Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

A multi-scale integrated modeling framework to measure comprehensive impact of coastal reclamation activities in Yellow River estuary, China

Yan Xu[a], Yanpeng Cai[a,b,c,*], Tao Sun[a], Qian Tan[d]

[a] State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University, Beijing 100875, China
[b] Institute for Energy, Environment and Sustainable Communities, University of Regina, 120, 2 Research Drive, Regina, Saskatchewan S4S 7H9, Canada
[c] Beijing Engineering Research Center for Watershed Environmental Restoration & Integrated Ecological Regulation, School of Environment, Beijing Normal University, Beijing 100875, China
[d] College of Water Resources and Civil Engineering, China Agricultural University, 100085, China

ARTICLE INFO

Keywords:
Modeling framework
Coastal reclamation
DPSIR
Indicators system
Yellow River estuary

ABSTRACT

In this paper, an improved multi-scale integrated modeling framework has been established to evaluate coastal reclamation intensity (CRI). About 7 indicators are considered, including ecological degradation intensity (EDI), hydrodynamic disturbance (IHD), engineering types, water quality, economic investment, population growth, and reclaimed land area. Meanwhile, an integrated framework enhanced methods in terms of (a) measuring intensity of ecological degradation process under multi-scale impact, (b) developing the indicator system of CRI, and discussing the driving forces and trends of coastal reclamation, (c) determining fuzzy preference relations of weight and calculating the specific value of CRI with the case study areas of Yellow River estuary from 2000 to 2015. As the result, the CRI has been expanded unceasingly in recent years. The total growth rate from 2000 to 2015 is about 37.97%. It is concluded that CRI has climbed to a higher intensity level in resent 15 years.

1. Introduction

For centuries, over 40% of the coastal region was heavily affected by anthropogenic disturbances (Halpern et al., 2008; Cai et al., 2009a,b, 2010, 2011; Tan et al., 2011). The coastal region in China covers 13% of the nation's territory, hosts 43.5% of the nation's population, and contributes 60.8% of the national gross domestic product (GDP) (Wang et al., 2014). In order to react to the appearing problems of population expansion and land use demand, coastal reclamation engineering, consisting of the embanking and filling of coastal wetlands and construction of barriers, seawall, levees, and dikes along the coastline, has becoming a popular and effective way with rapid urbanization and industrialization process. These types of engineering can result in degradation of coastal ecosystem and related environmental impacts in coastal areas (Yang et al., 2016). Coastal reclamation engineering has thus attracting increasing attentions on account of the modification of species habitats, hydrodynamic conditions, sediment transportation, and ecological landscape, as well as cascades of consequential impacts upon environmental quality, coastal wetlands health and ecological safety (Cheong et al., 2013; Pendleton et al., 2012; Stefano et al., 2015). Particularly, estuarine region is located in the intersection region between river and marine ecosystems, which will cause current mixing of runoff and tidal current. The continuous mixing process has created vulnerable environmental characteristic and unique biological composition in river estuary. Therefore, coastal reclamation engineering can easily cause intensive degradation by changing original structures and functions of estuarine ecosystem completely, potentially leading to soil shrinkage, coastline recession, as well as the occurrence of extreme environmental events in river estuaries areas (Shen et al., 2016; Shi et al., 2009). On the other hand, hydrodynamic disturbance caused by excessive reclamation engineering can produce decreasing of channel flow outside the port in the process of long-time operation, reducing number of creatures near the coastal shoreline and deteriorating of water quality (Maren et al., 2016). Accordingly, coastal reclamation activities have generated comprehensive negative effects on the estuary ecosystem, which has became a huge problem under extremely severe pressure and threat of ecological degradation in estuarine region, significantly increasing the complexity and uncertainty of relevant coastal management. Therefore, it has been causing great concern in understanding the comprehensive effect of ecological degradation and hydrodynamic disturbance process under coastal engineering pressure. Since the detail of quantitative method called coastal reclamation hydrodynamic disturbance (CRHD) to describe hydrodynamic disturbance has been established before in my previous study (Xu et al., 2017 in press), here we mainly talk about the method to measure ecological degradation and calculate comprehensive

* Corresponding author at: State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University, Beijing 100875, China.
E-mail address: yanpeng.cai@bnu.edu.cn (Y. Cai).

http://dx.doi.org/10.1016/j.marpolbul.2017.05.065
Received 9 January 2017; Received in revised form 16 May 2017; Accepted 27 May 2017
0025-326X/

