Acta Ecologica Sinica 37 (2017) 79–84

Contents lists available at ScienceDirect

Acta Ecologica Sinica

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

Dynamic assessment of the value of vegetation carbon fixation and oxygen release services in Qinghai Lake basin

Tao Zhang, Guangchao Cao *, Shengkui Cao, Xiaoge Zhang, Jing Zhang, Guangzhao Han

[a] College of Life and Geographical Science, Qinghai Normal University, Xining 810008, China
[b] Qinghai Province Key Laboratory of Physical Geography and Environmental Process, Xining 810008, China

ARTICLE INFO

Article history:
Received 21 October 2015
Received in revised form 18 December 2015
Accepted 21 May 2016

Keywords:
Vegetation carbon fixation
Vegetation oxygen release
Spatial-temporal dynamics
Qinghai Lake Basin

ABSTRACT

Studies on ecosystem service function have an important significance for analyzing and understanding global warming. With the introduction of geographic information system (GIS) and remote sensing (RS) technologies for the evaluation of ecosystem service function, the scope for analysis has been widening. Increasing number of researchers use these technologies to quantify the value of ecosystem service functions and reveal their spatial-temporal variability. By using the data for the interpretation of five RS images and net primary productivity (NPP) in Qinghai Lake basin, we assessed the value of vegetation carbon fixation and oxygen release services and revealed their dynamic variation in this basin. The result suggested that the average values of vegetation carbon fixation and oxygen release services in Qinghai Lake basin between 1987 and 2010 were spatially distributed in a ring shape around the Qinghai Lake and decreased from southeastern to the north and northwestern regions; the northwestern areas had the lowest value. The vegetation carbon fixation value between 1987 and 2010 was on an average 28.87×10^8 yuan/a in Qinghai Lake basin, whereas the oxygen release value was 64.41×10^8 yuan/a. Alpine meadow ecosystem showed the highest value of vegetation carbon fixation and oxygen release services function in Qinghai Lake basin, with average values of 18.28×10^8 yuan/a and 40.79×10^8 yuan/a, respectively, followed by those of temperate steppe and sparse vegetation. The vegetation carbon fixation and oxygen release values in Qinghai Lake basin gradually increased from 1987 to 2010, with the maximum value in 2010. By the end of 2010, the values increased by 7.19×10^8 yuan and 16.04×10^8 yuan, respectively. The values slightly decreased in barren land, lakeside marsh, river valley swamp, and sandy areas, but increased to different degrees in other ecosystems. Among them, the largest increase was noted in alpine meadow (4.38×10^8 yuan and 9.78×10^8 yuan, respectively), followed by those in temperate steppe with increased values of 1.12×10^8 yuan and 2.49×10^8 yuan, respectively.

1. Introduction

Since the industrial revolution, the global appeared a climate change characteristic by global warming, which have a serious threat to human survival, global warming has become the most serious challenge to the mankind; mitigate greenhouse gas emissions, protect the environment have become the focus of the international community attention. Different ecosystems absorb the CO_2 in the air, produce glucose and other carbohydrates and release O_2 through the photosynthesis of green plants, maintain the dynamic equilibrium of the CO_2 and O_2 in the atmosphere; this ecosystem carbon fixation and oxygen release services function have a big meaning to regulate the global carbon balance, mitigation concentrations of the CO_2 and other greenhouse gas in the atmosphere and stabilize global climate balance [1–4].

Carbon fixation and oxygen release services function assessment is an important part of the ecosystem service assessment; many scholars complete it in the process of the ecosystem service assessment [5–8]. Costanza is the first man who give a scientific define to the principles and methods of the global ecosystem service assessment in 1997 [2]; Ouyang completed the first comprehensive assessment to Chinese terrestrial ecosystem service [9]. Then many scholars evaluate the ecosystem service in many different regions [10–12]. Among them, Xie was the first man who completed the comprehensive assessment to the ecosystem service in Tibetan Plateau [13]; Lu completed the assessment of Tibetan Plateau ecosystem service function value in 2000 [14]. Yu using the RS and GIS technology for evaluating seasonal dynamic of the grassland ecosystem service function in Tibetan Plateau [15]; Liu completed the assessment of the interaction mechanism of alpine meadow ecosystem service function in Tibetan Plateau [16]. But many studies are

* Corresponding author at: College of Life and Geographical Science, Qinghai Normal University, Xining 810008, China.
E-mail address: caoguangchao@qhnu.edu.cn (G. Cao).

http://dx.doi.org/10.1016/j.chnaes.2016.12.005
1872-2032/

mainly static function assessment focus on few vegetation types such as the wetlands, meadows based on a single year land use or vegetation type, rare studies on ecosystem service spatial-temporal dynamics [17–19].

Qinghai Lake is the Chinese largest inland saltwater lake plateau, located in the intersection among the alpine region of Qinghai-Tibet plateau, the northwestern arid region and the eastern monsoon region, and the most important climate regulator of the region. It is an important water body maintaining ecological security in the northeastern of Tibetan plateau, and natural barrier preventing the western desertification from spreading to the eastern region, have a profound impact on the sources of rivers, the ecological environment of the Qaidam basin the Huangshui river valley [20–21].

Aiming at the situation of rare dynamic evaluation of carbon fixation and oxygen release services function in Qinghai Lake basin [22–23], the study using remote sensing images for a detail visual interpretation and classification, extraction different vegetation type in Qinghai Lake Basin, combining spatial NPP, for the first time complete the scientific assessment on long time scale of carbon fixation and oxygen release services value in Qinghai Lake Basin, and analyze the spatial-temporal dynamics.

