Ecological Indicators 77 (2017) 48–58

Contents lists available at ScienceDirect

Ecological Indicators

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

Original Articles

Economic values and dominant providers of key ecosystem services of wetlands in Beijing, China

Biao Zhang[a,*], Yun-ting Shi[a,b,1], Jun-hui Liu[c,2], Jie Xu[a,b,1], Gao-di Xie[a,3]

[a] Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Science, Beijing 100101, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] Chinese Research Academy of Environmental Sciences, Beijing 100012, China

ARTICLE INFO

Article history:
Received 22 August 2016
Received in revised form 4 February 2017
Accepted 6 February 2017

Keywords:
Wetland
Ecosystem service
Economic value
Dominant contributor
Beijing

ABSTRACT

This study estimates the economic values of and the dominant contributors to five key ecosystem services of wetlands in Beijing, by using the wetland inventory data in 2014 and economic valuation methods. Results indicate that the 51,434 ha of wetlands in Beijing annually provide 2.07 billion m^3 of flood regulation, 944.01 million m^3 of water provision, 42,154 tons of chemical oxygen demand (COD) purification, 3.03 PJ of heat absorption, and 9587 ha of habitat. Their economic values are estimated to be 15.89 billion RMB, 1.19 billion RMB, 169 million RMB, 421 million RMB, and 1.08 billion RMB in 2014 (RMB: Chinese currency, US$1 = RMB 6.14), respectively. The total values of five key wetland ecosystem services reach 18.76 billion RMB. In addition, the reservoir and river wetlands in Miyun, Yanqing, Fangshan, Huairou, and Mentougou Districts contribute 78% of key ecosystem services, whereas the urban wetlands in Xicheng, Dongcheng, Haidian, Chaoyang, and Tongzhou Districts more conveniently serve densely local people, hence they should be given particular attentions. In this paper, we develop the valuation methods of wetland ecosystem services, and recommend diversified strategies, regulations, and programs to protect the remaining wetlands in Beijing. This work can also provide a reference for the valuating of wetland ecosystem services for other urban-rural areas.

1. Introduction

Wetlands are among the most productive natural ecosystems in the world. They provide a wide range of benefits to humankind, including regulating climate and the global nitrogen cycle, providing recreational and cultural services, reducing flood peaks, purifying water, and providing habitat for wildlife (Keddy, 2010; LePage, 2011; Sharma et al., 2015). However, current market mechanisms neither capture these benefits nor set a price to them according to their true scarcity value, this has led to ill-informed management and development decisions that contribute to the continued rapid loss, conversion, and degradation of wetlands. The Millennium Ecosystem Assessment (2005) reported that over 50% of the area of certain wetland types was lost during the 20th century in Australia, New Zealand, Europe, and North America. Davidson (2014) estimated that wetland losses in the 20th century were 64%–71% based on the assessments of 189 wetlands. In the Lower Paraná River Delta (163,000 ha) in Argentina, one-third of the freshwater marsh was replaced by pasture (70%) and forest (18%) from 1999 to 2013 (Sica et al., 2016). Similarly, the wetlands in China presented rapid loss or degradation tendency. From 1978 to 2008, the wetland area in China decreased by approximately 33%, and the rate of wetland loss decreased from 5523 km^2/a in 1978 to 831 km^2/a in 2008 (Niu et al., 2012). The wetlands in urban regions are frequently threatened by development during the process of rapid urbanization. The wetland areas in Shanghai were reduced from 808,036 ha in 1987 to 655,833 ha in 2007 because of the rapid expansion of industrial lands, residential areas, and commercial crop planting areas (Yin et al., 2015). Given that the trend of wetland loss and degradation still continues worldwide (Gardner et al., 2015), quantifying these wetland ecosystem services and highlighting their dominant contributors are important to develop sustainable wetland management strategies.

* Corresponding author.
E-mail addresses: zhangbiao@igsnrr.ac.cn, zhangb8010@126.com (B. Zhang), shiyt.16s@igsnrr.ac.cn (Y.-t. Shi), liujh@craes.org.cn (J.-h. Liu), xuj.13s@igsnrr.ac.cn (J. Xu), xiegd@igsnrr.ac.cn (G.-d. Xie).
[1] Present address: University of Chinese Academy of Sciences, Beijing 100049, China.
[2] Present address: Chinese Research Academy of Environmental Sciences, Beijing 100012, China.
[3] Present address: Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Science, Beijing 100101, China.

http://dx.doi.org/10.1016/j.ecolind.2017.02.005
1470-160X/

The valuation of ecosystem services can provide a direct comparison between alternative land use options and facilitate a cost–benefit analysis of related policies (McPherson et al., 1997; Tyrväinen and Miettinen, 2000; Jim and Chen, 2009). Costanza et al. (2014) estimated the loss of global eco-services at US$4.3–US$20.2 trillion/year based on the updated unit ecosystem service values and land use change estimates between 1997 and 2011; moreover, the value of wetland ecosystem services decreased at US$9.9 trillion/year. Based on 1432 economic value estimates of 379 distinct wetlands from 50 countries, Chaikumbung et al. (2016) concluded that wetland size negatively affected wetland value per hectare per annum, and urban wetlands and marine wetlands more valuable than other types of wetlands. Moreover, they found that wetlands that provided water regulation and habitat biodiversity were more valuable than those used for recreation. The Koshi Tappu Wildlife Reserve in Nepal generates an annual economic benefit of US$16 million (Sharma et al., 2015). However, the high levels of poverty in the buffer zone communities and the limited alternative livelihood options have accelerated the degradation of vital services. Accordingly, Sharma et al. (2015) recommended that the ecosystem services provided by the reserve should be recognized as an integral part of a strategy that would ensure a sound policy and institutional mechanisms by using a holistic approach. In China, a magnitude of case studies on the valuation of wetland ecosystem services (Cui, 2001; Mao et al., 2007; Yang et al., 2008; Zhang et al., 2014a; Song et al., 2015; Cui et al., 2016) have been conducted. The economic value losses from wetland area changes have also attracted considerable concern (Zhang et al., 2009a; Zhang et al., 2009b; Meng et al., 2012a; Yin et al., 2015). However, few studies have elucidated the regional variations and dominant contributors of wetland ecosystem services. Therefore, this study attempts to quantify the contributions of different wetland types and districts to ecosystem services, and to provide a baseline for diverse and differentiated wetland utilization and protection policies.

