Investigations and Prediction of Vegetation changes and Corresponding Sediment transport Characteristics in Guandu Nature Reserve

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Abstract

The aerial photographs from 1986 to 2002 were used to analyze and predicted the temporal and spatial variations of the vegetation changes in Guandu Nature Reserve. The results revealed that the marsh habitat, dominated by *Cyperus malaccensis* Lam. and *Phragmites communis* (L.) Trin, has changed into a swamp habitat, dominated by *Kandelia candel* (L.). The coverage area of *Kandelia candel* (L.) has increased from 7.2 hectares in 1986 to 23.8 hectares in 2002. It causes significant impacts upon the ecosystem and flood control operations. GIS-based technique has been used to determine the vegetation changes in this area. TABS-2, a horizontal two dimensional sediment transport simulation model, can be utilized to evaluate the sediment transport characteristics of this estuarine wetland.

The *Shannon*'s diversity index decreased from 0.98 in 1986 to 0.77 in 2002. Additionally, the *Shannon*'s evenness index also decrease form 0.77 in 1986 to 0.5 in 2002. We have concluded that the habitat diversity became lower and lower and will be unbenefited to water birds.

Significant sediment deposition occurs due to the extensive root network of *Kandelia candel* (L.) Druce. The average deposition is about 33 mm during a 200 years return period flood event. Removal of *Kandelia candel* (L.) Druce is able to reduce the sediment deposition rate. When the removal ratio reaches 20%, the reduction in sediment deposition is about 5 mm. It is also found that mangrove remove will improve the ecological restoration of *Uca (Thalassuca) Formosensis* Rathbun which is an endemic species of the fiddler crab in Taiwan.

Keywords：intertidal wetland, vegetation change, sediment transport simulation, GIS-based technique, landscape type index, ecological restoration

1. Introduction

Coastal wetlands are widely distributed in estuaries throughout the world. Because of the tremendous volumes and varieties of inhabiting plants, they are regarded as being among the most productive ecosystems (Teal, 1962; Day et al., 1989). They are known to provide food sources and diverse habitats for large numbers of resident and migratory organisms. Wetlands have also been shown to be very efficient in removal of nutrients from agricultural runoff (Comín et al., 2001). The Guandu Natural Reserve (25^{o} 07’ N, 121^{o} 027’ E) lies in the west of the Guandu floodplain, which is located in the confluence of the Keelung and Tanshui Rivers, approximately ten kilometers from the river mouth, near Taipei, Taiwan(see also Fig. 1). The increase of *Kandelia candel* (L.) Druce cover has some adverse effects on the river hydraulic characteristics, including velocity retardation, increase of water surface elevation and sediment deposition. Increased roughness coefficient of the river leading to a higher mean water surface elevation (Chow, 1973; Lee and Shih, 2004).The original types of plant in this area are shrubs and trees adapted to the harsh seashore environment, having large and smooth leaves. Moreover, the thick inner tissues and well-developed cuticles of these plants allow them to reduce water evaporation. These plants also have special protective features against the salty environment. Some of these plants are oceanic drift plants, whose lightweight and fibrous fruits ride ocean currents and take root in faraway places. Analysis of aerial photographs taken from 1986 to 2002 revealed that the marsh habitat has changed into a swamp wetland habitat.

2. Material and methods

(1) GIS-base technique

The aerial photographs of Gunandu mangrove wetland from 1986 to 2002 (see detail in Table 2) have been employed in this study to evaluate the temporal and spatial vegetation variations. Both unsupervised and supervised classification methods of GIS-based technique (Duda and Canty, 2002; Hong and Chen, 1994) were applied and classification results are shown as Fig.2. The accuracy of this auto-detecting result was also calculated in Table2. The classification results are well obviously cause of the accuracy of auto-detecting can exhibit more than 83%.

(2) Numerical Simulation

The TABS-2 model is a two dimensional, depth-averaged, finite element hydrodynamic numerical model developed by the Waterways Experiment Station of U.S. Army Corps of Engineers. It computes water surface elevation and horizontal velocity components for subcritical, free-surface flow in two-dimensional flow fields. TABS-2 also computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated according to the Manning or the Chézy equation, and eddy viscosity coefficients are used to define turbulence characteristics. Both steady and unsteady state problems can be analyzed. Please refer to SMS 7.0 User's manual (2000) for more details.

