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논문

Application of RS/GIS Integration for the Landuse Planning in the newly Reclaimed Tideland

신규 간척지 토지이용계획을 위한 원격탐사 / 지리정보시스템의 응용

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초 록

지상관측위성에 탑재된 센서로부터 얻어진 자료는 지리정보데이터로 그 이용이 증가되고 있다. 이 연구에서는 신규간척지에서의 토지이용계획을 수립하기 위하여 위성자료를 이용한 원격탐사와 지리정보 체계를 종합하는 방법의 적용가능성을 다루고 있다. 현재 공사중인 간척사업지구를 커버하는 LANDSAT TM, MOS, SPOT 디지털데이터를 영상화하고, 영산강 3단계 사업지구 유역의 토지이용 현황을 분석하였으며, 신규간척지의 토지이용계획을 위하여 동원가능한 데이터를 이용하여 지리정보 시스템에 의한 토지능력구분을 시행하였다.

I. Introduction

With the proliferation of Geographic Information System(GIS) in both industry and government for numerous applications, there has been tremendous increase in demand for remote sensing as a data input source to spatial database development. Products derived from remote sensing are particularly attractive for GIS database development because it can provide cost-effective, large area coverage in a digital format that can be input directly into a GIS (Lunetta, 1991). Because remote sensing data are typically collected in a raster data format, the format can be cost-effectively converted to a vector or quadtree format for subsequent analysis or modelling applications.

A GIS enables different kinds of information to be recalled and combined; for example, areas both suitable for export crops and accessible to an all-weather road within the specified distance could be overlain and mapped. A GIS can offer valuable facilities to land-use planners. First, disaggregated data can be stored and retrieved by location. For example, crop

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yields may have been collected in order to calculate a financial measure of performance like a gross margin ; these data can be stored and subsequently retrieved and used again for other purposes. Point data can be stored as such, rather than being lost by incorporation into mapping units. Thus, in a soil survey, data such as soil depth and texture, gathered for individual locations in the field, can be stored and retrieved for use in land evaluation. A further facility is to undertake complex and manually tedious calculations using any combination of the data in store.

In general concept, land use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land use options. Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances (FAO, 1993).

All kinds of rural land use are involved in agriculture, pastoralism, forestry, wildlife conservation and tourism. Planning also provides guidance in cases of comflict between rural land use and urban or industrial expansion, by indicating which tract of land are more valuable under rural use.

In the Republic of Korea, the development potential for the tidal land reclamation has been estimated to be about 208, 000ha on the basis of net development area, mainly spreaded along the southern and western coastal lines; 73,000ha has been already reclaimed by the medium and large scale projects, 55,000ha under development and 80,000ha for planned future development(RDC, 1997). The reclaimed areas have been developed mainly as the paddy lands so far except some areas where have been changed to the industrial and garbage disposal areas, of which main reasons are ; (1) low lying locations which means some areas are below mean sea level, thus, susceptible to poor drainage and temporary inundation during the rainy seasons, (2) flooding irrigation methods for desalinization of the saline subsoil, suitable for paddy growing mainly due to the fine deposit soils and (3) the government policy to emphasize on grain crop production. However, nowadays land-use planning is not solely restricted to farm planning for paddy growing. Land use must be varied to meet new demands, which then brings new comflicts between competing sectors for the land and between the private and common interests. Land-use planning aims to make the best use of limited resources by (FAO, 1993) ;

- assessing present and future needs and systematically evaluating the lands ability to supply them,
- identifying and resolving comflicts between competing uses, between the needs of individuals and those of the community, and between the needs of the present generation and those of future generations,
- seeking sustainable options and choosing those that best meet identified needs,
- planning to bring about desired changes,

• learning from experience.

The objectives of this paper are; first, to identify the applicability of landsat image interpretation for the land-use planning ; second, to discuss and illustrate the consequences of integrations of remote sensing data into GIS to make decision for the land-use planning. This study is a part of ongoing research for the land-use planning for the newly reclaimed tidal flats using RS and GIS integration.

