system, it is imperative that administrators regularly inspect and maintain the data stored in the system's database. Additionally, using login accounts with strong passwords can enhance the system's resistance against illegal intrusion.

5 System Function Application

5.1 Data Management and Retrieval Function

The data management function is established to update or modify the data, ensuring the timeliness and dynamism of the database. The system provides data update ports, allowing for batch updates of coastline-related data, such as assessment factor scores, on-site photos, and vector data obtained at different periods. In addition, individual assessment factor scores also can be directly revised on the user interface. By comparing the results of coastline quality assessments from different period, the system can provide the changing trends and offer data support for making corresponding solutions.

The data retrieval function is established to improve the efficiency and facilitation of managing the database of the SPCQAIS. With the multi-condition screening function, users can easily locate the data they need and present or export the selected data in a standard format. Certainly, if users know the assessment unit number, they can directly input it on the user interface to retrieve the relevant data. Moreover, users have the option to click directly on a specific coastline assessment unit on the "One Map" to access the corresponding electronic data file, including coastline type, administrative region, quality grade, scores of various assessment factors, etc.

5.2 “One Map” Function

The “One Map” function is the most effective and convenient data display function in this system. It provides not only an overall review of the long-term coastal surveys, but also a visual display of the comprehensive coastline quality under the influence of multiple factors such as natural development, human interference, and management conditions. The “One Map” system function includes “one map of provincial coastline quality grade” and “one map of provincial natural coastline retention rate”.

The “one map of provincial coastline quality grade” employs an advanced assessment system to provide a visual representation of the quality grades of the provincial coastline. The map displays relevant information, such as length, assessment factors scores, coastline quality grades, and the proportion of different quality grades and types of coastlines. In addition, other supportive vector data, such as land and marine development pattern spots, water quality pattern spots, land-use planning pattern spots, ecological protection red lines, and multi-phase remote sensing images, can be directly overlaid on the “one map” to provide more detailed information to enhance its accuracy and completeness.

The “one map of provincial natural coastline retention rate” function is designed to focus on the protection and utilization status of the natural coastline. As an essential assessment indicator for the supervision and management of Shandong Province’s coastline, the natural coastline retention rate plays a crucial role in reflecting the management status of the coastline. The “one map of provincial natural coastline retention rate” function employs data visualization techniques to clearly and concisely present the characteristics of the natural coastline retention rate in different years for each administrative region.

5.3 Statistical Analysis Function

The statistical analysis function is designed to analyze the coastline quality grade and its affecting factors from various angles and scales. It provides a comprehensive tool to analyze the results of the coastline quality assessment, such as the length and proportion of different quality assessment units, the classification of coastline quality grade, and the proportion of coastline at different quality grades. The analysis results of this function can be displayed in three different ways, namely “Administrative Division”, “Assessment Units Types”, and “Quality Grade”.

The “Administrative Division” module can display the coastal quality analysis results for one or multiple administrative regions based on user requirements. The “Assessment Units Types” module offers options for different types of coastlines, including natural, artificial, and ecological restoration coastlines, and displays the quality grades and distribution of the selected assessment units. Additionally, a group of assessment units with the same type can be packed to calculate an overall score of the assessment factors, which can be analyzed to identify the main factors affecting the quality grade of these coastlines. The “Quality Grade” module provides a display of the distribution characteristics of coastlines with four different quality grades: “excellent”, “good”, “fair”, and “poor”. And based on the scores of assessment factors, the reasons for the differences in grade distribution can be analyzed.

Moreover, the three modules mentioned above can be used individually or in combination based on the user requirement. For instance, if you wish to obtain the distribution characteristics of excellent-grade natural coastlines in Qingdao, you can choose “Qingdao” in the “Administrative Region” module, “Natural Coastline” in the “Assessment Units Types” module, and “Excellent” in the “Quality Grade” module, to obtain the targeted analysis result.

5.4 Chart Output Function

The chart output function can automatically generate radar charts showing the assessment factor scores for each unit. It can also produce bar or pie charts that summarize the statistical analysis of coastline quality characteristics according to different screening conditions applied in the statistical analysis function. Furthermore, this function automatically organizes the input assessment results data to create standardized summary tables of coastline quality assessment factors or comprehensive coastline quality assessment results.

5.5 Other Functions

The other functions include commonly used auxiliary features that enhance the system’s operability and convenience. For instance, users can zoom in and out or pan across different layers, switch between satellite and vector maps, measure basic distances and areas, etc.

6 Conclusions

The Shandong Coastline Quality Assessment Information System represents a significant achievement of the “Smart Ocean” in Shandong Province and a major practice in the refined management of coastlines. It has enriched the existing policies and tools for managing natural coastal resources. The system uses the results of the coastline quality assessment as a guide and seamlessly integrates other coastal zone projects such as coastline survey, ecological restoration coastline identification, and change coastline investigation. As a result, the system provides a comprehensive and scientific basis for the protection and management of the coastline, and an important data support for the ocean management authorities to develop more scientific and rigorous coastal policies.

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