The *Manning's* n represents degree of the energy loss caused by the riverbed and riverbank roughness. Many studies investigated this roughness coefficient (Chow, 1973; Shoji Fukuoka et al., 1991). In this study, some findings of Lee and Shih's (2004) study were used to estimate the values of n and then the numerical model parameters were calibrated and verified using the experimental data conduced by the Water Resources Agency in Taiwan (1996).

The *Manning's* n increase with increasing return period flood and reaches to a maximum value of 0.283 when the return period flood equals to 20 years.

According to the data provided by the User's Manual of TABS-2, the eddy viscosity coefficient in the mangrove wetland and rest of the study sites have been selected as 5000 ($N{\bullet}sec/m^2$) and 2000 ($N{\bullet}sec/m^2$), respectively.

The finite element mesh generated from the digital maps defines only the x and y coordinates for the numerical node. The bathymetric information thus can be surveyed using field data and interpolated onto the finite element mesh. The x, y and z coordinates of this study site were provided based on the field data surveyed by the Water Resources Agency in 2003 and adjusted using the Taipei Government 1:5000 DTM data.

The upstream and downstream boundary conditions used in TABS-2's sediment transport simulations are provided in Fig. 4, 5 and 6, respectively (Water Resources Agency, Taiwan, 1996; Lee and Shih, 2004).

3. Results and discussions

(1) Vegetation changes

The temporal variation of mangrove spread from 1986 to 2002 in Guandu mangrove wetland was shown in Fig.7. The landscape coverage area, including mangrove, reed, mudflat and tidal slough, were also calculated and shown in Fig.8, 9, 10 and 11 compared with literature review (Lin, 1994; Wang, 1999 ; Hsu et al., 1994).

The spatial changing of vegetation reveals that mangrove spread from western to eastern part of this wetland (downstream to upstream). The tidal slough and mudflat which were important habitat type to waterfowls reduce year by year.

The Shannon's diversity index decreased from 0.98 in1986 to 0.77 in 2002. Additional, the Shannon's evenness index also decrease form 0.77 in 1986 to 0.5 in 2002 (see also Fig. 12). We have concluded that the habitat diversity became lower and lower and will be unbenefited to water birds.

The prediction of mangrove growth was shown in Fig. 13. The trend exhibits that mangrove coverage area will increase to 38.1 hectare in 2010 and 42.3 hectare in 2013 (occupied whole Nature Reserve), respective, without any thinning. It was therefore suggested that we should take action to prevent this worse condition carry on as soon as possible.

(2) Sediment transport simulation

Spatial variations of the riverbed elevations are provided in Fig. 14. The sediment transport simulations revealed that sediment deposition occurred in most of the 12 cross-sections, and thus the riverbed elevation increased after 46 hours of simulation. The sediment deposition depth ranged between 10.45 mm to 122.65 mm. We can conclude that mangroves will cause significant sediment deposition.

Furthermore, sediment transport simulations under four different mangrove removal ratios were also investigated. Riverbed deposition ranged between 10.5 mm and 122.7 mm, with the average value equals to 33.0 mm. The reduction in sediment deposition is about 5 mm when the removal ratio reaches 20%. Long-term sediment transport simulation is still under investigation.