Ⅱ. Study Area and Tools Used

1. Study Area

One of the major on-going tideland reclamation project areas is selected for the satellite image processing and land use planning by GIS, which is Yongsangang Stage Ⅲ comprehensive tideland reclamation project area. The main purposes of the project are the water resources development, tideland reclamation and enhancement of inland transportation. The project covers approximately 18,800ha of the development area, 12,000ha in Ⅲ-1 and 6,800ha in Ⅲ-2 subareas. The project area is located in Chonnam Province, south-western part of Korea. The major works of the project are three sea-dikes, 4.2km long ; three link canals, 15.7km long ; 13 pumping stations ; 392 km of irrigation canals for the tidal lands and surrounding existing arable lands ; 10,500ha of newly reclaimed tidelands and 740ha of land consolidation works for the existing paddy lands. The project has been implemented since 1989 and the main construction works of sea-dikes have been completed.

2. GIS Software

Two PC based GIS softwares are mainly used for image processing, digitizing and overlays. IDRISI is a grid-based geographic information and image processing system developed by the Graduate School of Geography at Clark University. IDRISI Version 4.0, Window Version 1.0 and TOSCA 2.0 were used mainly for image processing from the satellite data, and digitizing the geographic information. EPPL7, Environmental Planning and Programming Language Version 7.0 is a raster-based GIS, developed by University of Minnesota.

These two systems are relatively easy to use and its capabilities are substantial. Rectification of the satellite image to the geographical map was made by ARC/INFO which is more powerful but rather complicate system.

3. Satellite Data

The landsat MSS and TM data, SPOT and MOS data were utilized for the study. 〈Table 1〉 summarizes the features of commonly-used multispectral scanners and resolutions. The TM, MOS and SPOT images for the different bands were extracted at each concerning area by BILIDRISI. This is a generic routine for the conversion of band interleaved by line (BIL) image files into IDRISI format. Input data file exploration from the computer compatible tape (CCT) data into a series of band sequential (BSQ) images in IDRISI are as 〈Table 2〉.

〈Table 1〉 Features of commonly-used multi-spectral scanners

Satellite	Scanner	Channel	Wave length (μm)	IFOV* (m)	Country launched
Landsat-1, -2, -3	MSS	4 5 6 7	0.5-0.6 0.6-0.7 0.7-0.8 0.8-1.1	80 80 80 80	U.S.A
Landsat-4, -5**	TM	Blue Green Red near-Infr. mid-Infr. Infrared Them.-Infr.	0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90 1.55-1.75 2.1-2.35 10.4-12.5	30 30 30 30 30 30 120	U.S.A
SPOT**	Multi-Spectral mode Panchromatic mode		0.5-0.59 0.61-0.68 0.79-0.89 0.51-0.73	20 20 20 10	U.S.A
MOS**	MESSR		0.51-.059 0.61-0.69 0.72-0.80 0.80-1.10	50 50 50 50	U.S.A

*Instantaneous Field of View
**utilized for the study
MSS : Multispectral Scanner
TM : Thematic Mapper
SPOT : Satellite Pour l'Observation dela Terra
MESSR : Multispectral Electronic Self-Scanning Radiometer

The Thematic Mapper (TM) data which was taken on September 22, 1992 by Landsat-5, the Marine Observation Satellite (MOS) data taken on February 2, 1993, and SPOT data taken on October 8, 1992 were used for the study.

After extraction to different bands, image rectification and restoration are needed. The intent of the process is to correct image data for distortions or degradations that stem from the image aquisition process. Raw digital images usually contain geometric distortions so significant that they cannot be used as maps.

The sources of these distortions ranges from variations in the altitude, latitude, and velocity of the sensor platform, to factors such as panoramic distortion, earth curvature, atmospheric refraction, relief displacement, and nonlinearities in the sweep of a sensor's IFOV. The geometric correction is to compensate for the distortions introduced by these factors so that the corrected image will have the geometric integrity of a map. Systematic distortions are well understood and easily corrected by applying formulas derived by modelling the sources of the distortions mathematically. The deskewing process is used for skew distortion. Random distortion and residual unknown systematic distortions are correc-

〈Table 2〉 Input data on image exploration by BILIDRISI

Items	MOS	TM	SPOT
Name of BIL format	YAMOS003. DAT	TMYA05.DAT	SPXS003.DAT
New name of for Idrisi	YAMOS 1)	YATM 1)	MKSPXS 2)
Number of band	4	7	3
No. of column in each band	2,520	7,020	5,400
No. of row in each band	1,800	2,000	3,000
Name of reference system	UTM	UTM	UTM
Unit of reference	m	m	m
Minimum X	0	0	0
Maximum X	126,000	210,600	108,000
Minimum Y	0	0	0
Maximum Y	9,000	60,000	60,000
Unit distance	50	30	20

1) covering Yongsangang III project area
2) covering new Mankeum project area

ted by analyzing well distributed ground control points (GPSs) occuring in an image and a digitized map. These processes are done by a rectification module of ARC /INFO.

