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Environmental impact assessment with remote sensing at Isahaya land reclamation site

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ABSTRACT:

Environmental impact assessment (EIA) is a sequence of procedures to evaluate a project and to make it sound in terms of environmental conservation. It plays a vital role to protect our environment from developments which inevitably give impact on surrounding environment. It is, however, not easy to carry out the EIA for big scale of projects since the EIA requires to collect various kinds of data in spatial and temporal dimensions. In this study remote sensing methodologies are investigated for monitoring environmental parameters in spatial and temporal dimensions in the environmental impact assessment. As a case-study, Isahaya land reclamation project in Kyushu, Japan was selected, and satellite remote sensing methods were investigated with LANDSAT/TM, ADEOS/AVNIR and TERRA/ASTER to produce environmental thematic maps including suspended sediment concentration and land-cover distribution in and around the project site.

1. INTRODUCTION

Environmental impact assessment (EIA) is a very important legislative procedure to combine a development successfully with environmental conservation, and to realize sustainable development. But in Japan the EIA has not been sufficiently conducted, especially in ecosystem impact assessment. One reason for it is that the EIA requires intensive data collection ranging from physical, chemical, and biological to socio-economic variables in spatial and temporal dimensions. The objective of the study is to investigate remote sensing methodologies for the EIA. As a case-study, Isahaya land reclamation project in Kyushu, Japan was selected, and satellite remote sensing methods were investigated. Isahaya land reclamation project was conducted in 1997, and from the winter of last year, it has been a very big social issue that the harvest of laver is sharply reducing. It is pointed out that this problem is likely to be caused by the project conducted in 1997. In this case study water quality in Isahaya Bay area and surrounding sea and land-cover characteristics along coastal zone are the parameters of importance with respect to the environmental impact, therefore, the suspended sediment concentration in the sea and the land-cover conditions along the Bay were selected as key variables to measure with satellite data.

Firstly, satellite images over the area were collected including LANDSAT/TM, ADEOS/AVNIR and TERRA/ASTER, and by combining satellite data with ground truth data, which were surveyed by Environmental Agency of Japan, distribution of suspended solid concentration (SS) was estimated before and after the project. Statistical regression analysis between SS and satellite radiance was examined to produce the SS estimation model from remotely sensed data. Secondly, to assess the changes along coast land-cover characteristics were examined by classifying land cover types with satellite images. The spatial distribution of SS and land cover characteristics from satellite data indicates the changes in marine and land environment before and after the project.

2. RESEARCH FLOW AND DATA USED IN THE STUDY

In this study Suspended Sediment (SS) concentration and land-cover condition were selected as the key variable to assess the impact of the land reclamation to the surrounding environment. Mapping of these two variables over the area before and after the project was done with optical sensor data including LANDSAT/TM, ADEOS/AVNIR and TERRA/ASTER. The flow diagram to produce distribution maps for the SS and the land-cover are illustrated in Figure 1 and 2 respectively.

