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A Base Study of Intergrated Map for Integrated Coastal Zone Management

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연안통합관리를 위한 통합수치도 개발에 관한 연구

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Abstract : Integrated approach is presented by developing the technology and the ways of the practical use of the integrated digital map of and Electronical Navigational Chart (ENC) and Digital Terrain Map (DTM) for the effective and scientific based conservation, development and management of coastal area in this study. At first, as preliminary studies to make eventual integrated maps, the necessity of the integrated map is described with the concept of coastal areas. Then, the characteristics of digital maps developed by Korean Geography Institute and National Marine Investigation Institute are carefully analyzed and integrated to a digital map as a test for edge matching in coastal line. Developed test coastal map was overlayed with a high-resolution satellite image (KVR-1000). The ground survey using Global Positioning System was conducted for the analysis of edge matching along the coastal line. Results from the edge matching analysis of coastal lines showed about 14 meters mean difference in artificial terrain and 4 meters mean difference in natural terrain. The problems, causes and solutions for the edge-matched differences are described. Furthermore, the value of utilization, the future use and various fields of application produced by the integrated digital map database are suggested as a basis for ICZM implementation in South Korea.
Key words : Integrated coastal management, Integrated digital map, Electronical Navigational Chart (ENC), Digital Terrain Map (DTM), Database

요약 : 본 연구는 연안지역의 과학적이고 효과적인 개발, 보존, 관리를 위해 항해용 전자해도와 수치지형도를 통합한 통합수치도를 개발하기 위한 기술과 개발된 통합수치도의 활용방안을 모색하였다. 연구의 예비적 단계에서, 연안지역과 연안통합관리의 개념이 정리되었으며, 한국의 국립지리원과 국립해양조사원에서 제작된 국가 수치지도들의 구조적 차이와 특성이 파악되고 난 후, 수치지도들은 KVR-1000고해상도 인공위성자료와 중첩되어 통합수치도로 제작되었다. 제작과정상에 발생된 해안선 오차를 분석하기 위해 부산광역시 서구 해안지역의 인공지형 2개 지역과 자연지형 지역 1개를 대상으로 전자해도와 육도의 매칭과 GPS 측량에 의한 해안선 불일치의 원인 및 차이를 분석한 후, 그 문제점, 원인 및 해결방안에 대해 서술하였다. 또한, 본 연구에서는 제작된 통합수치도를 기반으로 연안통합관리에 필요한 다양한 응용방안 및 활용가치를 서술하였다.
주요어 : 연안통합관리, 통합수치도, 항해용 전자해도, 수치지형도, 데이터 베이스

1. Introduction

Integrated resource management is a fundamental prerequisite of sustainable development. Sustainability has emerged as dominant paradigms of Coastal Zone Management Programs (CZMP) in the late 20th centuries around the world (Kay and Alder, 1999). Mandates for the better use of more integrated management approaches were prominent in the recommendations in Agenda 21,

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an action program emanating from the United Nations Conference on Environment and Development (UNCED), held in Rio de Janerio, Brazil in 1992. Such mandates are also found in the 1982 United Nations Convention on the Law of the Sea. In addition, measures for protecting marine diversity are called for in the 1992 Convention on Biological Diversity.

In order to succeed these mandates, many countries are developing their own Integrated Coastal Zone Management (ICZM) Program. Even there is general acceptance of the basic concept of ICZM, ICZM require better information toward continuous process of governmental decision-making, wise use of resources and conflict resolution among stakeholders in the interface area of land-water surface.

Chapter 17 of Agenda 21 played an important role in starting the ICZM of Korea since 1992. With the understanding of Agenda 21, S. Korea moved to the direction of more sustainable society based on the UNCEDs recommendation (Kim, 2000). The Ministry of Maritime Affairs and Fisheries (MOMAF) was established in 1997 and the Division of Coastal Zone Management under the Ministry took over the authority to establish ICZM program and formulated the CZMA (Coastal Zone Management Act) in 1998 after understanding the seriousness of coastal degradation due to overuse and misuse (i.e. large-scale reclamation), the importance of coastal zone management and decentralization trend by increased local governments power on the coastal use policy and coastal resource management(Hong and Lee, 1995).