As the capital of China, Beijing has undergone rapid urbanization, and placed its abundant urban wetlands in danger (Zhang et al., 2015a). The wetland area in Beijing declined from 68,492 ha in 1978 to 31,416 ha in 2005, with a 54% decreasing trend (Gu et al., 2010). After 2005, the wetland area in Beijing slightly increased because of the implementation of the "Green Olympic" projects; consequently, the wetland landscape patterns significantly changed (Gong et al., 2011). However, only a few studies have estimated the ecological benefits of wetland ecosystem services in Beijing for sustainable wetland policies. Sun et al. (2012) investigated the cooling effect of urban wetlands in Beijing and concluded that the shape and location of wetlands significantly influenced temperature difference between a wetland and its surrounding landscapes. However, they did not estimate the economic value of the wetland cooling effect nor prove the importance of urban wetland protection to human well-being. Although Yang et al. (2013) calculated the economic values of wetland ecosystem services such as carbon dioxide sequestration, oxygen release, and water evapotranspiration in Beijing, which represented only a fraction of wetland ecosystem services, they neglected the regional variations of and the dominant contributors to these services. Miao et al. (2013) established the importance order of wetlands located in different districts of Beijing via a comprehensive assessment index system; however, they did not valuate wetland ecosystem services.

The main objective of this paper is to estimate the economic values of key ecosystem services provided by the wetlands in Beijing, and to elucidate their dominant contributors and respective contributions. Accordingly, this study will provide a reference point for diverse wetland protection policies in Beijing and other regions with a similar problem. The rest of this paper is organized as follows. Section 2 provides a background of the study area, data, and evaluation method. The results are discussed in Section 3. The findings and conclusion are presented in Section 4.

2. Materials and methods

2.1. Study area

Beijing is located in North China at 39°38′–41°50′ N and occupies a total area of 16,410 km^2. Its administrative area comprises 16 districts that are divided into three zones: the urban area (Dongcheng, Xicheng, Chaoyang, Fengtai, Haidian, and Shijingshan), the suburban area (Changping, Daxing, Fangshan, Tongzhou, and Shunyi), and the outer suburban area (Huairou, Mentougou, Pinggu, Miyun, and Yanqing). The total population exceeded 21.51 million and the average population density reached 1311 people/km^2 by the end of 2014 (Beijing Municipal Statistical Bureau, 2015). However, considerable gradient differences occur in population density from the urban area to the suburban area and the outer suburban area. For example, population density reached 25,767 people/km^2 in Xicheng and only 158 people/km^2 in Yanqing. The built-up area in Beijing expanded from 109 km^2 in 1949 to 1386 km^2 in 2014 (National Bureau of Statistics of China, 2014).

Beijing is situated in the temperate climatic zone, with an average annual temperature of 14.1 °Cand annual precipitation of 461.5 mm (Beijing Municipal Statistical Bureau, 2015). Owing to global climate change, Beijing has been suffering from a gradual decline in annual precipitation since 1950 (Yue, 2007). Beijing has approximately 160 rivers that flow into 5 river systems, namely, Beiyun River, Daqing River, Yongding River, Jiyun River, and Chaobai River. In addition, 85 reservoirs are found in the northern and western areas of Beijing, with a total storage capacity of 9.4 billion m^3. The Miyun Reservoir has the largest area among 18 reservoirs and is the primary source of drinking water for Beijing's population. The Yeyahu Wetland has the largest area among the wetland nature reserves in North China and is the only wetland bird reserve in Beijing. In addition, a wide distribution of pond wetlands and paddy wetlands are found in Beijing.

2.2. Data

The present study adopts the wetlands survey data generated by the Beijing Municipal Bureau of Landscape and Forestry by applying 3S technologies, i.e., geographic information system (GIS), remote sensing, and the Global Positioning System, and by conducting field investigations. The bureau surveyed all the wetlands in Beijing, including the lake larger than 8 ha, marsh, artificial wetland, and river longer than 5 km and wider than 10 m, based on the Ramsar Convention and the National Wetland Resources Technical Specification of the Investigation (for trial implementation). The bureau investigated 1916 wetland patches, including 534 river patches, 121 reservoir patches, 75 park patches, 6 marsh patches, 1065 pond patches, and 115 paddy patches. It collected patch information such as spatial location (latitude and longitude), area, wetland type, and numbers of plant and animal species. The Beijing Forestry Survey and Design Institute assessed the quality of the survey data, which achieved a high rate of 95%. These spatial and attribute data are stored in the wetland resource database of the web-based GIS and managed by the Beijing Forestry Survey and Design Institute.

As indicated in the survey data,[5] the wetland area in Beijing reached 51,434 ha in 2014, with 46% natural wetlands and 54% artificial wetlands. River wetland and reservoir wetland constituted 49.56% and 30.55% of the total wetland area, whereas pond wet-

[5] http://www.bjyl.gov.cn/zwgk/tjxx/201510/t20151012_160552.html.