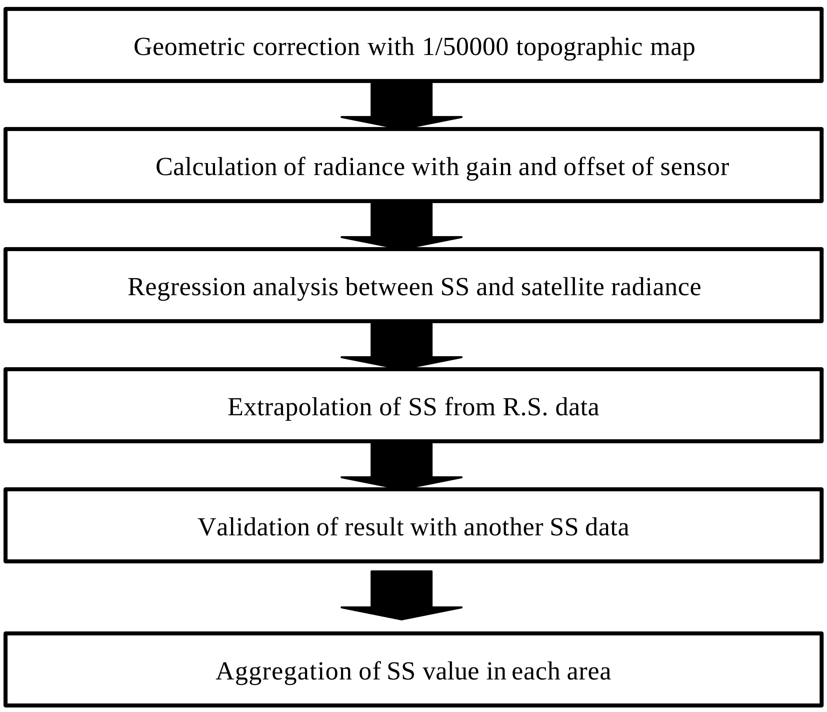


Figure 1 Flow diagram for the estimation of SS

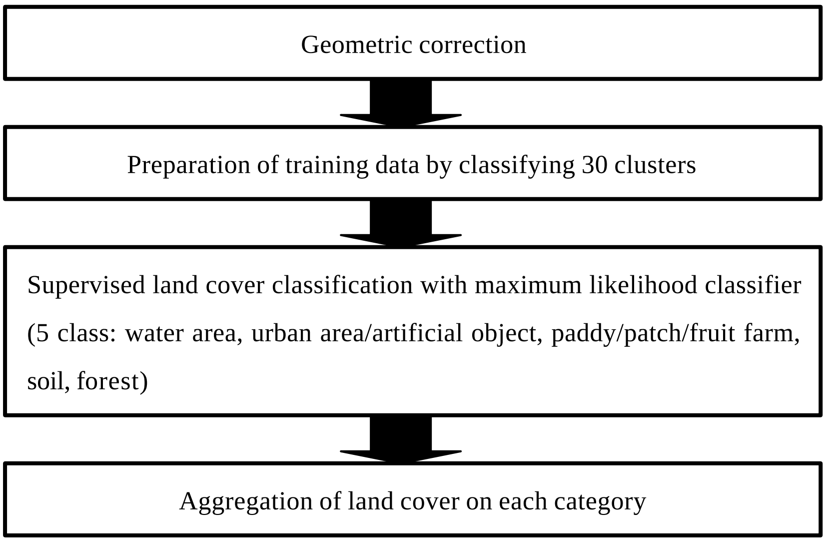


Figure 2 Flow diagram for land-cover mapping.

The satellite data and the ground truth data used in this study are summarized as follows;
Satellite data: ADEOS/AVNIR (1997.3.30,1997.5.5), LANDSAT/TM (1997.4.24,1997.5.10),
TERRA/ASTER (2000.4.8)
Topographic map: Geographic Survey Institute, Ministry of land, Infrastructure, and Transport, Japan
Ground observation data of SS: Environmental Agency of Japan, Fukuoka Prefecture, The Ministry of agriculture, forestry and fisheries of Japan

3. RESULTS

(1) SS distribution

Three types of statistical models including single band model, band ratio model, and multi regression model are examined to estimate the SS from the satellite radiance. Regression analysis showed that the multi regression model shown in the equation (1) was the best for the SS estimation, and the results of regression analysis are summarized in Table 1.

$$C_k = a(d_{ik}) + b(d_{jk}) + c \qquad ??? \ (1)$$

C_k: Observed SS concentration at point k
d_{ik}, d_{jk}: satellite radiance of band i(j) on point k
a, b, c: regression coefficients

Figure 3 is an example of the relation between the observed SS and the estimated SS. Estimated distributions of the SS before and after the shutting the dykes are demonstrated in Fig. 4 (a)-(d), and they showed the clear difference in the patter of the SS distributions.

Table 1 Multi regression analysis for estimating SS concentration

Date	No. of data	R^2	RMSE (mg/l)	F_0	AIC
March 30	12	0.53	9.46	4.99	30.11
April 24	14	0.84	116.82	4.99	102.35
May 5	5	1.00	2.80	618.09	8.27
May 10	14	0.92	28.67	67.04	63.02

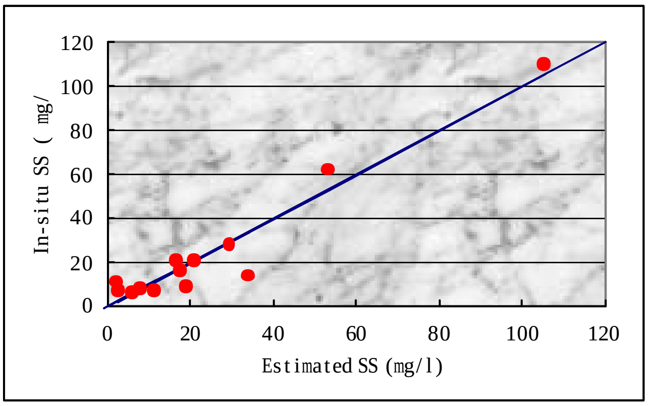
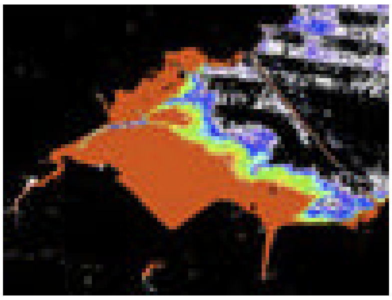
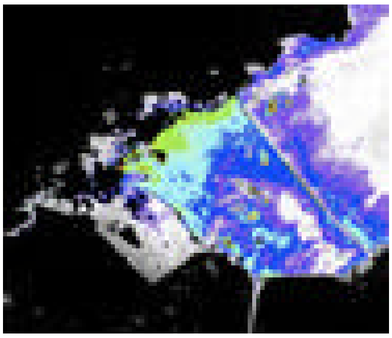