The principal objective of CZMA is to ensure sustainable use of coastal resources. Therefore, the use of coastal land water resources should be guided to provide social benefits. In order to implement this objective better, researchers have recently adopted such new technologies as Geographic Information System (Hamilton et al., 1995; Yunn, 1999) Global Positioning System (August et al., 1994; Wellech et al., 1992) and Remote Sensing (Klemas et al., 2000; Mumby et al., 1999; Jensen et al., 1990). These researchers identified the usefulness of GIS in CZM by providing a common platform for the collection and sharing data from diverse sources, improving the visualization of data and interacting among various uses and links, supporting the statistical, modeling, impact and sensitivity analyses, making better use of remotely sensed data, and helping the more efficient and effective decision making process. Nowadays, the use of GIS in CZM in a few countries in the area of coastal planning has become an important mechanism due to the recent development in computer technologies with cheaper, easier and more reliable to use (Ministry of Home Affairs, 1996; NOAA, 2002).

This paper is written based on the most fundamental concept that ICZM decision making rely on the better accurate information of land-water surface. This paper is also written based on the assumption that the executive strategy of the integrated coastal management plan should rely on the knowledge based coastal management which require comprehensive coastal information system providing the scientific information toward the effective policy development for successful ICZM program. However, there are few studies in the practical use of existing digital database and technologies of GIS, Remote Sensing and GPS for ICZM at this point in S. Korea. At present there is no concise digital shoreline for the country.

Considering all these situations, the objective of this study is to develop the technology and the ways of the practical use of the existing digital maps of Electronical Navigational Chart (ENC) and Digital Terrain Map (DTM) for the effective and scientific based conservation, development and management of coastal area in S. Korea. Therefore, as preliminary studies to make eventual integrated digital maps, the characteristics of digital maps developed by Korean government are carefully analyzed and integrated to a digital map as a test for edge matching in coastal line. The developed test coastal map was overlayed with a high-resolution satellite image (KVR-1000). The ground survey using Global Positioning System was also conducted for the analysis of edge matching along the coastal line. Finally, the value of utilization, the future use and various fields of application produced by the integrated digital map database relating to ICZM are suggested. The aim of these suggestions is to provide a relatively simple overview or synthesis outlining the ways in which integrated digital map database can assist in many necessities in ICZM implementation.

2. Development of Integrated digital map for ICM

1) Necessity for developing Integrated digital map of ENC and DTM

ICZM require such several data as physical, economic, and social characteristics of the coastal zone, as well as political jurisdictional boundaries. S. Koreas CZMA also requires appropriate planning, management and monitoring on both land and ocean side of coastal areas. The notion of delineating a zone or area is important for the continuous planning and management of the use of coastal areas and their resources. However, the delineation of the boundary between land and water is not easy due to dynamic nature. In a temporal context, coastal areas are dynamic system and subject to change in response to such natural factors as water level fluctuation, flooding, climatic change as well as human influence. Many countries developed artificial boundaries on the geographical extent of this transition by defining coastal line on the map (Sorensen et al., 1990). Korean government also made the artificial baseline for coastal boundary on the national topological maps based on MSL (Mean Sea Level) of Inchon bay for the Korean peninsula except Jeju Island. Artificial shorelines are determined based on regional tidal datum (usually local mean high water level) (Kwon, 1998). At a policy level, coastal areas are defined in many countries by the concept of hybrid fixed distance, as the name implies, specify a fixed distance away both from the landward limit from the coastal line and seaward limit. In the Koreas CZMA, coastal areas are comprised of coastal waters and coastal land area. Coastal waters are defined as the area from Mean High Water Level (MHWL) to territorial water line and coastal land as the area from the artificial coastal boundary up to 500 to 1000 meters to land except river. The landward limit of coastal land in the port and industrial zone designated by several Korean laws is up to 1000 meters (MOMAF, 1998). The MOMAF which is in charge of CZMA and the production of ENC concerned about getting, collecting and managing various coastal information for ICM. If existing digital maps are available, why the development of integrated digital map is required. There are serious problems without careful integration of existing digital maps. The first problem is the lack of accuracies the coastal line. In cases of where existing digital maps doest not match with others at the desired level may result the great difficulty in ICZM policy making. This is particularity true in the areas of documenting the planning reports of specific area. A second problem related to the information about the limited use of existing digital database. Integrated database from combined existing database will facilitate to provide better information of coastal areas. Thus, a new digital map database for