4. Figures & Tables

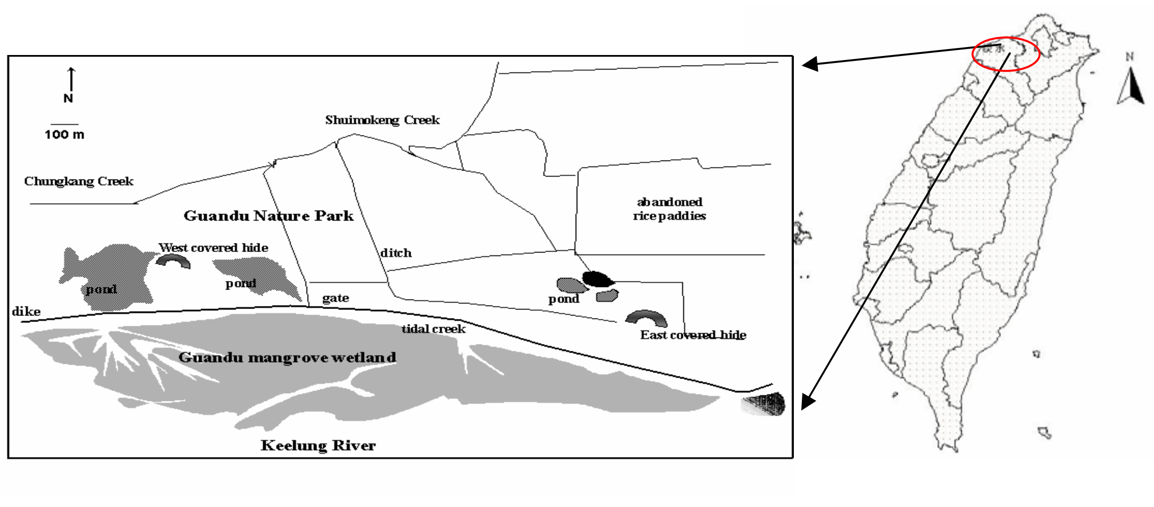

Fig. 1 The location map of the Guandu mangrove wetland.

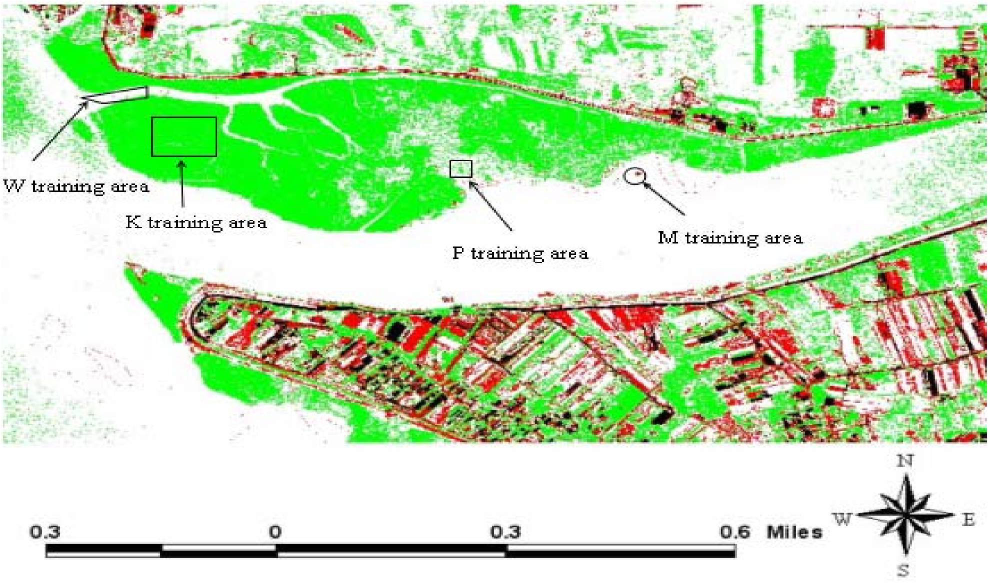

Fig. 2 The results of unsupervised classification of vegetation cover in Guandu mangrove wetland.