2. Materials and methods

2.1. Data and methods

2.1.1. Study area

Qinghai Lake basin (36°15′N-38°20′N, 97°50′E-101°20′E) located in the northeast of Qinghai-Tibet Plateau, an area of about 29,646 km^2, elevation ranges from 3164 m to 5279 m, lying northwest to southeast, is a closed inland basin surrounded by mountains. The research area is a typical plateau continental climate characterized of dry, cold and windy. Its multi-year average temperature is −0.7 °C. the multi-year average precipitation is 379.09 mm [24–25]. Vegetation types in the study area are mainly alpine meadow, temperate steppes, swamps and shrubs.

2.2. Data and methods

2.2.1. Data source

The remote sensing data using for visual interpretation in this paper are Landsat remote sensing image data in summer of 1987, 1995, 2000, 2005 and 2010 years; LTDR provide AVHRR-NDVI dataset and NASA (http://ladsweb.nascom.nasa.gov/data/search.html) provide MODIS09A1 and MODIS15A2 datasets; National land cover data was provided by the Earth system Science data sharing platform (http://www.geodata.cn/Portal/metadata/); meteorological data including daily precipitation, minimum temperature, maximum temperature, daily average temperature, sunshine hours, average daily humidity average daily vapor pressure and average daily wind speed of Tuole, Yeniugou, Qilian, Delingha, Gangcha, Menyuan, Dulan, Qiabuqia, Xining, Xinghai, Tianjun, Haiyan, Huangyuan and Datong 14 meteorological stations in 1987–2010 years [25].

2.2.2. Data processing

Refer to the national land use classification standards (GB/T21010-2007) and land use characteristics in Qinghai Lake basin, divided the Qinghai Lake basin land use into barren rock, barren land, gravel ground, river, lake, alpine meadow, sparse vegetation, temperate steppe, valley shrub, mountain shrub, alpine swamp, lakeside swamp, valley swamp, farmland, sandy and residents land 16 types. Then through man-machine interactive classification interpretation, we got the vector data of different types from 1987 to 2010 in Qinghai Lake basin.

Reference CASA Model, NPP was determined by two variables: absorbed photosynthesis active radiation (APAR) and light energy conversion (ε):

$$NPP = APAR(x,t) \times \varepsilon(x,t) \quad (1)$$

where: APAR (x, t) as the absorbed photosynthesis active radiation; ε (x, t) representative of the actual solar energy utilization [25–28].

2.2.3. Assessment model of vegetation carbon fixation and oxygen release value

Photosynthesis equation shows that the plant product 1 g dry matter requires 1.63 g CO_2, release 1.20 g O_2, so through the NPP we can calculate the mass of CO_2 fixation and O_2 release. In this study we using carbon tax and industrial oxygen for calculating vegetation carbon fixation and oxygen release value in Qinghai Lake basin. Meanwhile, the paper chooses year 2007 as the base year, the value of ecosystem service Qinghai Lake basin switches to 2007 constant price accounting with growth rates comparable concept in economics.

To reduce greenhouse gas emission, the international enactment different carbon tax, the Swedish carbon tax of $ 0.15 kg^{-1} C in 1990 was universally accepted and recognized in the international arena, equivalent to RMB 1200 yuan/t (2007). Prices of industrial oxygen using the average oxygen price of 1000 yuan/t in the spring of 2007 from People's Republic of China Ministry of Health website (http://www.moh.gov.cn). Value of the vegetation carbon fixation and oxygen release is calculated as follows:

$$Ec_i = 1.63 \times A_i \times NPP_i \times R_C \times P_C \quad (2)$$

$$Eo_i = 1.19 \times A_i \times NPP_i \times P_O \quad (3)$$

where, Ec_i as the annual value of vegetation absorb CO_2 (yuan/a); A_i is area of a vegetation type (m^2); NPP_i as organic matter of vegetation production ($g/m^2 \cdot a$); R_C for carbon content in the CO_2, about 27.27%; P_C is fixed CO_2 price (yuan/t); Eo_i as annual value of release O_2 (yuan/a); P_O is release O_2 price (yuan/t).

3. Result

3.1. Dynamic change of the vegetation carbon fixation value

Using the assessment methods in the vegetation carbon fixation value calculate model to obtain the value of vegetation ecosystem carbon fixation of different periods in Qinghai Lake Basin (Table 1). The result showed that vegetation carbon fixation values of the entire basin were 26.14×10^8 yuan, 28.05×10^8 yuan, 27.1×10^8 yuan, 29.75×10^8 yuan and 33.32×10^8 yuan in 1987, 1995, 2000, 2005 and 2010 years, average value of 28.87×10^8 yuan/a, and the values present a growing trend, with an average annual growth rate of 1.61×10^8 yuan/a, the total value of vegetation carbon fixation maximized in 2010.

From 1987 to 2010, alpine meadow have the highest value of vegetation carbon fixation among the ecosystems, its value changed between 16.29×10^8 yuan/a and 20.68×10^8 yuan/a, averaging 18.28×10^8 yuan/a, accounting for 63.33% of the average value of total vegetation carbon fixation in basin. Visible, alpine meadow ecosystem is the main ecosystem of the vegetation carbon fixation in Qinghai Lake basin. After the alpine meadow, the temperate steppes and sparse vegetation have the high carbon fixation value, and their average value were 3.93×10^8 yuan/a and 2.66×10^8 yuan/a, accounting for respectively 13.62% and 9.2% of the vegetation carbon fixation value in the basin.

The value of vegetation carbon fixation distribution from low to high in a ring shaped around the Qinghai Lake (Fig. 1), and showed a decrease trend from southeast to northwest, appear low in the northwest of the vast region. The northern shore of Lake Qinghai vast areas as the