Ⅲ. Results and Discussion

1. Image Interpretation

Landsat TM images are useful for image interpretation for a much wider range of application than MOS and Landsat MSS images. This is because the TM has both an increase in the number of spectral bands and an improvement in spartial resolution as compared with MOS and MSS. As far as resolution is concerned, SPOT image is better than TM. More specific mapping, such as detailed land cover mapping, is difficult on MOS and MSS images because so many pixels of the original data are "mixed pixels," pixels containing more than one cover type. With the decreased IFOV of the SPOT and TM data, the area containing mixed pixels is smaller and then interpretation accuracies increased. The TM's improved spectral and radiometric resolution also aid image interpretation. In particular, the incorporation of the mid-IR bands (band 5 and 7) has greately increased the vegetation discrimination of TM data (Lillesand, 1994).

〈Fig. 1〉 shows the MOS image of the Haenam tideland reclamation project area completed, in the vicinity of the study area, and 〈Fig. 2〉 shows the TM image of the estuary of Youngsangang Ⅱ and Ⅲ. It shows Mokpo and sea-dikes of stage Ⅱ, Ⅲ and their surrounding areas. 〈Fig. 3〉 shows a SPOT band 1 image illustrating the land cover in Kaewha tideland reclamation area, in the vicinity of Saemankeum project area. The reflective colored pixels are clearly seen in the parcel boundaries.

2. Land Use/Land Cover Classification

Land use information is an important input to a host of planning decisions and for this reason which has been gathered by various level. The overall objective of image classification procedures is to automati cally categorize all pixels in an image into cover classes or themes. Normally, multispectral data are used to perform the classification and the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. That is, different feature types manifest different combinations of digitial numbers (DNs) based on their inherent spectral reflectance and emittance properties. In this light, a spectral "pattern" is not at all geometric in character. Rather, the term pattern refers to the set of radiance measurements obtained in the various wavelengh bands for each pixel. Special pattern recognition refers to the family of classification procedures that utilizes this pixel-by-pixel spectral information as the basis for automated land cover classification.

For the land cover mapping, there are supervised and unsupervised classification methods. In the supervised classification, the image analyst "supervises" the pixel categorization process by specifying, by the computer algorithm, numerical descriptors of the various land cover types present in a scene. To do this, representative sample sites of known cover type, called training areas are used to compile a numerical "interpretation key" that describes the spectral attributes for each feature type of interest. Each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of category it "looks most like".

In the unsupervised approach the image data are first classified by aggregating them into the natural spectral groupings, or cluster present in the scene. Then the image analyst determines the land cover identity of these spectral groups by comparing the classified image data to ground reference data.

〈Fig. 4〉 shows the land use /land cover mapping in the watershed area of the Yongsangang Ⅲ area through analyzing the TM data taken on September 1992. The supervised classification was adopted, which the training area was carefully analyzed using local knowledge and applied for the whole area. Using local knowledge to augment remote sensing data to map land use /land cover is especially worthwhile in an information system (Bronsveld, 1994). A study at the USGS EROS Data Center showed an interpretation preference for several specific band-combinations for various features(Lillesand, 1994). For the land cover analysis, a normal color composit of band 2, 3 and 4 (displayed as blue, green and red) was used. It is known that TM composit of 2, 3 and 4 bands is sensitive to green vegetation (portrayed as red), coniferous as distinctly darker red than deciduous forests, and roads and water bodies are clear. 〈Table 3〉 shows the acreages by different land cover categories in the watershed of Yongsangang Ⅲ area. The distinct identifications among harvested paddy lands, villages, uplands are not clear in the image, mainly due to any single date image.