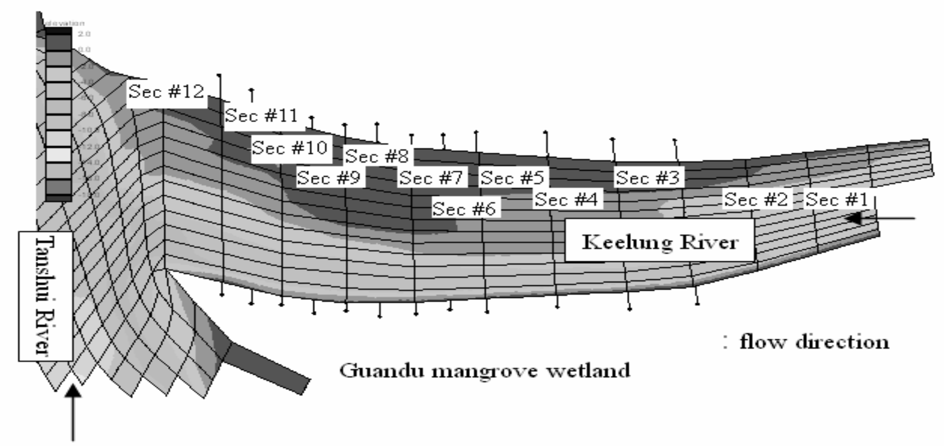

Fig. 3 TABS-2 mesh grid of the study site. The TABS-2's mesh grid of study site. The above and below plots are the Tanshui River System and Guandu mangrove wetland, respectively. The twelve cross-sections site of Guandu mangrove wetland which were used to calculate the bed elevation changes. The numbers of twelve cross-sections were assigned orderly sequentially from upstream to downstream of Keelung River.

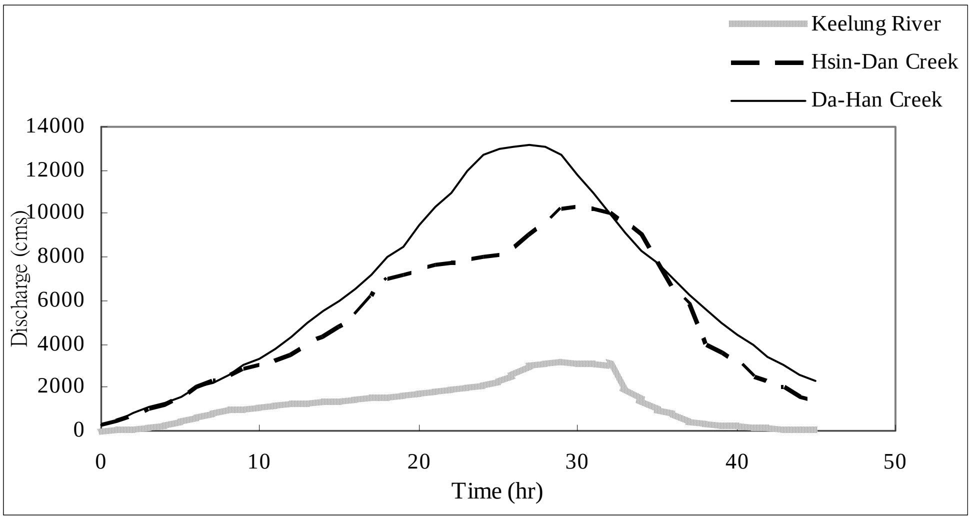

Fig.4 The 200-year flood hydrograph of Tanshui River System.

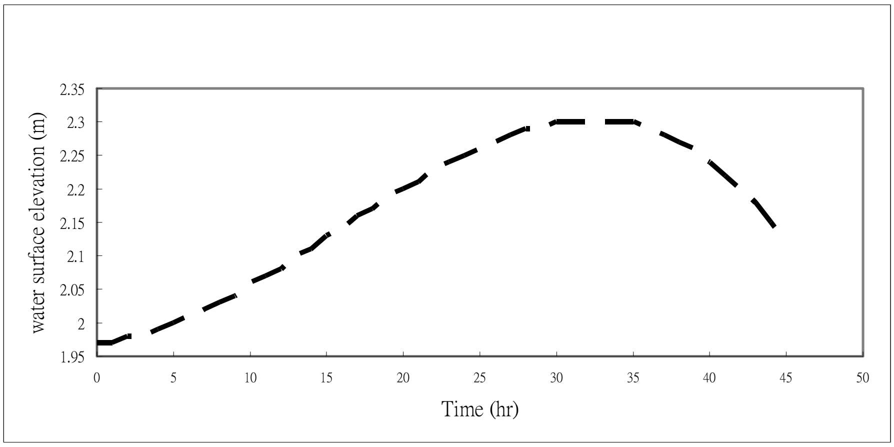

Fig. 5 Temporal variations of the water surface elevations at the river mouth during a 200 years flood event.