ICZM is proposed in this study by integrating existing digital maps of ENC and DTM developed by Korean govermen agencies.

2) Characteristics of Digital Topographic Map Database

National Geography Institute, as a primary producer of Korean terrain maps, had published several series of topographic paper maps of Korean peninsula. In the early 1990's the Korean government recognized the National Geographic Information System (NGIS) as one of the most fundamental infrastructure components required in promoting national competitiveness and productivity, and they began construction of a digital map database system, focusing on the development of a spatial database and standardization of information. The database is composed of 10 layers (i.e. Road, Railway, River, Building I & II, Vegetation, Facility, Topography, Administrative or Regional Boundary, Annotation). This database became the National Base map under the scheme of NGIS Plan since 1995. Most of the database have been produced and updated from the form of paper maps with different scales of 1/1,000, 1/5,000, 1/25,000 and 1/50,000. The coordinate system of the DTM is Transverse Mercator projection and the file type of the database is Drawing eXchange Format (DXF). The DXF which is a vector format that has been known as the de facto standard for transfer of data among different Computer Aided Design (CAD) systems has entities comprised of group code in 1st line and such various AutoCAD entity elements as INSERT, LINE, POLYLINE, VERTEX, SEQEND, TEXT (Autodesk, 1996). This DXF format can be used transfer geometry information and a source for GIS database, but DXF is not well suited for transferring attribute.

3) Characteristics of Electronical Navigational Chart

ENC is a digital chart which have the data of depths of seawater, port facilities, marks and coastline on the monitor based on Special Publication No. 57 (S-57) named Transfer Standard for Digital Hydrographic Data published by International Hydrographic Organization (IHO)s Organizations committee (IHO, 2000). It describes the standard to be used for the exchange of

Fig. 1. An integrated digital database for SeoGu, Busan by overlay of KVR-1000 satellite image, DTM and ENC

digital hydrographic data between national hydrographic offices and for its distribution to manufactures, mariners and other data users. National Oceanographic Research Institute (NORI) has developed ENC since 1995 in Korea. The developed ENCs can contribute to the prevention of marine accident and pollution and is utilized for Electronic Chart Display & Information System (ECDIS). The coordinate system of the ENC is Universal Transverse Mercator projection and ENC standard includes a theoretical model, on which it is based, a catalogue of all object classes of interest to hydrography, and an exchange format (DX-90) providing mechanisms to encode the data. The object Catalogue of the Standard defines simple object classes describing the real world, attributes to these simple objects and composite objects for the text style and placement and symbolization of non-standard point and line features. The database is divided into Feature Objects and Spatial Objects and attributes are related to these objects and have identifiers for each object. Feature Objects are classified into 4 types of objects (Meta, Cartographic, Geo, Collection). Spatial Objects are classified into 3 types of models (Vector, Raster, Matrix) but Vector Model is used currently. Point, line and polygon are used to represent the real world in the Vector Model. 4 types of topology (Cartographic spaghetti, Chain-node, Planar graph, Full) can be built in the Vector Model.

