Vol. 13(31), pp. 1551-1563, 2 August, 2018
DOI: 10.5897/AJAR2017.12732
Article Number: E45996B57976
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Sustainable land management and ecological service assessment in Northwest of China: Case study of Yanchi, People's Republic of China

Kossi Fandjinou[1,2], Kebin Zhang[1*], Fousseni Folega[2] and Xiaohui Yang[3]

[1]College of Soil and Water Conservation, and Desertification Combating, Beijing Forestry University, 35 Qinghua East Rd 10083, Haidian District, Beijing-China.
[2]Laboratoire de Botanique et d'Ecologie Végétale, Université de Lome, BP 1515, Lome-Togo.
[3]Institute of Desertification Studies, Chinese Academy of Forestry, P.O. Box 35, Chinese Academy of Forestry, Yiheyuanhou, Haidian District, Beijing,100091, China.

Received 18 September, 2017; Accepted 20 October, 2017

This research aims to assess the driving factors hindering the effectiveness of these protected areas implemented to counter land degradation and evaluate the services provided by these ecosystems in the North West of China. With Ningxia province, Yanchi County chosen as experimental research area, preferential sampling technique was used with 50 plots of 1 m^2 (quadrat) laid for plant community characteristics survey combined with species and biomass measures mainly in three different areas, along with unit price system of evaluating ecosystem services values based on Costanza's evaluation model also used to quantify the V_{ei} (Ecosystem Service Value). The results showed both up and down trends of vegetation characteristics in protected areas including E, E1 and E2 year-round enclosure, seasonal and un-enclosed area respectively where anthropogenic disturbance has been prohibited for natural restoration. Moreover, compared to 1999, the total ecosystem service values of the year 2004 increased by 6.75% and those for 2010, 2015 increased by 7.28 and 5.55% respectively, indicating some positive effects of the protected on the total value of the grassland ecosystem service. In addition, regulatory and support services occupied the largest proportions: 52.08 and 32.69% respectively, followed by supply and cultural services 8 and 7% respectively. These results prove that the protected areas are improving the grasslands by reducing the soil loss and increasing their ecosystem services provision. Thus, sustainability and guarantee of the ability of the arid ecosystem to continue to provide the ecological services is important in the management taking into account the limiting factors.

Key words: Land degradation, limiting factors, sustainable management, Ecosystem Service Value (V_{ei}).

INTRODUCTION

The Millennium Ecosystem Assessment (MEA) discovered that approximately 60% of the World's ecosystem services were degraded due to human being disturbance (MEA, 2005). In addition, after publication of the Economics and Ecosystems and Biodiversity (TEEB, 2010) coupled with MEA, the attention of the scientific

