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Short communication

Assessment of coastal zone sustainable development: A case study of Yantai, China

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ABSTRACT

The assessment of sustainable development is a challenging task as its measuring is rather complex without a mature framework. In this paper, as a case study, a coastal city of China-Yantai was assessed for sustainable development in the period from 1998 to 2007. We used a methodological framework based on 36 indicators and three composite indices from the dimensions of environment, economy and society subsystems. The assessment results indicated that Yantai was almost in the potentially unsustainable development or intermediate sustainable development, except in 1998 and in 2007. Accordingly, the progress of sustainable development was divided into two stages in the light of the relative changes of three subsystems. Some relevant issues, such as natural capital, GPI vs. GDP in sustainable development assessment were discussed. Finally, an uncertainty analysis was also given in the assessment. In conclusion, the sustainable development in Yantai had experienced a shift from environment-based to social–economic-based in the past 10 years.

1. Introduction

As a result of the rapid development of industrialization and urbanization, the coastal zone in China showed a rapid change during the past few decades. In particular, the issues about coastal ecology and environment had brought about a serious challenge for coastal zone sustainable development (CZSD) (Chen and Chen, 2002; Huang et al., 2008). Ecological sustainability has also been put forward due to the foreseeable threats represented by a serious worldwide environmental degradation, this gives rise to an increasing awareness of the profound impact of humans on the functioning of marine ecosystems (Marques et al., 2009).

According to the definition of sustainable development (Brundtland, 1987), the sustainable development of coastal zone not only meets the increasing demand, but also protects ecology and environment, without prejudice to future generations access to adequate food security. However, the concept of sustainable development is a rather vague nonoperational definition, researchers from different disciplines attempt to understand and define more precisely the meaning of sustainable development, which requires a suitable quantification in socio-economic, cultural and scientific terms (Marques et al., 2009). In order to provide a scientific basis for decision-makers, therefore, it is very necessary to comprehensively assess the status of regional development with regard to economy, resources and environment (UNDP, 2007). Although a lot of effort had been done by the Government and the non-governmental organizations (Alves et al., 2007; Nader et al., 2008; UNDP, 1990), the methodology of monitoring and evaluation was still in issues. Meanwhile, people had investigated the sustainable development from different perspectives, such as the separate indicators and composite index (Krajnc and Glavic, 2005; López-Ridaura et al., 2002; Shi et al., 2004; Singh et al., 2007, 2009; Xiong, 2007). But a versatile method was still an open question. A Pilot Program was established in 2003 under the auspice of intergovernmental Oceanographic Commission (IOC) of UNESCO to promote the development and use of ICOM indicators (IOC and Heileman, 2008), by developing, selecting, and applying indicators to measure, evaluate, and report on the progress and outcomes of integrated coastal and ocean management initiatives (DEDUCE, 2006, 2007). The EU ICZM Expert group in November 2004 also called for an integrated approach to monitor and measure the sustainable development of the coastal zone (Breton et al., 2006). DEDUCE (Développement Durable des Zones Côtières Européennes), supported by the Interreg III-south Community Initiative Programme, gave a core set of

Abbreviations: CZSD, coastal zone sustainable development; ENS, environmental subsystem; SO, Ssocial subsystem; ECS, economic subsystem; DCZ, integrated coordinate degree; SCZ, developmental sustainability; KSD, sustainable development degree; GDP, gross domestic production; GPI, genuine progress indicator.

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27 indicators, composed of 46 measurements, to monitor sustainable development of the coastal zone by means of environmental, social and economic indicators for measuring the degree of sustainable development of the European coastal zones (Breton et al., 2006; DEDUCE, 2006). In Europe, besides, Belgium had pioneered in implementing a set of 20 indicators for the coast through developing an interactive website, a publication 'the coastal compasses, a SWOT-analyses and evaluation of the indicators, etc. (Hannelorel et al., 2007)'.

Although there have been proposed many principles and theoretical frameworks about sustainable development assessment, cases studies are still scarce. This paper is such an interesting study that a detailed analysis of sustainable development of a coastal city of China will be presented. The methodology was introduced to assess the coastal sustainable development progress, which designed a framework of 36 indicators represent environmental subsystem (ENS), social subsystem (SOS) and economic subsystem (ECS). As an example, the method was extended to analyze the regional development of Yantai as a case for one decade (1998–2007) by examining economic performance and considering various eco-environmental factors.

2. Materials and methods

2.1. Study area

Yantai is a coastal city, which is located in the middle part of Jiaodong peninsula, the largest peninsula in China (see Fig. 1 for more details). The coastline is 909 km (702.5 km mainland coastline and 206.5 km island coastline) and the coastal zone in Yantai amounts to 2100 km^2. Since the implementation of the reform and opening up policy, Yantai is one of the most rapid developed areas in China.

2.2. Data and methods

2.2.1. Data sources

Data collection is an important work before operating an assessment. The good indicators should be easy to be understood, sensitive to changes and relevant among themselves (OECD, 2008; UNDP, 2007). Especially, they will be evaluated to be scientifically sound and statistically valid, capable of providing quantitative information. According the designed index system (Appendix A), the data collected was ranging from socio-economic (population, ports, GDP, etc.) to environmental data (arable land, SO_2 emissions, forest cover, etc.). That is, the data of population, social and economic mainly came from local public statistical administration, while the environmental data came from local environment, forest, sea bureaus administrations. In total, the number of final dataset was consisted of more than 400 including information of eco-society and resource environment in the period of 1998–2007.

2.2.2. Index system and models

The index system framework can be seen from Appendix A, which consisted of 36 indicators (I_1–I_{36}). I_j is the variable from the raw data normalized with max–min method (Salvati and Zitti, 2009; UNDP, 2007). Among them, six indicators were grouped into a set called thematic index (B_1, B_2, B_3, B_4, B_5 and B_6). B_1, B_2 and B_3 were designed to represent the coordination degree of three subsystems, while B_4, B_5, and B_6 represented the sustainability of three subsystems. And three models that represent integrated coordinate degree (D_{CZ}), developmental sustainability (S_{CZ}), and sustainable development degree (K_{SD}) were also given (Niu, 1999; Xiong, 2007). D_{CZ} measures the development level and coordination degree of ENS, SOS, and ECS, S_{CZ} measures the size of sustainability of three subsystems, and K_{SD} comprehensively measures the development

Fig. 1. Map of Yantai, China, Its administrative area includes five districts (Zhifu, Fushan, Laishan, Muping and Economic Development Zone), seven county-city (Laizhou, Zhaoyuan, Longkou, Penglai, Laiyang, Haiyang, and Qixia), and one island county (Changdao).