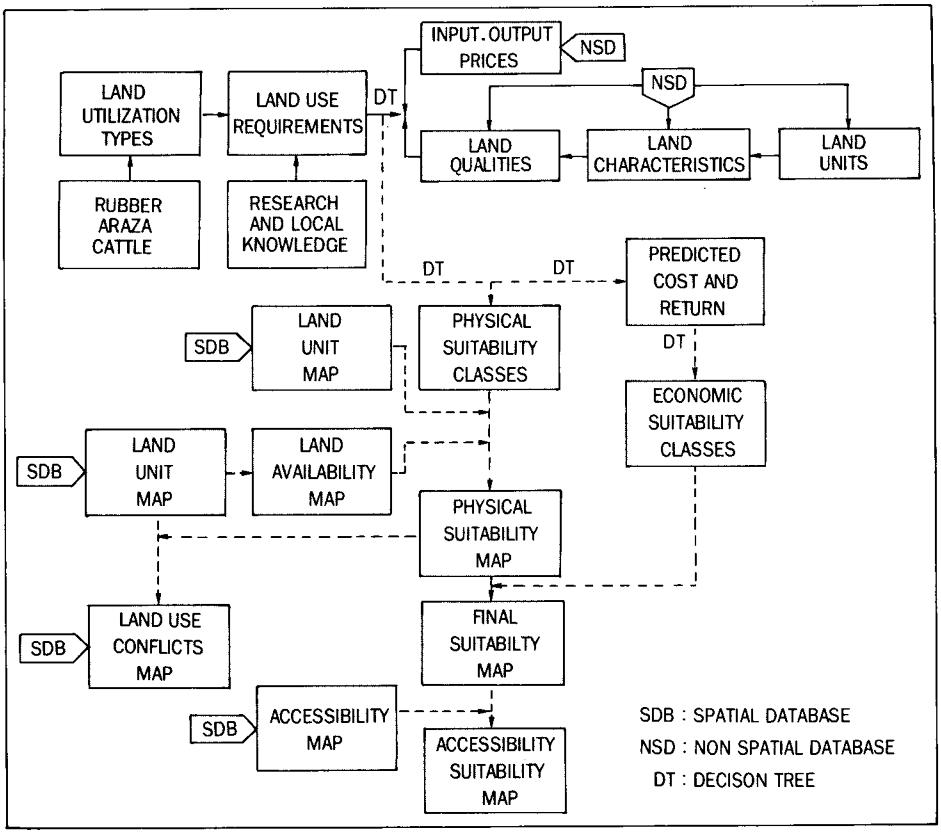
3. Land Use Planning using GIS

A GIS can offer valuable facilities to land-use planners. An integrated information system that includes a GIS with remote sensing image processing capabilities, a relational database and overlaying related information is a powerful tool for the evaluation of the suitability of land use systems.

〈Table 3〉 Land use/ land cover classification in the watershed of Yongsangang Ⅲ Project

Classes	Land Categories	Area(ha)
1	deep water	7,237
2	forest	11,390
3	upland	11,630
4	paddy land before harvest	5,077
5	village/ paddy land after harvest	2,925
6	shallow water	5,095
7	reclaimed tideland	7,843
8	coastal low lands	1,271
Total		52,468

In the spatial land use planning process in general, several phases have to be undertaken, such as an assessment of the present state, the definition of models for prospective situations, the planning and implementation of the selected action and finally the evaluation of the entire process. A land evaluation carried out in this second stage based on the principles of the FAO framework (FAO, 1976, 1984, 1993).



〈Fig. 5〉 Land evaluation method (after L. J. Martinez, 1994)

〈Fig. 5〉 shows the data flow diagram used for land evaluation method. In this study the physical land suitability is analyzed.

Assessing the land use suitability is a basic step in defining the best use for each particular land unit. Especially for the tideland reclamation areas, the land use has the limitations due to its topography, location and soil conditions. Almost all lands are located below mean sea level, nearly flat with gullies, deposited with saline fine soils. Five suitability classes for the elevation, soil and accessibility from the villages and roads are adopted as 〈Table 4〉.