*Corresponding author. E-mail: ctccd@bjfu.edu.cn

community has been raised toward the urgency to combine ecological research to Economic Sciences in order to balance the development of the society (Costanza et al., 2004). Therefore, the need to undertake actions and plans both scientifically and socially remains obvious at each level and scale; local, national, regional and global. In China, the most populated country in world, the research on ecosystem service (ES) has become one of the growing areas in the last decades (Liu and Costanza, 2008). Nevertheless, those publications were in Chinese language making them not easily accessible to the global scholars (Wei Jiang, 2017). The first study on ES in China was conducted in 1999 by Ouyang et al. (1999), to estimate the economic values of Chinese terrestrial ES based on ecological models and economics valuation techniques. The ecosystem services represent then the process through which the natural ecosystem (grassland…) and the species that composed them, sustain and fulfill the human life (Ouyang et al., 1999). Those natural ecosystems were disturbed by human activities which hinders their ability to provide those natural services. Therefore, grassland ecosystems, as one of the world's most widespread terrestrial ecosystems, occupy approximately 13% of the earth's surface (Gong et al., 2009) and hold approximately 20% of global carbon storage (Scurlock and Hall, 1998). The degradation of grasslands can affect the carbon balance, biodiversity and food production (O'Mara, 2012) which are mainly ecosystem services provided by the global ecosystem for the welfare of humanity. Since the end of the twentieth century along with population growth and rapid economic development in China, strong pressure from human activities and global climate change was put on desert ecosystem structure and biological processes has changed dramatically. The stability of desert ecosystems and the overall level of ecosystem services have been reduced. Thus, the degradation of desert vegetation has resulted in reduction of plant biodiversity. In addition, the wind erosion process and sand storms are increasing, and the rapidly expanding desertification zone is highlighted. The degradation of the desert ecosystem has seriously constrained sustainable development so that the arid and semi-arid areas can be quoted among the regions whose economic and social developments are lagging behind in the World especially in China. Faced with this reality, China's national strategic objective was to build a harmonious society, maintain, improve and restore the structure, function and stability of the desert ecosystem (Zhang et al., 2000; Yan et al., 2011). Several protected areas (fencings or enclosures) have been set for reclamation in semi-arid and arid ecosystems everywhere in the country Therefore, grassland management has become one of the priorities of the Chinese government which recognizes that land degradation can be combated by herbaceous plant recovery for sustainable purposes due to increasing demands which were inconveniencing strongly the natural ecosystems and their service provision especially the terrestrial ecosystem. In fact, when the demands become too much, the soil becomes degraded. Soils are therefore the basis of all terrestrial ecosystems; meanwhile a degraded soil means lower fertility, reduced biodiversity, human poverty (Bridges and Oldeman, 2010) and explaining the direct link between ecosystem services and its limiting factors. Therefore, sustainability science raises questions about interactions between society and environment, and how these interactions affect both social and environment needs. Researches should then include more than just a single academic discipline's concern, and adopts a multidisciplinary focus that accounts for the complex interactions between people and their environment (Carpenter et al., 2009). In the literature review concerning this topic, none of the last research combined, the management methods and the ecosystem services provide their limiting factors. In fact, when focusing on the countries that are experiencing the consequences of desertification, China can be quoted as desertified lands in China are distributed in 471 counties, 18 provinces and regions, including Xinjiang, Tibet, Qinghai, Gansu, Hebei, Ningxia, Shaanxi and Shanxi. Thus, desertification means indirectly the loss or reduction of the ecosystem services. Therefore, one of the causes of desertification includes natural climatic factors and human factors which represent the most dominant causes. Human factors include: overgrazing, which is the main cause of rangeland degradation, over collection of fuel wood and Chinese medicinal herbs, over exploitation of mineral resources, and over cultivation of dry-land. Among the ecological issues confronted by China, land degradation in arid zones, especially in Western China, is one of the most serious challenges (Fandjinou et al., 2016). To overcome these challenges, several projects are being set up by the Chinese Government, among which can be quoted: the Grain for Green project through farmland converted to grassland and artificial fencing. These programs are based on the principle of offering compensation to farmers: grain, cash, and free seedlings (Cao et al., 2008) to the land users taking part in the program. Nevertheless, many articles related to grassland degradation omitted the crucial impact of the limiting factors of the projects implemented on land degradation in arid zones and the quantification of the services provided by these threatened ecosystems to make decisions and policy makers aware of the need to speed up sustainably the management plans and integrated strategies. This paper aims at analyzing the factors which limit enclosure or artificial fencing implemented for soil management in China especially in the Northern part of the country and provide a numerical value (Qian et al., 2014) of the services provided by the ecosystems in order to draw the attention of the policymakers to continue and reinforce what is being done to overcome the challenges of arid zones degradation which result in the decreasing of those ecosystem services.

