



# Changes in coastal city ecosystem service values based on land use—A case study of Yingkou, China



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## ABSTRACT

The valuation of ecosystem services is intended to facilitate the rational and sustainable utilization of natural resources. However, calculating the values of natural resources is complex, and research is underway in this regard. The change of land use types can reflect the changes in the area of each ecosystem; therefore, in this study, land use changes in Yingkou (located in the south of Liaoning Province and an important port city) over a 10-year period (2004–2014) are assessed using a geographic information systems platform and the 2004, 2009 and 2014 Thematic Mapper remotely sensed images of the area. The Costanza calculation method and classification system are used to estimate changes in the total values of ecosystem services in the Yingkou area from 2004 to 2014 and to investigate the causes of these changes. The “change tendency” of particular ecological communities is calculated using the Variable coefficient, the Gini coefficient, and the Theil index. The results reveal the following: (i) The total value of ecosystem services in the Yingkou area decreased drastically (i.e., from \$2567.60 million to \$2127.26 million, representing a 17.2% decline) between 2004 and 2014. (ii) Aquatic ecosystem services are valued greater than terrestrial services. In Yingkou, a decline in the value of aquatic ecosystem services accounts for 88.6% of the total decrease in ecosystem service value. (iii) Land reclamation in the Yingkou urban area emerges as the primary factor influencing ecosystem service values for the various ecological communities in the region. The ecosystem service value of each ecological community is different, and the differences between the contributions made by the various communities to the total ecosystem services value are increasing over time. (iv) The decline in ecosystem service values in Yingkou is linked to urban development. Following widespread land reclamation, an increase in land area intended for urban construction is associated with a decrease in water area.

## 1. Introduction

“Ecosystem services” refers to the set of environmental conditions and products – important for human survival and development – that an ecosystem can provide while maintaining the integrity of its own ecological processes (Burnett et al., 2006), and humans can gain benefit directly or indirectly from it. Therefore, ecosystem services are the foundation conditions for human survival and development, and are the key natural capital for human production and living. The “coastal zone” refers to the special ecosystem at the transition between ocean, land and atmosphere which, with its abundance of resources and biomass, supports the economic development of coastal areas (Gao and Chen, 2012). However, injudicious development practices and overutilization of coastal resources has led to the destruction of many coastal zone ecosystems, an increase in the fragility of these systems, and an increase

in the frequency of coastal disasters worldwide (Shih and Chiau, 2009). The degree of systematic preservation and protection of coastal zone ecosystems in China is not commensurate with their importance. Coastal nature reserves account for a mere 0.59% of the total Chinese national nature reserve area (Guo et al., 2001). The estimation of a monetary value for coastal zone ecosystem services stands to provide environmental managers with a realistic indication of the ability of the coastal ecosystem to support current land use practices, and represents a foundation for the rational and sustainable utilization of environmental resources (Clark 1992). Any research that contributes to a prevention of coastal zone ecosystem damage is important, and the healthy development of the world’s coastal zones depends on it (Craft et al., 2009).

The study of coastal zone ecosystem functions and services began in the 1900s and has gradually developed as a research focus over

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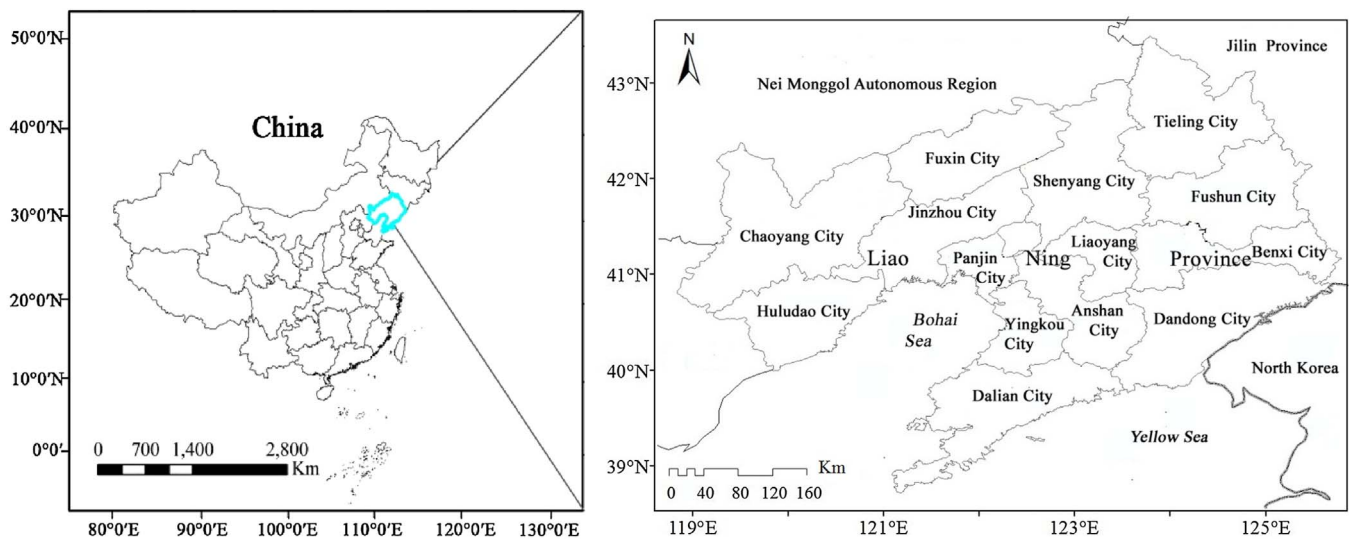