4) Developing Integrated digital map

Development of an integrated digital map using existing digital maps raised such many questions as test area, coordinate system, data type, format, scale, creation date and the transfer medium for the data set. Considering these questions, a coastal region of SeoGu-Busan is selected as a test area based on the availability of the data. At first, one DTM data with scale of 1/10,000, one ENC with scale of 1/5,000 and a KVR-1000 satellite image were collected. Then, a test DTM was projected to Universal Transverse Mercator projection and a test data type of ENC was changed to DXF in order to have same characteristics of the data. Finally, the same test area was cut and adjoined using the shoreline as a connecting basis overlayed on the top of a satellite image of KVR-1000. The figure 1 shows the created integrated digital map data of the test site. Arc/info, AutoCAD, ECDIS, ER Mapper software were used for these tasks.

5) Accuracy test of integrated digital database

The selected test area is comprised of artificial and natural coastal terrain, port and other urban facilities. The coastal lines of each original data were not matching consistently. Thus, 2 different accuracy tests were adopted by edge matching. The first one is to compare the shoreline between DTM and ENC. The second one is adopting the ground survey using Global Positioning System for the analysis of edge matching along the coastal line. The length of coastal line is approximately 14 km. Site A & C are comprised of artificial terrain with various shoreline facilities and Site B is comprised of natural terrain.

Figure 2 & 3 shows maps of test area in artificial terrain. 15 nodes were selected in site A and 7 nodes in Site C. Figure 4 shows the map of test area in natural terrain. Area of individual polygon produced by crossed coastal lines and distance to other coastal lines was compared because its not easy to find distinguishable nodes from natural terrain. 19 polygons were identified on Site C.

In order to do the edge matching analysis of the artificial terrain site, the dispersion of each node toward x, y direction, total mean dispersion,

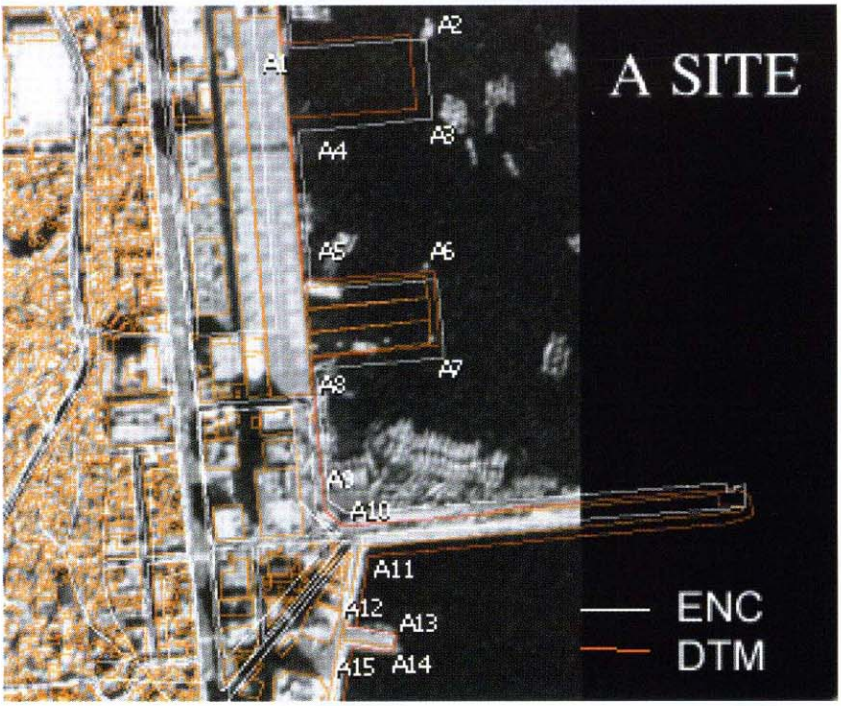

Fig. 2. Edge Matching of Coastal Line in Artificial Terrain-A Area

Root Mean Square (RMS) values and the indication toward the inner vs. outer direction based on the coastal lines was carefully calculated (Yi et al., 1999). Overall mean of RMS value over artificial terrain site is 13.83 m (x direction 8.87 m and y direction 10.62m). This value is much bigger than the allowable maximum drawing error 2.24 m in the scale of 1/5,000 map, 11.57 m in the scale of 1/10,000 map.