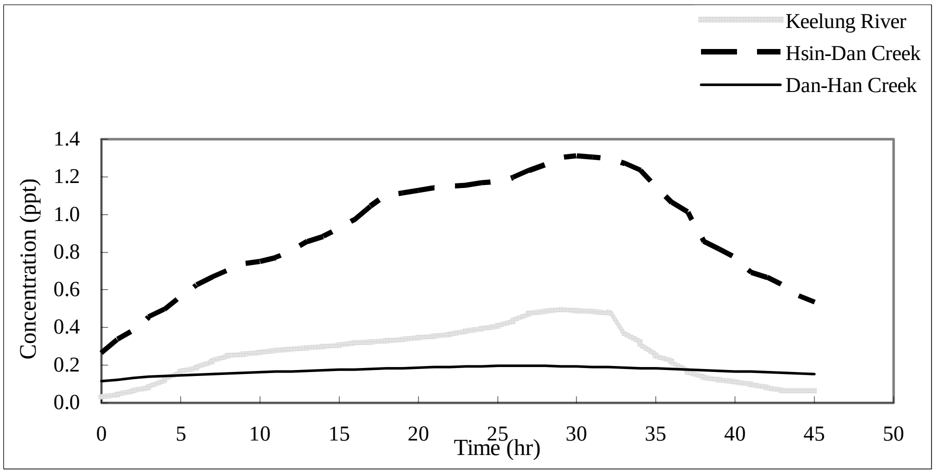

Fig.6 The upstream sediment supplies of the Tanhsui River System, which includes. Keelung River, Hsin-Dan Creek and Dan-Han Creek, respectively.

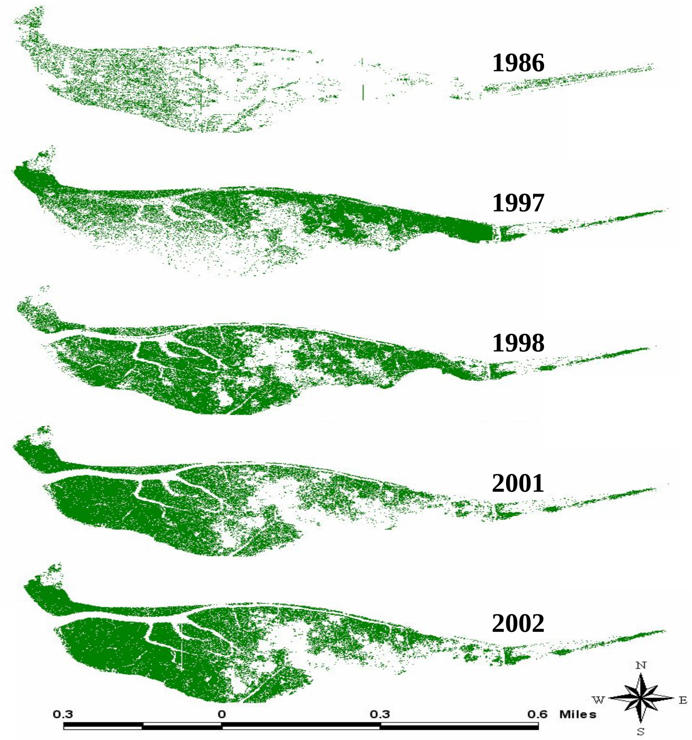

Fig.7 The temporal variation of mangrove spread from 1986 to 2002 in Guandu mangrove wetland.