MATERIALS AND METHODS

Research area

The study zone lies between 37° 10'04''N and 106° 30' 41''E (Figure 1). It is located in East of Ningxia Hui Autonomous Region. The total area of Yanchi is 8661.3 $\mathrm{km}^2$with a North-South distance of 110 km and east-West of 66 km. Yanchi is located at the junction of four provinces (regions), Shaanxi, Ningxia, Gansu and Inner Mongolia. The Southern part is Loess hilly landscape while the middle is occupied by hilly land with an altitude ranging from 1295 m to 1951 m (above sea level). The mean annual temperature is 8.1°C. The annual highest and lowest average temperatures are 34.9 and -24.2°C, respectively whereas the annual average frost-free and average precipitations are 165 days and 250 to 350 mm/yr respectively. This confirms the dry, windy and sandy weather that prevails in this county. The natural landscape mainly consists of prairie (sand wilderness). From a pedological perspective, Yanchi County is mainly denuded peneplain with a typical serosem, dark humus soil, sandy soil loess and a little salty clay, mainly white bentonite.

Data collection method

The field work was carried out every July during the vegetation growing season (VGS), species richness (number of species), height (relative biomass) and abundance (relative recovery) were collected. The sample plots were surveyed as recommended for phytosociological releves in grassland (Figure 1, Photo 1) (Dierschke, 1994; Chytrý and Otýpková, 2003). Sampling plot coupled with linear transect method were used for vegetation species frequency and abundance survey (Photo 1). Mechanical method was used with a metal tube containing a spring to measure the degree of land compactness by the depth of the whole it made in the soil in a surveyed plot and soil biological crust were measured (Belnap et al., 2003).

Data processing

The vegetation height field survey, coverage, biomass and other basic data processing was computed in EXCEL, SPSS software's worksheets to analyze the plant community structure according to the abundance, height, coverage, biomass, frequency and importance value. The plant community structure shows the plant density and relative importance of plant species in grassland vegetation (EC, 2013). Most scientists use the following three indices, such as coverage and height (Zhang et al., 2000) but in this study, plant height, abundance, coverage, biomass and frequency were used as follows:

Relative abundance (R_a= (a_i/*a*) × 100 (1)

Where a_i is abundance of a given plant *i* and *a* is abundance of all plants species.

Relative height (R_h) = (h_i/*h*) × 100 (2)

h_i = height of a given plant; *h* = height of all plants species surveyed.

Relative coverage R_c= (c_i/ c) × 100 (3)

Where:

Photo 1. $1\ m^2$ sample plot for plant species abundance, height, frequency survey (taken in 2014).

c_i represents the coverage of a given plant *i* and c the coverage of all plants.

Relative biomass R_b= (b_i/*b*) × 100 (4)

b_i is biomass of a given plant *i* and *b* refers to the biomass of all plants species surveyed.

Relative frequency R_f= (f_i/*f*) (5)

where f_i represents the frequency of a given plant *i* and *f* is the sum of the frequency of all plants species surveyed.

Frequency (f_i) = (Ni/N) × 100 (6)

Where Ni is quadrate number in which a given plant appeared and N is the number of quadrat surveyed.

Plants importance value: It involves the number of species, their relative biomass, relative height, relative coverage and relative frequency.

The equation used to calculate plant importance value is:

Plant Importance value (*Piv*): *Piv* =$\frac{\mathrm{Ra+Rc+Rf+Rh+Rb}}{5}$ (7)

Where *Piv*, R_a ,R_h, R_c, R_f and R_b represents respectively the plant importance value in a given area, relative abundance, relative height, relative coverage, relative frequency and relative biomass. The importance value is used because it takes into account the main characteristic of the plant species in order to calculate the community structure index that will show the state of the community there. The importance value then combines the five parameters above to form a synthetic index where the plant with the highest importance value is the most important; however, in that importance, another index can show the real structure of that community. This means that the synthetic index is insufficient itself, and explains the reason why the index of diversity of Shannon-Weiner and the ecological dominance of Simpson and the Evenness indexes are combined with the synthetic index to illustrate the whole aspect of the community.