The result of the edge matching analysis of the natural terrain site was derived from the examination of the individual polygons, dispersion of each polygon toward inner and outer direction, total polygon area, mean of dispersion toward inner vs. outer direction based on the coastal lines. RMS value over natural terrain site is 4.37 m (+ direction 4.37 m and - direction 4.02 m) (Yi et al, 1999).

Based on the previous analyzed results, artificial terrain showed higher difference in RMS values. In order to determine the accuracy of shoreline, ENC and DTM data were compared using GPS survey. 7 GPS baseline surveys were conducted along the coastal line in Site C and the surveyed data of the WGS 84 coordinate system is converted to the TM system (Figure 5).

Table 1 is the result of the edge matching analysis of the GPS test site over artificial terrain site showing section, length of GPS survey baseline, length of shoreline shown in ENC and DTM and RMS from GPS survey baseline as basis. RMS value over DTM is 6.40 m and over ENC 10.82 m. based on the GPS survey results, we concluded that DTM is more accurate than ENC in the shoreline representation. However, this value is much bigger than the allowable maximum drawing error 3.50m in the scale of 1/5,000 National Base map set up by National Geography Institute of Korea.

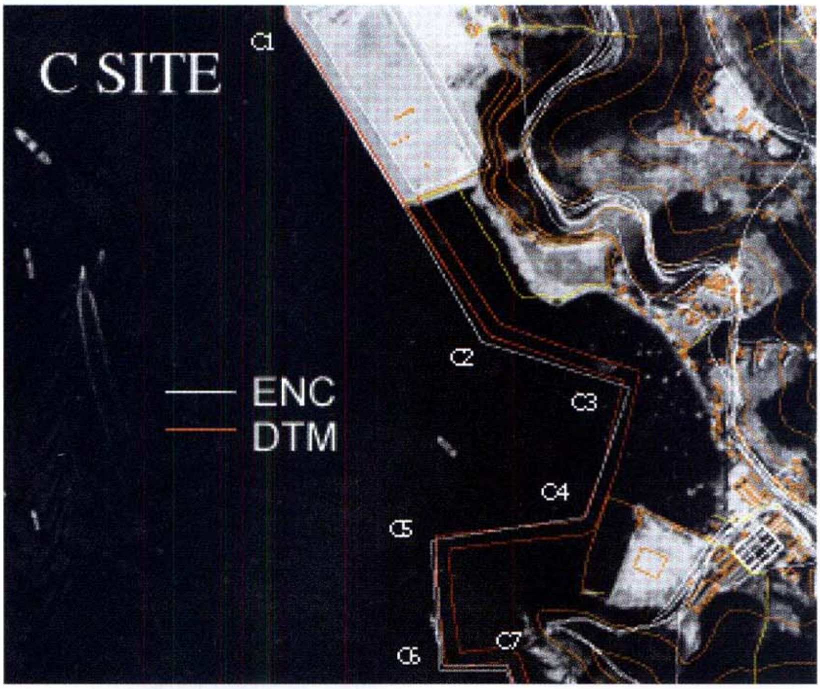

Fig. 3. Edge Matching of Coastal Line in Artificial Terrain-C Area

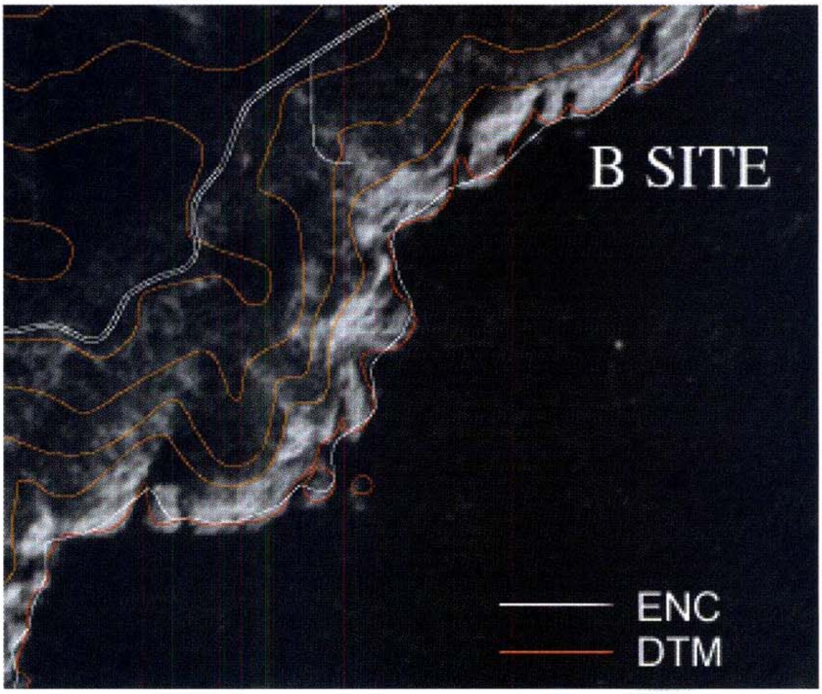

Fig. 4. Edge Matching of Coastal Line in Natural Terrain-B Area

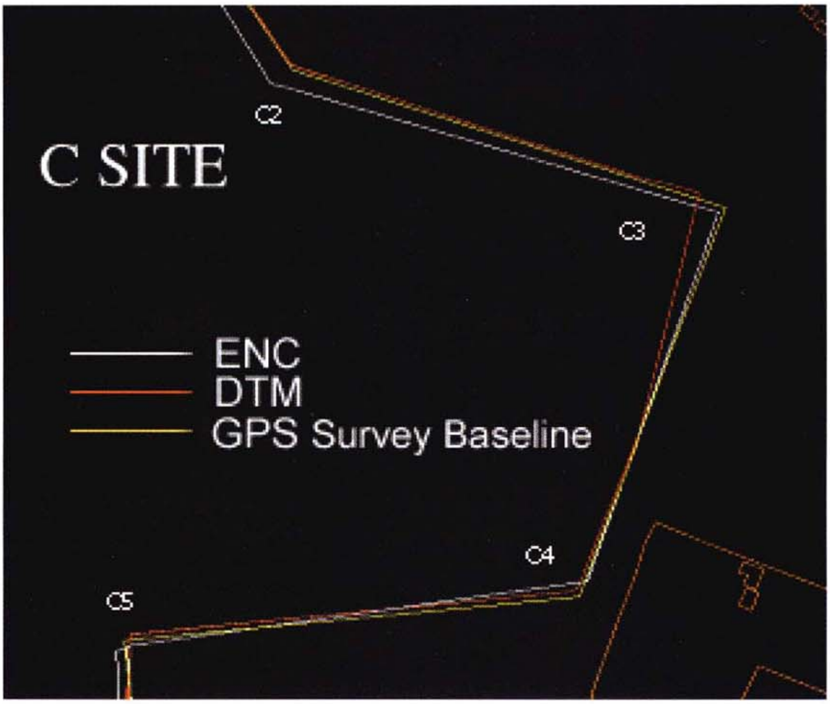

Fig. 5. Overlay of GPS Survey Data and an Integrated Digital Map

Table 1. A distance analysis of DTM and ENC on the reference of GPS baseline vector

Surveyed section	Length of GPS survey baseline	Length of shoreline in DTM(m)	Length of shoreline in ENC(m)	RMS of DTM(m)	RMS of ENC(m)
C1~C2	669.5	666.97	657.13	2.58	12.42
C2~C3	260.63	244.81	267.40	15.82	-6.77
C4~C5	256.20	255.63	240.71	0.57	15.49
C6~C7	259.76	255.40	264.29	4.36	-4.53
C8~C9	229.98	232.47	220.33	-2.49	9.65
C10~C11	102.79	102.00	111.82	0.79	-9.03
Total RMS				6.40	10.82

6) Discussion of accuracy test results

The adopted 2 different accuracy tests by edge matching of the coastal lines between DTM and ENC showed no tendency to seaward or landward direction. GPS survey comparing ENC and DTM showed that DTM has higher accuracy than ENC. This means that its better to use DTM for the base map of Koreas ICM.