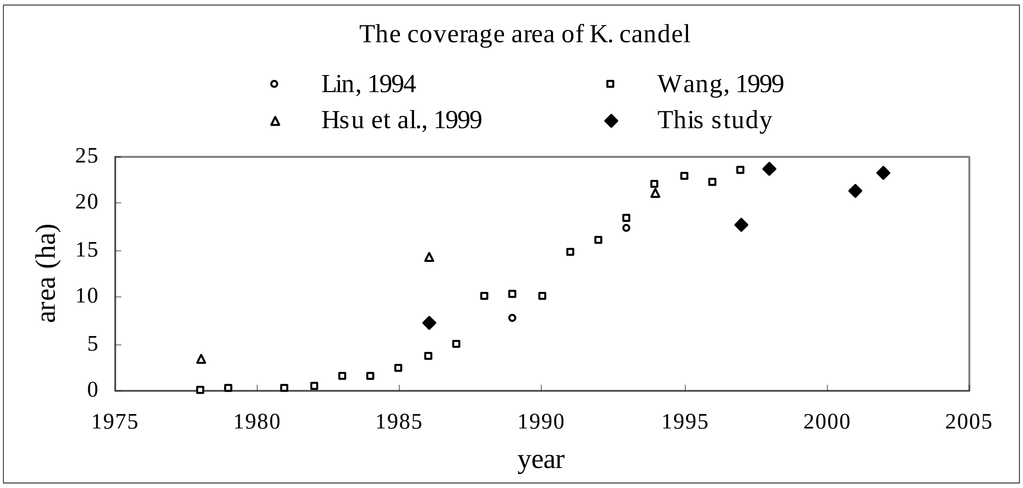

Fig.8 The temporal variation of mangrove coverage area in Guandu mangrove wetland. The results of this study also been compared with literature review.

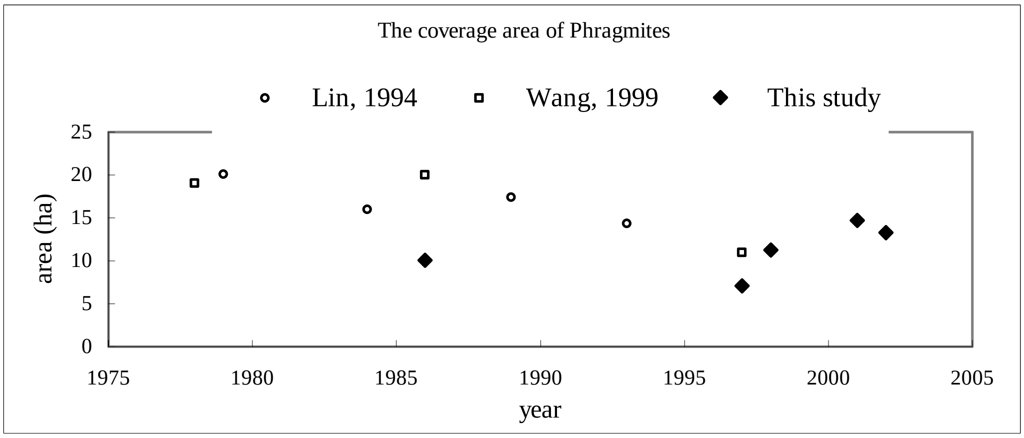

Fig.9 The temporal variation of reed coverage area in Guandu mangrove wetland. The results of this study also been compared with literature review.

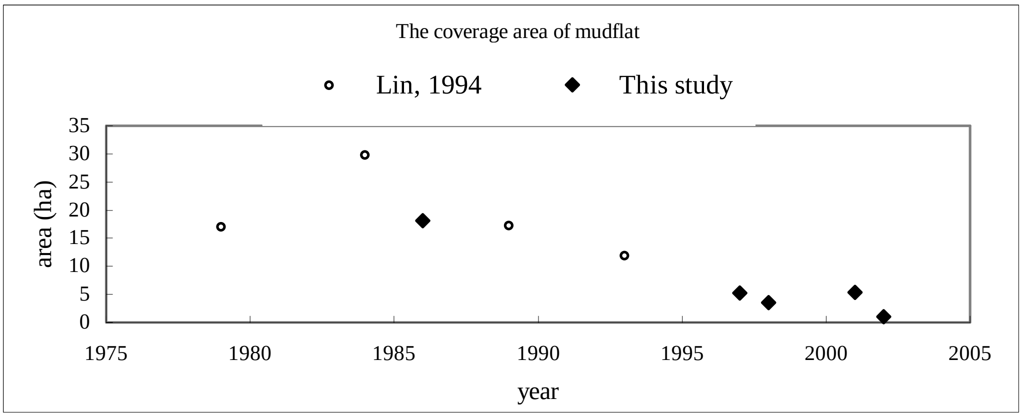

Fig.10 The temporal variation of mudflat coverage area in Guandu mangrove wetland. The results of this study also been compared with literature review.