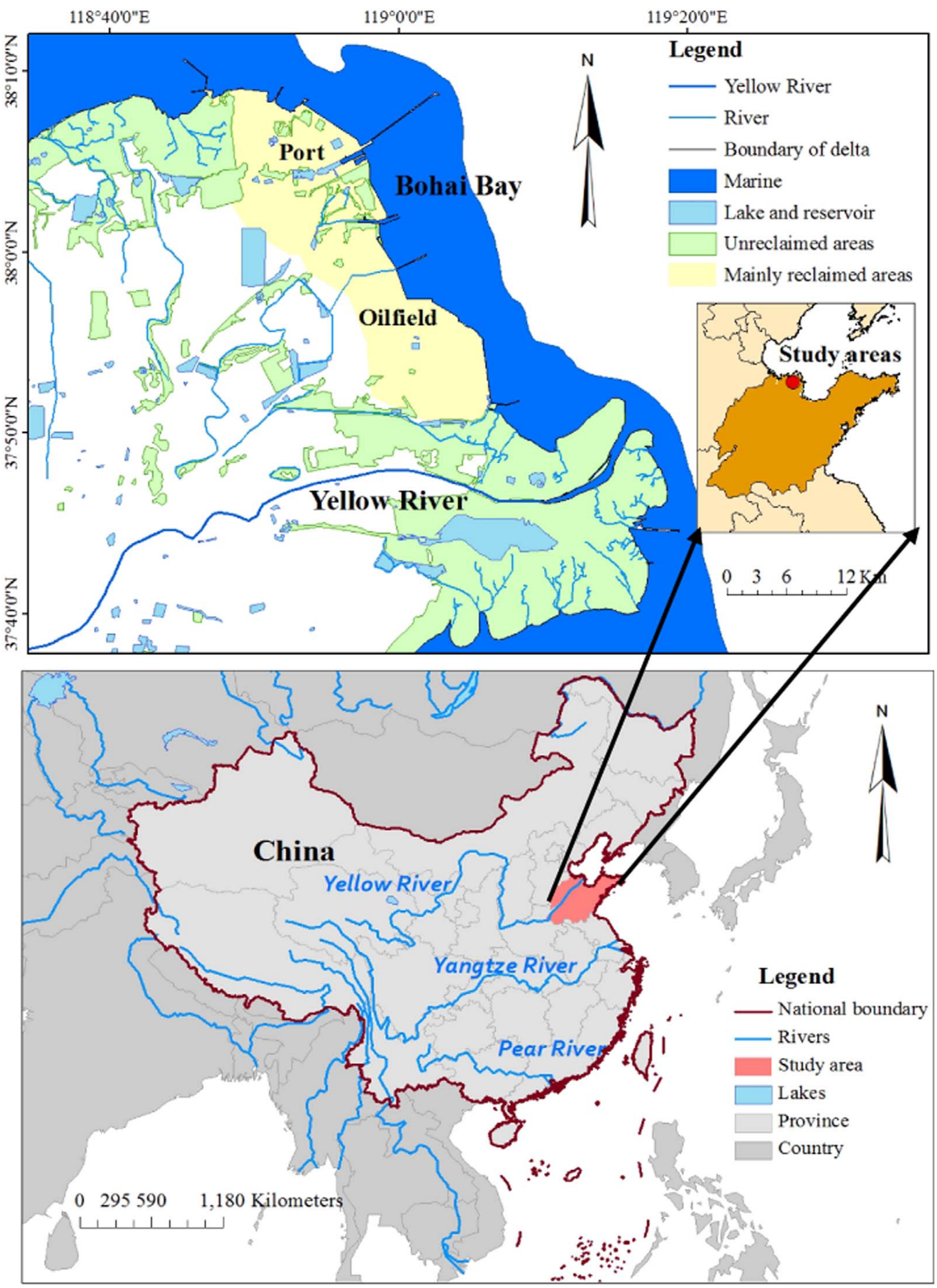

Fig. 1. Location map of study area in Yellow River estuary.

indicators of coastal reclamation intensity.

Ecological degradation is a slow process of evolution, which can introduce loss of ecosystem service, damage of biodiversity, and fragmentation of species habitat (Heinrichs et al., 2016; Kelsic et al., 2015; Sutton et al., 2016). Especially for coastal reclamation activities as one important disturbance factor will induce severe ecological degradation in coastal region (Sun et al., 2015). Several literatures had considered the impacts of coastal reclamation engineering on the ecological degradation (Gibson et al., 2007; Valipour et al., 2015), which discussed the ecological degradation process, and the indicators to describe the characterization of ecological degradation, such as diversity of benthic organisms (Ito et al., 2016), coastal vegetation habitat (Mccain et al., 2016) or ecosystem service value (Caffey et al., 2014; Ghermandi et al., 2016). Furthermore, several models have applied to focus on the change of land and habitat by using multi-temporal Landsat remote sensing data, such as PSR (Jin et al., 2016) to assess ecological risks and feedback in engineering activities; system dynamics model (Zhang et al., 2014) to calculate the vitality and resilience in ecosystem under anthropogenic disturbance; and multi-parameter indicator system (Ma et al., 2012; Shi et al., 2016) to establish correlation among different indicators. A qualitative "driver-response" model was built to discuss the relationship between coastal reclamation activities and related ecological environment (Bergström et al., 2016). According to preliminary researches, the coastal reclamation intensity was defined to quantify the area (ha) of land reclamation per kilometer of shoreline per year in the coastal region based on the specific year period (Tian