Indices of community structure: The Shannon's diversity index (SW) is commonly used to characterize species diversity in a plant community and it helps to determine the spatial distribution of each plant gender. Moreover, the ability to quantify diversity in this way is an important tool to understand a plant community structure. In this study, Importance Value has been used to calculate the indexes of plant community structure.

(a) Shannon's diversity index formula is as follows:

$$SW= -\sum P_{piv} \ln P_{piv} \quad (8)$$

Where, SW= Shannon index of diversity; ln is the natural logarithm, P_{piv} is the proportion of importance value of the i^{th} species, (P_{piv} =ni/∑ *N) is the importance value of* i^{th} *species and N is the importance value of all the species*)

(b) Simpson Index of Dominance:

The equation used to calculate Simpson's index was

$$SP = 1/\sum_{i=1}^{n} {P_{piv}}^2 \quad (9)$$

Where, SP= Simpson index of Dominance; $P_{piv}$is the proportion of importance value of the i^{th} species (P_{piv}=ni/∑ *N, is the importance value of* i^{th} *species and N is the importance value of all species*).

(c) The species evenness was calculated by the equation

$$EV= (Sw -1)/ (PS-1) \quad (10)$$

Where, EV= Species Evenness index; PS is the number of plant species in the transect and SW= Shannon index of diversity.

Evaluation of Ecosystem Service (V_{ei})

Evaluation of V_{ei} has been widely used as a research method in academic fields (Wang et al., 2003). The value of ecosystem services can be estimated in various ways. In general, the framework is composed of three main parts: (1) measuring the provision of ecosystem services (Table 1); (2) determining the V_{ei}; and (3) designing policy tools for managing ecosystem services (Poplasky, 2008) On the basis of Cotanzas's Evaluation Model, a unit price system of evaluation suitable for China was developed (Xie et al., 2008). According to the area correction coefficient of V_{ei} in each province of China and with a consideration of the special study area, a junction of four provinces (Ningxia, Inner Mongolia, Shaanxi and Gansu) (Dierschke, 1994), the correction coefficient of Yanchi county is 0.66 by weighted average. Equivalent factors of V_{ei} of Yanchi County are shown as follows:

$$V_{eik}= \sum_f (A_K \times VC_{kf}) \quad (11)$$

$$V_{eif}= \sum_k (A_K \times VC_{kf}) \quad (12)$$

$$V_{eik}= \sum_k \sum_f (A_K \times VC_{kf}) \quad (13)$$

Where, V_{ei} stands for the total value of ecological service, *VC* is ecological service value per area, *A* is the land area, *k* is one type of the first services, and *f* is one type of the second service (Table 1).

Also, eco-compensation standard has been calculated using this equation:

$$E_o = \frac{1}{n}\sum_{i=1}^{n} \mathrm{Vei} \times L_i \quad (14)$$

where, E_o is the eco-compensation and represents each district considering location (RMB/ha/a), Vei is the ecosystem services value of the ith sample plot (RMB/ha/a), Li is the adjusting indicator value of the ith sample plot, and n is the number of the sample plots in each area (Sheng et al., 2017).

Table 1. Ecosystem services (Sources: Harper et al, 1988; Malinga et al, 2013; MEA, 2005).

The first services	The second services
Supply services	Food production Raw material production
Regulating services	Air regulation Climate regulation Water conservation Waste disposal
Support services	Soil conservation Biodiversity conservation
Cultural services	Landscape regulation

Sources: Harper et al. (1988), Malinga et al. (2013) and MEA (2005).