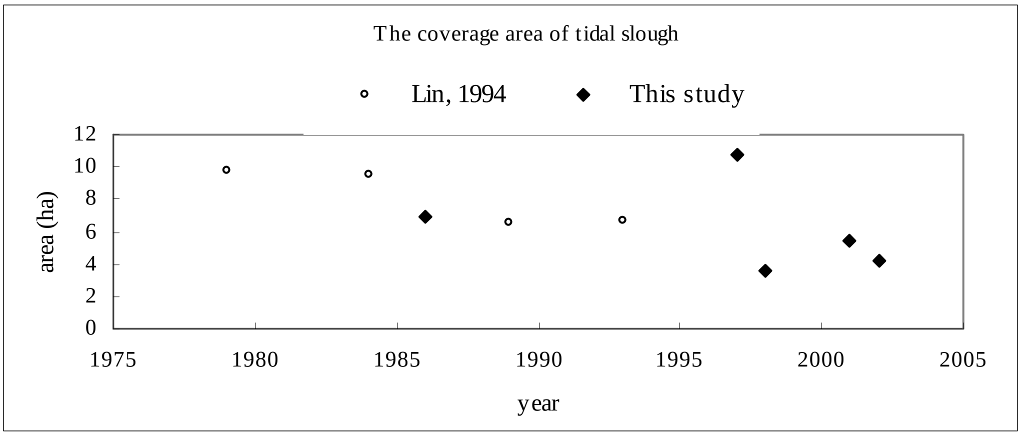

Fig.11 The temporal variation of tidal slough coverage area in Guandu mangrove wetland. The results of this study also been compared with literature review.

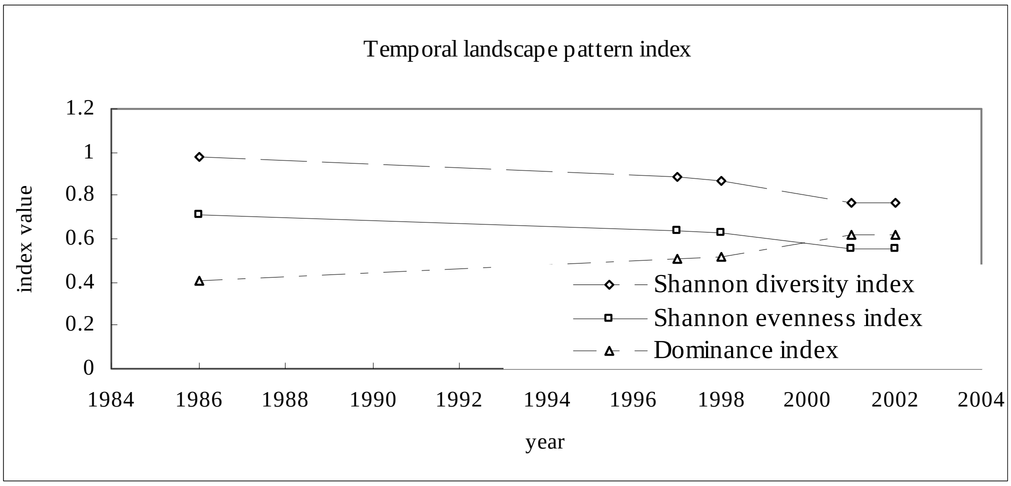

Fig.12 The landscape index variation of Guandu mangrove wetland from 1986 to 2002.