But, the RMS value (13.83 m over artificial terrain) seemed to have more serious problems than natural terrain areas (4.37 m over natural terrain). The differences in shoreline boundaries of ENC and DTM are due to the different concept of coastal lines, independent mapping agencies, and different agencies different transformation procedure from paper maps to digital maps and different scale of original paper maps.

However, there is necessity to execute other shoreline boundary comparison study on the other area of Koreans coast. The techniques of integrating ENC, DTM, GPS and high-resolution satellite image proved to be efficient for executing the accurate delineation of shorelines.

3. Suggested use of the developed integrated digital map for ICM

This chapter focuses on the future uses of integrated coastal digital map created through the techniques of this study. The integrated digital data will be valuable to both direct and indirect usage in multitude applications. In focusing on the uses of coastal digital map database, this study necessarily takes a broad-brush approach (Yi et al., 1998).

1) Marine and Coastal Resources Inventories and Conservation

Korean govt. now face the seriousness of coastal degradation due to overuse and misuse (i.e. large-scale reclamation of large coastal tidal flat) of coastal resources. The integrated digital database can be utilized by local and central government agencies in coastal resources management and a means to quickly and efficiently provide quantitative assessments describing the status and trends of coastal resources. Such important coastal resource inventories as fish stock, wetlands, natural dune etc. and their locations, how much of each type or species is present, the condition of the resources (pristine, overused, degraded, depleted, etc) over time can be visually inspected (Yi et al., 1997). The displayed map data and statistics generation will help to identify and prioritize areas of special interests or critical areas for conservation. The integrated digital database can also serve as a basis for real time data collection, coastal change detection due to natural effects (coastal erosion, storms etc.) or artificial effects (reclamation, dam, port construction, drudging etc.). Establishing set-back lines to control placement of buildings or mark hazardous facilities due to natural disaster will be also possible.

Furthermore, environmental sensitivity map due to an accident of oil spill can be effectively built for the people who are involved in the accident. In addition to these uses, integrated digital database will help to identify locations of existing & potential habitat for threatened and endangered species, and types of pollution causing the ecosystem destruction.

2) Marine Industries and Development

Infrastructure development on the Korean coast include a variety of human settlement (buildings, village, towns etc.), facilities (port, marinas, sewage disposal etc.), utilities (power transmission lines, pipelines, telephone lines, electronic cable etc.), support facilities for operation of various transport systems (road, bridge, causeways etc.) for different types of industries including aquaculture, mining, tourism and military and defense use. Renewable coastal resources are exploited too much due to the concern of over fishing especially inshore fisheries, industrial and urban development. Numerous potential applications using the integrated digital database to these various development activities exist. Everyone who uses the coastal area or coastal ocean can use the integrated digital database for the development of his or her plans and management tools. Siting of any facilities in coastal zone require careful planning and management. The suitability analysis of specific development activities can be conducted using the integrated digital database with GIS overlay and cartographic modeling techniques (Clark, 2002).

3) A basis for ICZM implementation tool

Generally there are many potential users in coastal area. ICZM require intelligent program which require a tool or mechanism for the data collection, assembly, analysis, interpretation and simulation can provide information that may come as a part of proposal for a new use of coastal resources, or government documentation for such various program as Zonation, Set-back lines, Protected/Conserved area, Special Area planning, Acquisition, Easements, Development Rights, Mitigation, Restoration and Coastal permits. Coastal management plans with the use of integrated digital database will serve as a basis for future development or conservation of a specific area.