Elevation factor is the most important in low land concerning with inundation during flood season and drainage conditions. Characteristics of soil determine the internal drainage conditions and desalinization process. Accessibility from the inland, village and existing roads can be taken into ac-

〈Table 4〉 Land suitability classes for tideland reclamation areas

Class	Elevation	Soils	Accessibility
1	above 0 m	Silty Loam Very fine S. Loam Shelly Sandy Loam	0~1 km from inland
2	0−(−)1 m	Gravelly Loam Sandy Loam	1~2 km
3	(−)1−(−)2m	gravelly S. Loam	2~3km
4	below (−)2m	Loamy Sand	>3km

- Elevation based on MOC datumn
- Normal water level in the fresh water lake in Yongsangang Project is (−)1.0m

count, however, it would mainly depend upon the land consolidation planning. For the farming purpose, soil condition will be the first considering factor, but for the urban and industrial purpose, elevation and accessibility factor more important.

As shown in ⟨Table 5⟩ the data sets were derived from a number of different sources, including thematic maps such as topography, soil, geology and navigation, and remote sensing. It quite became apparent during the creation of the database layers for GIS that the existing data were of an unsatisfactory and very much limited.

⟨Table 5⟩ Databases in Youngsangang Ⅲ Project

No	Data	Map/ Source	Processing	Classes
1	catchments	topo map	digit	2
2	coastal line	topo map	digit	1
3	road network	topo map	digit	1
4	administration	topo map	digit	1
5	land cover	TM image	RS	8
6	tidal land	TM image	digit	1
7	gullies	TM image	digit	1
8	soil	soil/ RDC	digit	8
9	elevation	navigation	digit	4
10	distance		GIS	4
11	slope		GIS	5
12	aspect		GIS	5

topo : topographic map 1 : 50,000
digit : digitizing
RS : processed remote sensing products
TM : Thematic Mapper
RDC : Rural Development Corporation/ Korea

⟨Fig. 6⟩ shows soil map prepared by RDC soil specialists, which covers Youngsangang Ⅲ-1-3-1 subproject area. Land suitability classification is made from the ovelaying several files mainly based on soils, ground elevation and accessibility from the existing roads and inland villages.

As shown in ⟨Fig. 7⟩, physical suitability classes for crops such as S1 very suitable, S2 moderate suitable, S3 suitable, S4 suitable with consideration, N not suitable are classified from the integrated data related to different map units.

⟨Table 6⟩ Land capability classification

Land Suitability class	Area(ha)	Ratio(%)
S1	324.4	15.0
S2	848.6	38.0
S3	656.6	29.4
S4	391.1	17.5
N	13.1	0.1
Total	2,233.8	100.0

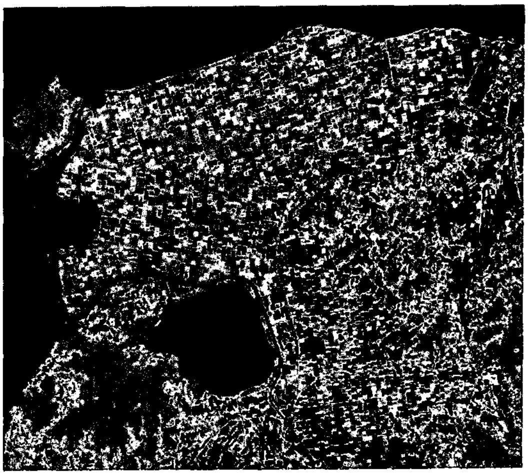
Ⅳ. Conclusion

Land evaluation gives information on the suitability of different tracts of land(land map units) for selected land uses. Most land evaluations are biophysical suitability classes (eg. S1, S2, S3, S4) which rates the biophysical performance of each land use system. This performance is generally related to the expected yield, practical possibilities/limitations for implementing the use and the suitability of the land use system. Biophysical land use evaluations provide only part of the information needed for land use planning. Because decisions on land use are often based on social and economic criteria, information on biophysical suitability alone is not sufficient for land use planning.