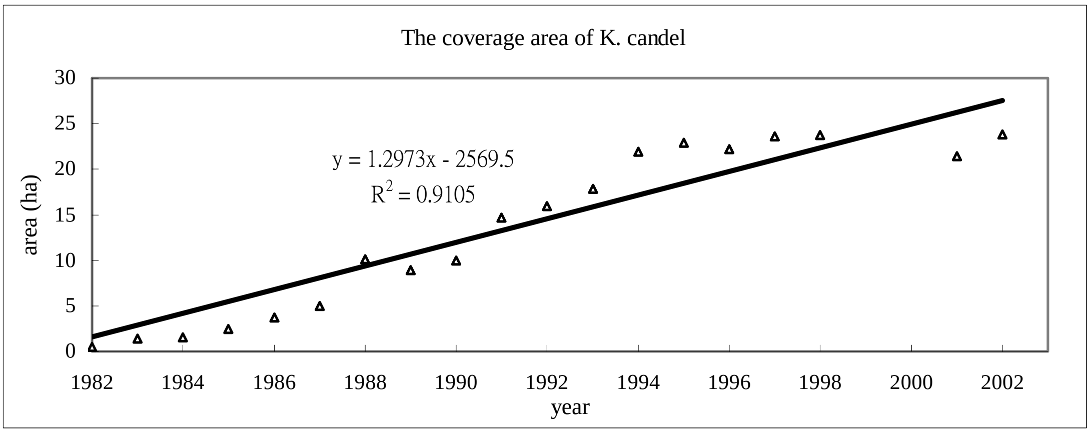

Fig.13 The prediction of mangrove coverage area in Guandu mangrove wetland.

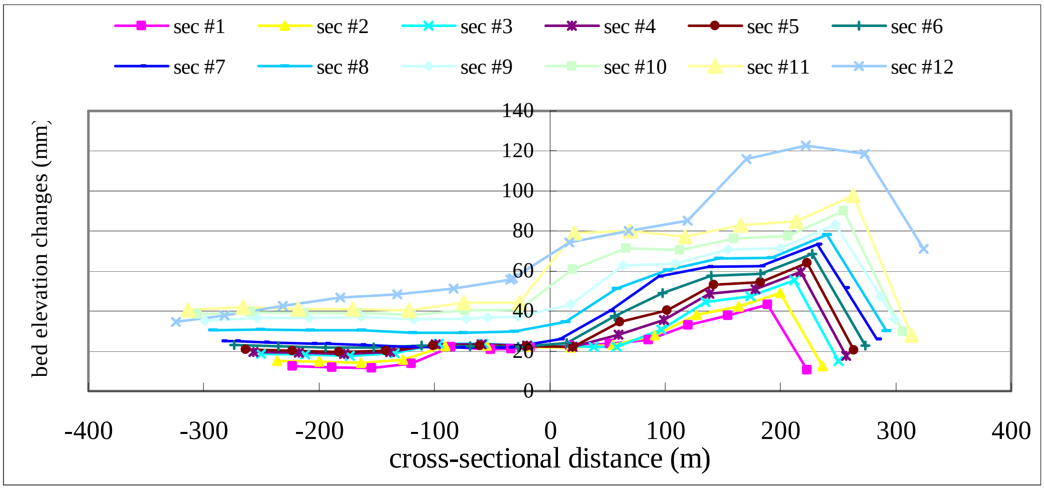

Fig. 14 Spatial variations of the riverbed elevation under a 200-year flood in the Guandu mangrove wetland

Table2 The information of study area of aerial photograph

Study area	**Year**	**Accuracy**
Guandu	1986	0.5m* 0.5m
Guandu	1997	0.5m* 0.5m
Guandu	1998	0.5m* 0.5m
Guandu	2000	0.5m* 0.5m
Guandu	2001	0.5m* 0.5m
Guandu	2002	0.5m* 0.5m

Table2 The accuracy of GIS-based auto-detecting technique

Item	True value (m^2)	Measured value (m^2)	Absolute error (m^2)	Relative error (%)
Mangrove area	285,802	238,184	47,618	16.7

* Absolute error： $\Delta A = A_m - A_t$ ； Relative error： $\delta A(\%) = \frac{\Delta A}{A_t} \times 100\%$

5. References

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