S. Korea has recently finished 1st strategic planning document providing a long term vision with a basis of broad regulation and recently encouraged local governments to develop their own coastal zone management plan under the first fiver-year (2002~2006) program. Here, S. Korea used coastal planning framework to consider the various types of plans to address the particular management action and how the plans would interact with other issues and overall coastal management objectives to assist in achieving desired outcomes relating to the sustainable development of the coastal area. Such various plans as zoning, development, conservation plans relating to the coastal area addressing specific issues with different scale may provide great difficulties due to the such various plan outputs as paper and/or digital maps with various format particularly for the government officers of Division of Coastal Zone Management under MOMAF who is in charge of CZMA. Coastal planning activities using integrated digital database would help minimize these problems by providing a common flat form whatever documents they produce, users may share common base map if S. Korea adopted the ways conducted in this study.

The method incorporated in this study is a systematic compilation of existing database, which suggests utilizing the attributes of the existing database (i.e. Road, Railway, River, Building I & II, Vegetation, Facility, Topography, Administrative or Regional Boundary from NGIS and bathymetry, tide, navigation related facilities etc. from ENC) for ICZM policy decision-making. This approach is different to simple mapping for one site during the planning process. Rather the database will provide a basis for issue-oriented thematic map (i.e. habitat map, oil spill sensitivity index map) for the S. Koreas coastal area consistently and meaningfully. The information provided by the database would be easily retrievable and updateable. This would help to provide correct temporal information of coastal area and would help greatly to detect spatio-temporal change of the coastal area. This will especially good for periodic identification or updating and tracking the change from the past to the present [21]. Furthermore, in some cases, a series of descriptive and interpretive maps can be created to characterize the physical, chemical, biological, thermal, geographical and land use related featured on the coast and sea specifically through the aid of the remote sensing technologies [22].

For ICZM, the integrated database can be further organized to have a series of tables relating to natural parameters (i.e. soil type, vegetation, geology materials etc.) and artificial parameters (i.e. land use and cover, population, pollution etc.). With the advent of better reliable, low cost, easily accessible computer development when times pass by, the integrated digital database can play a central role in facilitating a more integrated and better informed approach to the interest parties of ICZM. By bringing together data from different aspects of environment, the database would emphasize the interaction of specific components of environment. However, to be effective management or decision making tool, further studies in the area of various application of using the integrated digital database should be demonstrated and linked to a prescriptive set of decision making and actions rather than problem identification. Attempts to apply this idea would be one of the next approaches that need to be carried out.

The author hopes that developed digital data base can play a significant role to support these various decision-making processes to such a variety potential users as commercial and recreational fishers, offshore oil and gas developers, marine sand and gravel users, farmers using land in the coastal area, environment and conservation groups, coastal land developers, coastal tourism operators, military personals and govt. officers.

4. Conclusion

This study is to develop the technology and the ways of the practical use of the integrated digital map of and ENC and DTM for the effective and scientific based conservation, development and management of coastal area. In this study, the existing digital maps were integrated for the source of basic database for ICZM. The characteristics of digital maps developed by Korean Geography Institute and National Marine Investigation Institute are carefully analyzed and integrated to a digital map overlayed with a high-resolution satellite image (KVR-1000).

The adopted 2 different accuracy tests by edge matching of the coastal lines between DTM and ENC showed no tendency to seaward or landward direction. GPS survey comparing ENC and DTM showed that DTM has higher accuracy than ENC. Thus, the shoreline of DTM is suggested as the base line of Koreas coast for the time being. However, the differences in shoreline boundaries of ENC and DTM should be carefully checked before creating the National database. The RMS value (13.83 m over artificial terrain) might be able to create serious problems for some specific application. However, the techniques of integrating ENC, DTM, GPS and high-resolution satellite image proved to be efficient for executing the accurate test of shoreline comparison. Thus, the techniques adopted in this study should expand to other area of Koreas coast. The technique developed in this study is one of very rare approaches in S. Korea and the integrated digital database will facilitate numerous governmental decision making activities if implemented by the Korean government. The attributes of ENC and DTM would be valuable to the policy decision-making in ICZM and the integrated digital database can be used as a source for providing valuable information on a particular interest of coastal area to various users.

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