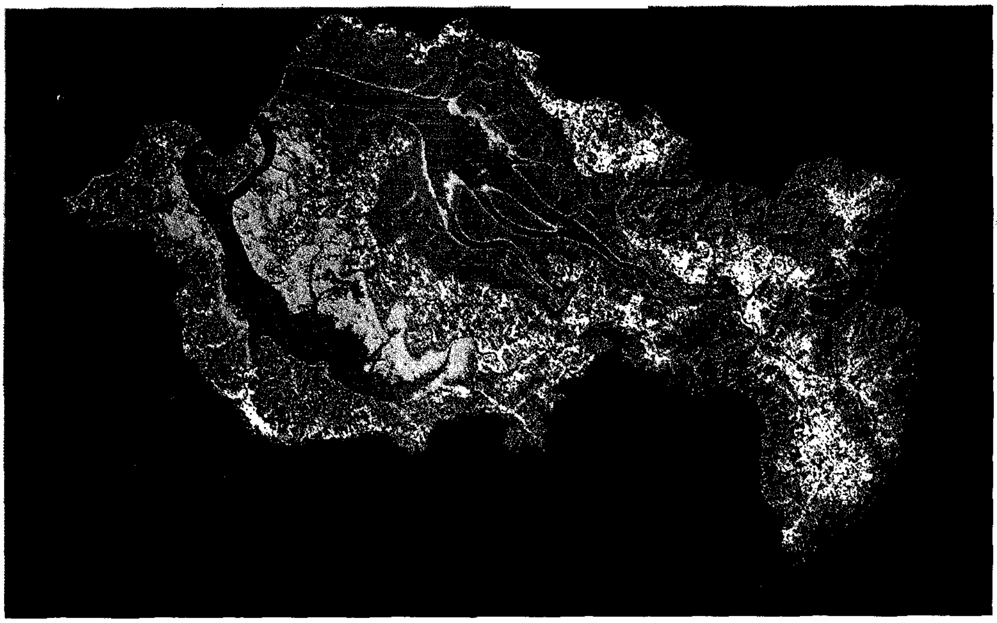
An integrated information system that includes a GIS with remote sensing image processing capabilities, a related database

〈Fig. 1〉 MOS band-1 image on Haenam tideland reclamation area

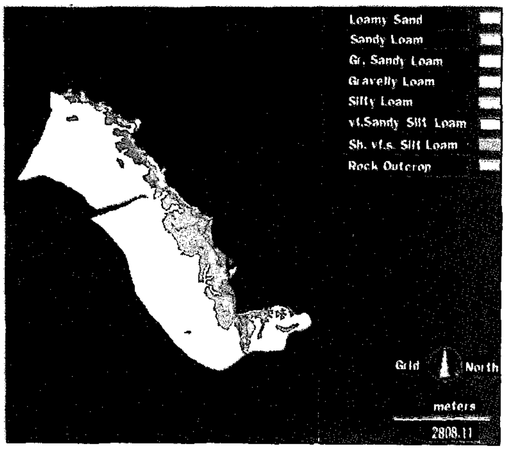
〈Fig. 2〉 TM band-5 image on Yongsangang tideland reclamation project area



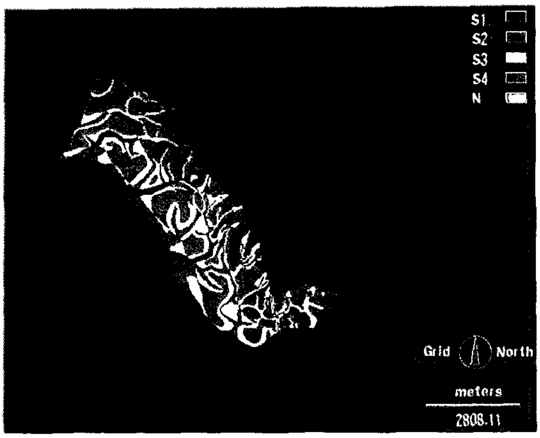
〈Fig. 3〉 SPOT band-1 image on Kaehwa tideland reclamation area



〈Fig. 4〉 Land use/ land cover map in the watershed of Yongsangang Ⅲ area produced color composit of TM 2,3,4 bands



〈Fig. 6〉 Soil map in Yongsangang Ⅲ-1-3-1 subarea



〈Fig. 7〉 Land suitability map in Yongsangang Ⅲ-1-3-1 subarea and modelling technique is a powerful tool for the evaluation of sustainability and suitability of land use system and planning. The case study described is applied in the newly reclaimed tideland in Youngsangang stage Ⅲ-1 project which is located in south western part of Korea. GIS /RS integration technology could be powerful for land use planning when necessary databases are available.

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