Estimation of Sea Surface Temperature Change by Tide Embankment Construction

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Abstract:

This study investigates to detect sea surface temperature (SST) and land cover change after tide embankment construction using Landsat Thematic Mapper (TM) thermal infrared (TIR) band data at Shihwa Lake and surrounding area. SST measurement is important for studies of both the structure of the ocean and as the thermal boundary between the ocean and the atmosphere. The TIR band of TM images can be used to detect SST change whose shoreline is complicated and narrow like the study site. The purpose of this study is to estimate SST and land cover change at Shihwa Lake and surrounding area.

Key words: Tide Embankment Construction, Sea Surface Temperature, Land Cover

1. Introduction

Satellite imaging can provide synoptic views of the earth surface over large areas and extended time periods (Lillesand and Kiefer, 1999). Sea surface temperature (SST) measurement is important for studies of both the structure of the ocean and as the thermal boundary between the ocean and the atmosphere (Emery and Yu, 1997).

Satellite remote sensing (RS) technique can be useful in extracting the information from the area concerned whose data are relatively homogeneous like the sea. Since 1970s, the derivation of SST by satellite RS has been applied to earth surface using Advanced Very High Resolution Radiometer (AVHRR) and Landsat Thematic Mapper (TM) (Badenas, 1997; Jeong and Yoo, 1999; Thomas *et al.*, 2002; Alvarinho and Kawamura, 2003; Barale *et al.*, 2004; Hareman-Mountford and McGlade, 2003; Peter, 2003; Borges *et al.*, 2004; Gloersen and Huang, 2004; Jeremy and Mustard, 2004; Murtugudde *et al.*, 2004).

Spatial resolution of AVHRR is 1.1 km × 1.1 km while Landsat TM has 120m spatial resolution and Enhanced Thematic Mapper Plus (ETM+) has 60m. AVHRR has restriction in deriving SST and SRT in the area whose shoreline is complicated like western coast in South Korea. The TIR band of TM images can be used to detect SST difference whose shoreline is complicated and narrow like the study site. Thus, multi-temporal TM images can be effectively used for SST change detection.

The purpose of this study to estimate SST and land cover change after tide embankment construction using Landsat TM images at Shihwa Lake and surrounding area.

2. Materials and Methods

2.1. Study Site

The study site is Shihwa Lake and its surrounding area located in western coast of central Korean peninsula. Original Shihwa Lake was a bay with tidal lands surrounded by Ahnsan City, Shiheung City and Hwasung City. But, tide embankment construction was propelled since June 1987. It's surrounding area, Banweoul and Shihwa industrial complex area was constructed together with seashore landfill project since 1988. Shihwa Lake shore area has been filled with land by seashore landfill project. And industrial factories began to move to industrial complex area in early 1980s and 1990s. Shihwa Lake has been blamed for many environmental problems due to rapid water pollution after tide embankment construction.

2.2. Data

For RS data, Landsat 5 TM images were used in this study to investigate the SST change of the study area after tide embankment construction. 1:25,000 and

1:5,000 scale digital topographic maps were used to select ground control points (GCP's). Table 1 shows RS and Geographic Information System (GIS) data used in this study. Also IKONOS satellite image were used to verify land use classification.

Table 1. RS data used in this study.

Data source	Resolution/Scale	Date	Data type
Landsat 5 TM	Visible: 30m NIR : 120m	1987. 5. 20 1999. 5. 21	Digital
IKONOS	4m	2003. 3	Digital
topographic maps	1:25,000 1:5,000	1996	Digital

2.3. Methods

TM images taken on May 20, 1987 and May 21, 1999 were geometrically corrected into 30m resolution images by using the second order polynomial transformation and nearest neighbour resampling. For reference data, 1:25,000 and 1:5,000 scale digital topographic maps were used to select ground control points (GCP's). Then, land use was classified by using the hybrid classification method for both TM data. After the land use classification of study site, classification accuracy assessment was done by referring to IKONOS image. The classification accuracy was obtained by overlaying classified image IKONOS interpreted land use map based on pixel by pixel comparison.

After classification they are reclassed into seven classes - urban, forest, agricultural area, bare soil, tidal land, sea water and fresh water -. In order to verify weather effects five date weather data were checked including the data TM scene taken and prior two days and later two days (May 18, 1987 - May 22, 1987 and May 19, 1999 - May 23, 1999) in this study.

SRT was calculated from TM TIR band where spatial resolution is 120m. The equation was used to convert the digital number of TM TIR band into spectral radiance (Landsat Project Science Office, 2002). The next step is to convert the spectral radiance into the absolute temperature value. This is the effective at-satellite temperatures of the viewed earth-atmosphere system under an assumption of unity emissive and using pre-launch calculation. The conversion formula referred Landsat Project Science Office (2002). Also, constants that is required at calculating referred Chander and Markham (2003).

However, temperature values obtained above are referenced to blackbody. Therefore, emissivity was corrected according to the nature of land cover. Finally, the absolute temperature value was converted into Celsius value. For RS and GIS software, PCI Ver. 7.0 and ArcView Ver. 3.2 were used in this study.

3. Results and Discussion

To understand SST change by tide embankment construction, SRT change of each land use type was derived. SRT increased at forest changed from sea water by 8.47℃, 5.43℃ at agricultural area changed from sea water, 13.51℃ at bare soil area changed from sea water, 3.13℃ at tidal land changed from sea water, 2.75℃ at fresh water changed from sea water. For both sea water areas between 1987 and 1999, SST increased by 2.44℃. SRT increased at urban area changed from sea water by 14.77℃ due to the urbanization such as increase of urban structures and pavements along with industrial complex construction. Especially, SRT increased at industrial complex changed from sea water by 15.11℃. For the SST distribution, in 1987 SST increase as it goes closer to the land. However, in 1999 high SST were observed near industrial complex the water is flowed in Shihwa Lake from Shiheung and Ahnsan City and low SST where were observed near sluice gate where seawater flows into the lake.

To detect SST change after tide embankment construction, SST changes of inside and outside Shihwa Lake were derived (Table 4). Inside Shihwa Lake mean SST increased by 3.02℃ between 1987 (13.73℃) and 1999 (16.75℃). Outside Shihwa Lake mean SST increased by 1.59℃ between 1987 (13.26℃) and 1999 (14.85℃). The overall SST increased by 2.44℃ between 1987 (13.54℃) and 1999 (15.98℃). This means that sea surface water has been more turbid and warm after tide embankment construction.

SST change shows the change of marine environment due to the change of flow direction and turbid material increases. Therefore, results in this study suggest that multi-spectral and multi-temporal satellite data provide continuous monitoring about these environmental changes.

4. Conclusions

This study carried out to detect the change of land cover and SST after tide embankment construction using TM images. SST increased and land use changed in the study site after the tide embankment construction.

(1) The largest changed land use type is urban (increased by 81.30㎢), followed by sea water (decreased by 79.04㎢) and bare soil (increased by 48.06㎢) due to seashore land fill project and tide embankment construction.

(2) Mean SST increased inside Shihwa Lake by 3.02℃ and outside Shihwa Lake by 1.59℃. The overall SST increased by 2.44℃. This means that sea surface water has been more turbid and warm after tide

embankment construction.

(3) SRT increased at industrial complex, urban, bare soil area, forest, agricultural area, tidal land and fresh water changed from sea water by 15.11℃, 14.77℃, 13.51℃, 8.47℃, 5.43℃, 3.13℃ and 2.75℃, respectively.

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