Figure 3 Relation between the in-situ SS and the estimated SS by multi regression model (May 10,1997)

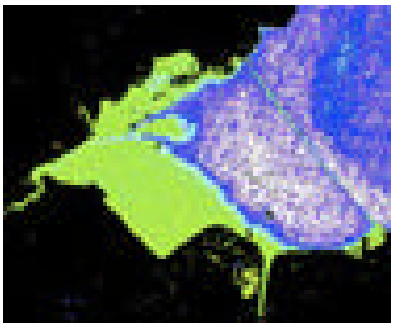
March 30,1997 (15 days before)



April 24,1997 (9 days after)



May 5,1997 (21 days after)



May 10,1997 (26 days after)

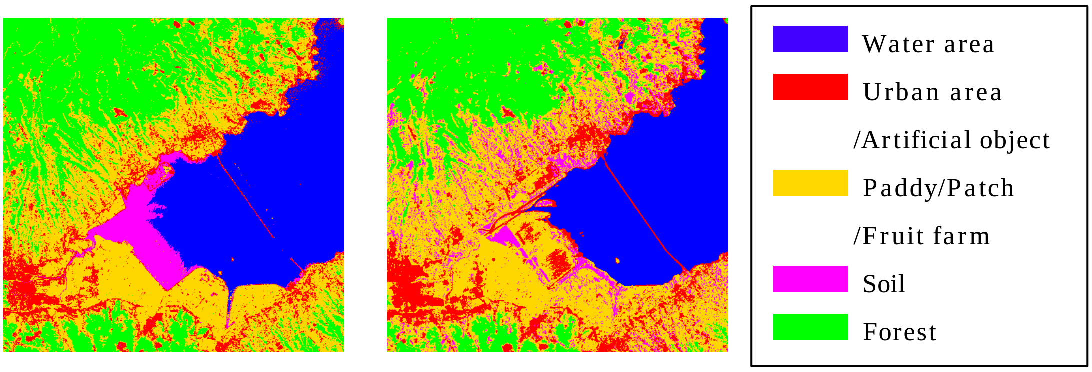
Figure 4 SS distribution in Isahaya detention pond

As is shown in Figure 4, SS value increased after shutting dykes. Especially in the detention pond, SS value was under 50 mg/l before the project, but on April 24,1997 there were some points where SS value is over 200 mg/l. Also on another days maximum SS value was about 150 mg/l, the increment of SS is very big. Environmental standard of SS in river is under 25 mg/l. Usually SS value is higher in river than in sea, so the result indicates that SS value is abnormally high in this site. It is thought as the cause that SS from Honmyo river had been accumulated after shutting dykes. Honda reported that 5,900 kg of SS flowed into Isahaya bay from the river around there per day.[1] Also it is thought that a clarifying function of tidal flat has been lower after shutting dykes.

(2) Land Cover Mapping

To assess the changes in land-cover characteristics along coast the land cover before and after the project were examined by classifying land cover types with satellite images. Figures 5 shows the result of land cover classification by maximum likelihood classifier, and Fig.6 summaries the changes in land cover characteristics before and after the shutting of dykes.

In Figure 6, it is shown that the area of forest decreased and areas of paddy, patch, fruit farm and soil increased. It indicates that the construction works has progressed around the site.



March 30,1997 (Before) April 8,2000 (After)

Figure 5 Land cover changes around Isahaya land reclamation site

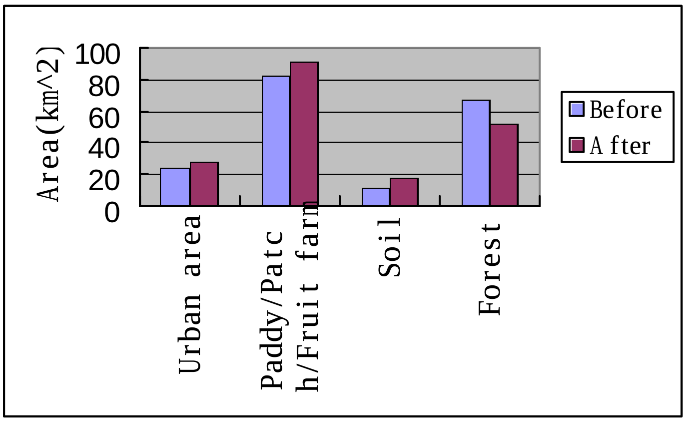


Figure 6 Land cover change before and after project

4. CONCLUSIONS

In this study application of remote sensing to the environmental impact assessment was investigated with an example of the land reclamation project in Isahaya. The spatial distribution of SS and land cover characteristics from satellite data indicates the clear changes in marine and land environment before and after the project, and it also indicates the effectiveness of remote sensing to environmental impact assessment.

ACKNOWLEDGEMENTS

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REFERENCE

(1) Honda, K., Kondo, Y., Kuwahara, H.: Water quality of the detention pond originated from Isahaya-bay land reclamation (1998), Nagasaki Prefectual Institute of Public Health and Environmental Sciences.1999