RESULTS AND ANALYSIS

Table 2 shows E, E1, E2 which are year-round enclosure, seasonal and non-enclosure areas respectively. It displays also *Ra*, SW, SP and EV which represents Relative abundance, Species Shannon Diversity and Ecological dominance and Evenness Index respectively. The plant community structure characteristic displays the land cover of the plant community as the relative abundance itself can be an insufficient indicator of soil coverage. Therefore, comparing the values of Abundance for the three types of enclosures, it can be seen that seasonal enclosure E1 (Figure 2) is more abundant than E and E2. The diversity index is the highest in the year round enclosure until 2009 when it decreases resulting in E being the highest from 2009 to 2011. From 2011, E2 increases until 2012 with a little decrease between 2012 and 2014. The ecological dominance index increases from 2003 to 2009, 2009 to 2012 and from 2012 to 2014 in E, E1 and E2 respectively (Figure 2). These variations explain the fact that according to the enclosure type, the grass land restoration behaves concomitantly. Moreover, the Evenness index shows the uniformity of plant community distribution on the soil. According to Table 1 and Figure 2, it can be seen that the three enclosure types have approximately the same plant spatial coverage variation although the highest values appears in E2. Figure 2 shows that the variation of the number of species is highest in 2007 and 2011 for the seasonal enclosure area. The trend of abundance in the year-round oscillates with a minimum in 2006 and 2012 respectively.

Evolution of the plant community indexes shows that the species diversity is more stable in the seasonal enclosure area with slights oscillations. This evolution is not significant in the annual or year-round enclosure areas but very remarkable in the external area (E2).

Table 2. Species diversity indices under different grasslands enclosure.

Index		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	E	16	13	13	11	17	12	12	17	18	13	16	22
Ra	E_1	17	10	8	15	20	19	16	16	22	19	21	19
	E_2	9	4	6	10	10	8	10	15	15	19	17	16
	E	2.4	2	1.7	2.2	2.2	2.3	2	2	2.4	2.3	2.4	2.1
SW	E_1	2.2	2.1	2	1.7	2.2	2	2	2.3	2.2	2.	2.1	2.3
	E_2	1.4	0.7	1	1.6	1.5	1.3	1.5	2.1	2	2.5	2.4	2.3
	E	8.2	5	4	6	6.7	8.1	7.7	3.8	3.6	8.4	6.8	5.6
SP	E_1	5.7	5.6	5.2	4.5	6.1	5.8	5.8	5.6	8.1	6.3	9.6	7.8
	E_2	2.6	1.6	2.1	3.2	3.2	2.6	2.6	3.5	4.9	5.2	10.2	8.2
	E	1	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.8
EV	E_1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8
	E_2	0.6	0.5	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.9	0.9	0.9