Fig. 1. Location map of research area.

approximately 70 years. Costanza was one of the earliest and most influential pioneers of research around the importance of ecosystems, the classification of ecosystem services and functions, and appropriate principles and methods of global ecosystem assessment. This early work remains a vital reference in the field of ecological research (Gill 2005; Kremen et al., 2007). Up to now, most coastal zone ecosystem research studies began with an analysis of the ecological characteristics and services of the system in question, and an assessment of its health and vulnerability statuses using appropriate indices (Balick and Mendelsohn, 1992; Costanza et al., 2014; Hein et al., 2006; Wilkins 1998). Such assessments then inform discussions regarding the sustainable development of the system, appropriate ecosystem-economic coupling, and the diagnosis of existing coastal ecosystem degradation (Granek et al., 2010; Martínez et al., 2008; Pomeroy 1995; Silow and Mokry, 2010).

In recent years, land use activities such as large-scale land reclamation projects have intensified significantly in the Circum Bohai Sea region. This can be attributed to growing economic development needs and the enhancement of technology, the latter speeding the pace of change in ecosystems. Land reclamation may result in certain economic and social benefits but also endangers the health of the coastal zone ecosystem (Naser 2011). At present, domestic scholars only study the ecosystem service value of the Bohai sea area, and there is little research on the change of ecosystem service value in Yingkou. Compared with previous studies, this paper not only calculates the value of ecosystem services in Yingkou but also analyzes the reasons and the differences for the changes. In addition, Yingkou is an important port city in Northeast China, and its ecological environment has a direct impact on Northeast China. Therefore, the purpose of this study is to analyze the change of ecosystem services values in Yingkou and to explore the main factors affecting the value of ecosystem services.

Yingkou is a city located alongside the Liaodong Bay in the Bohai Sea. The establishment of a new coastal district in Yingkou led to a large area of land being reclaimed from the sea, alleviating the shortage of land in this coastal area (Yim et al., 2005). However, at the same time, the area's ecosystem was damaged, because land reclamation destroyed the original marine ecosystem or wetland ecosystem, and then the underlying surface properties and biodiversity were affected, so the value of its services changed as a result.

Based on the results of previous research, this paper divides the ecosystem in Yingkou into seven ecological communities and nine ecological service types, all of which are considered in the context of the study area. Using remote sensing (RS) and geographic information

systems (GIS) to calculate the areal extents of discrete ecological communities, this study systematically investigates changes to ecosystem service values in Yingkou between 2004 and 2014. The aim of the research is to calculate ecosystem service values and evaluate the impacts of urban sprawl on ecosystem services; the significance is that the ecosystem can provide better services for humans.

## 2. Materials and methods

### 2.1. Overview of the study area

Yingkou City (39°55'–40°56' N, 121°56'–123°02' E) is located in the south of Liaoning Province, The city's east-west span is approximately 50 km, with a north-south length of approximately 112 km, and its total land area is more than 5000 km<sup>2</sup>. Yingkou is an important port city in Liaoning province. It lies on the east side of the Bohai, which is China's inland sea and is surrounded by the Liaodong peninsula, Shandong peninsula and the North China plain. The Bohai Sea and Yellow Sea are interlinked, and the Bohai Sea is the main seaport serving Northeast China, North China, Northwest and parts of East China. It has three bays, with Liaodong bay located in the north. In a narrow sense, the Circum Bohai Sea region refers to the Liaodong peninsula, Shandong peninsula, coastal economic belt of Circum Bohai Sea, meanwhile extending to Shanxi province, Liaoning province, Shandong province and the mid-east of Inner Mongolia (Fig. 1).

Yingkou city is located in Liaodong Bay (Steenveeld et al., 2011). The elevation of Yingkou is relatively low, mostly between 0 and 1000 m (Fig. 2). Yingkou falls within a maritime temperate monsoon climate zone. Yingkou has a resident population of approximately 2.4 million people. In recent years, rapid economic development in the area has led to the designation of the Bohai Sea region as one of the three most economically developed regions in China (Roso 2007), along with the Pearl River and Yangtze River deltas (Dai et al., 2014). Between 2004 and 2014, the total GDP for the Bohai Sea region increased by \$4493.3 million to \$22460.8 million-representing an increase of approximately 400%. As one of the main urban areas near the Bohai Sea, Yingkou is an important port city that connects other industrial towns, such as Shenyang and Anshan. With the rapid development of Yingkou and the establishment of new coastal developments, various land-use types have changed significantly over the past decade.

### 2.2. Data sources

The land use data used in this study were obtained from remote

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