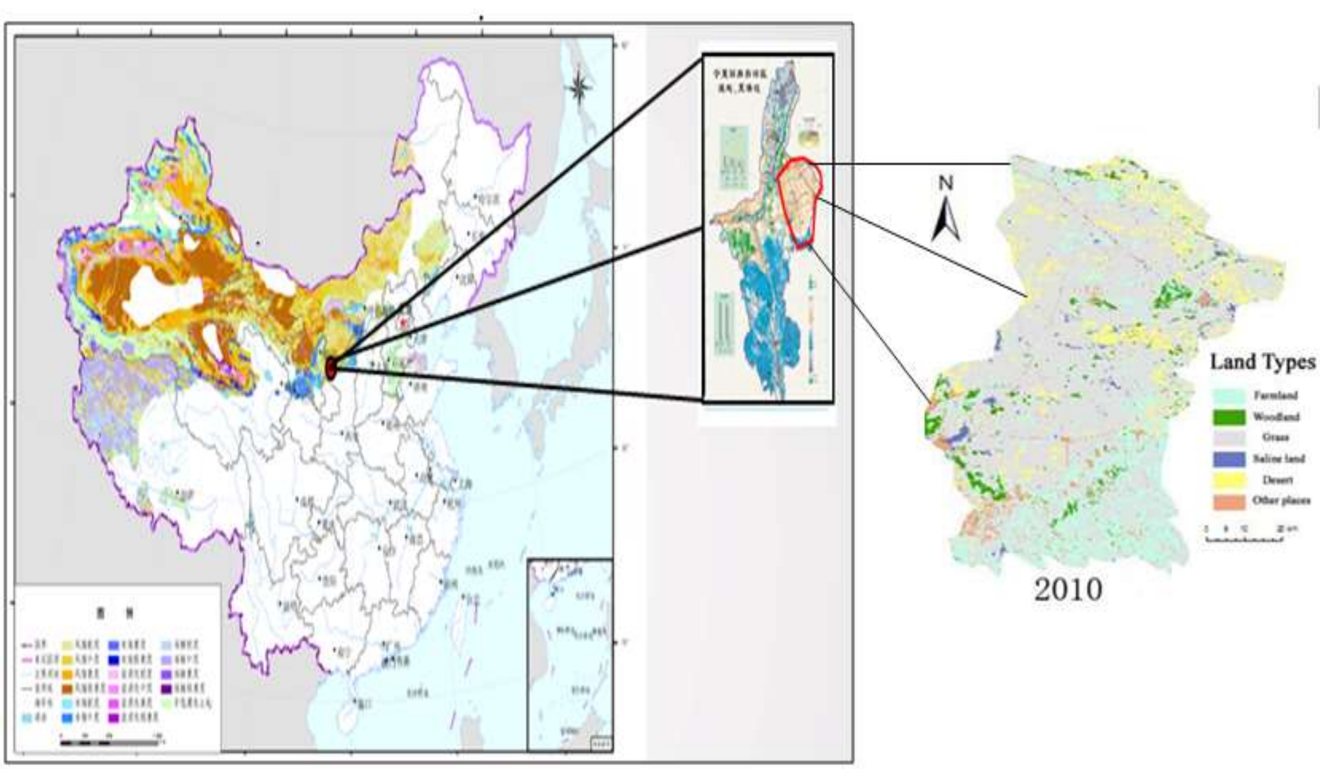

Figure 1. Research area.

These remarkable differences can be explained by the human activities and disturbance because of the open access due to an absence of enclosure or man-made fences around this area. In fact, animal grazing is the main form of human disturbance influencing the grassland of the research area. When the soil is bare, the erosion agents can easily degrade it. Hence, vegetation recovery becomes imperative for soil conservation by sustainable management.

In addition, the changes that occurred in ecological dominance index in the three land use types express the structure of the plant community on the soil. Moreover,

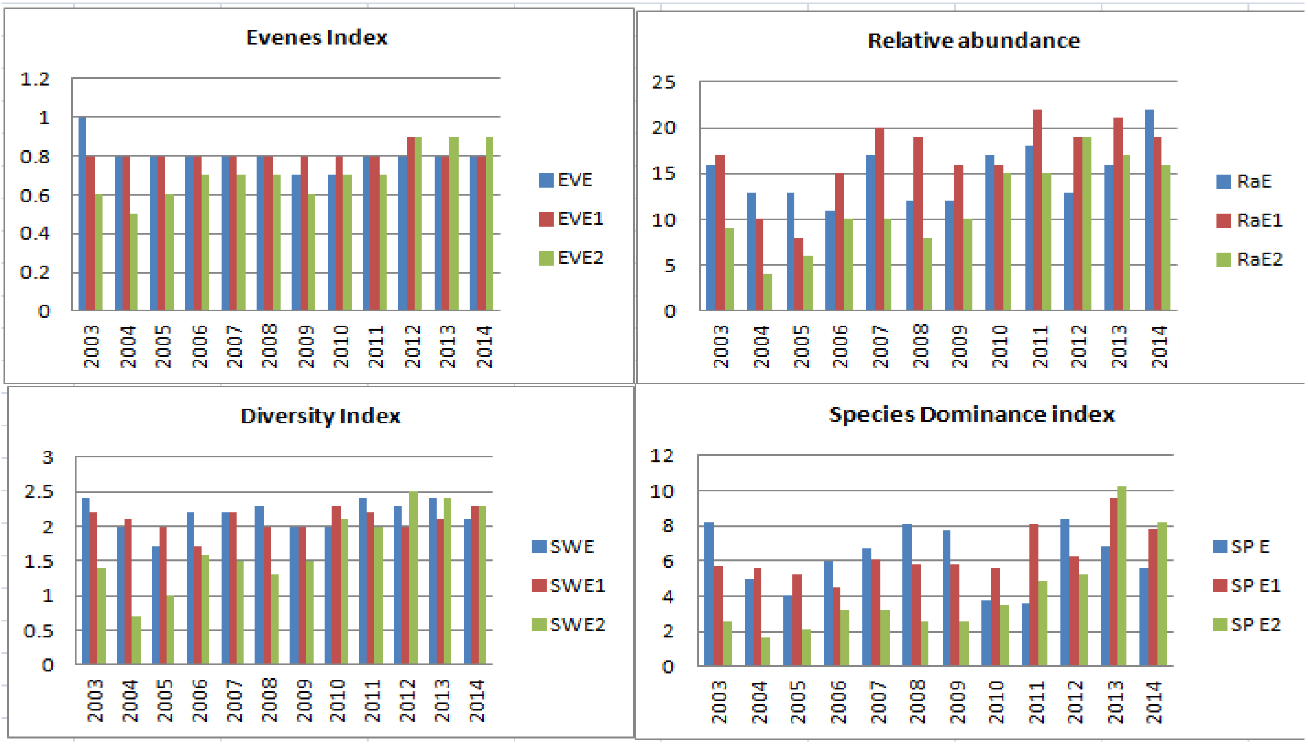

Figure 2. Plant community structure indexes.

Figure 2 shows also that plant recovery varies according to the land management technique. In fact, when analyzing this Figure 2, it was seen that the most even area is the seasonal enclosure area followed by the year round area and the unfenced area. The greatest values of Evenness occur in this seasonal area which has a good soil recovery and can resist erosion. This means that when implementing enclosure method, the purpose of the implementation and the length of fences period need to be taken into account. This characteristic shows that the artificial fencing can restore the soil ecosystem for vegetation recovery and indirectly the support services reinforcement. Therefore, any factor disturbing the fulfillment of this function hinders indirectly the support services of the natural ecosystem restoration. All the ecosystem services are provided in different proportions, the highest peaks are reached for biodiversity conservation and soil conservation (Table 3, Figure 3) during 1999, 2004, 2010 and 2015.

Table 5, Figure 5 indicates the plant characteristics under different soil use type and management. Between these five types of soil, from the diversity index part, it appears that the quick sand (moved dunes) area is the most diverse followed by the natural grassland and the farm land converted to grassland and finally the less diverse is the artificial fencing. This shows that each use or monitoring technique impacts the ability of the soil ecosystem to provide its service (Table 5).

Table 3. 1999 to2015 V_{ei} per unit area of Yanchi County (Yuan.hm^{-2}.a^{-})

	1999	2004	2010	2015
Food production	0.98	1	0.95	0.94
Raw material production	0.998	0.78	0.82	0.78
Air regulation	2.68	2.43	2.64	2.58
Climate regulation	3.118	2.85	3.16	3.1
Water conservation	2.98	2.73	3.04	2.98
Waste disposal	2.78	2.73	2.91	2.89
Soil conservation	3.84	3.7	3.9	3.84
Biodiversity conservation	3.4	3.22	3.4	3.36

The Biological Soil Crust (BSC) stabilizes the sand by its filament and protects against erosion (Anderson et al., 1982). This biological soil crust did not appear in (A) which is like an indication of the efficiency of that enclosure technique (Photo 2).

The most important biological soil (BSC) crust is very thick and abundant in the artificial fencing than in the ancient farmland and in wetland. In fact, the soil crust is very important for soil sand fixation and desertification combating. The farmland converted to grassland contains a crust more than a wet land. This observation shows also that this method impacts positively the soil and increases its capacity to produce support services. (Table 6, Figure 6).

The Ordinary Square analysis has been used to show

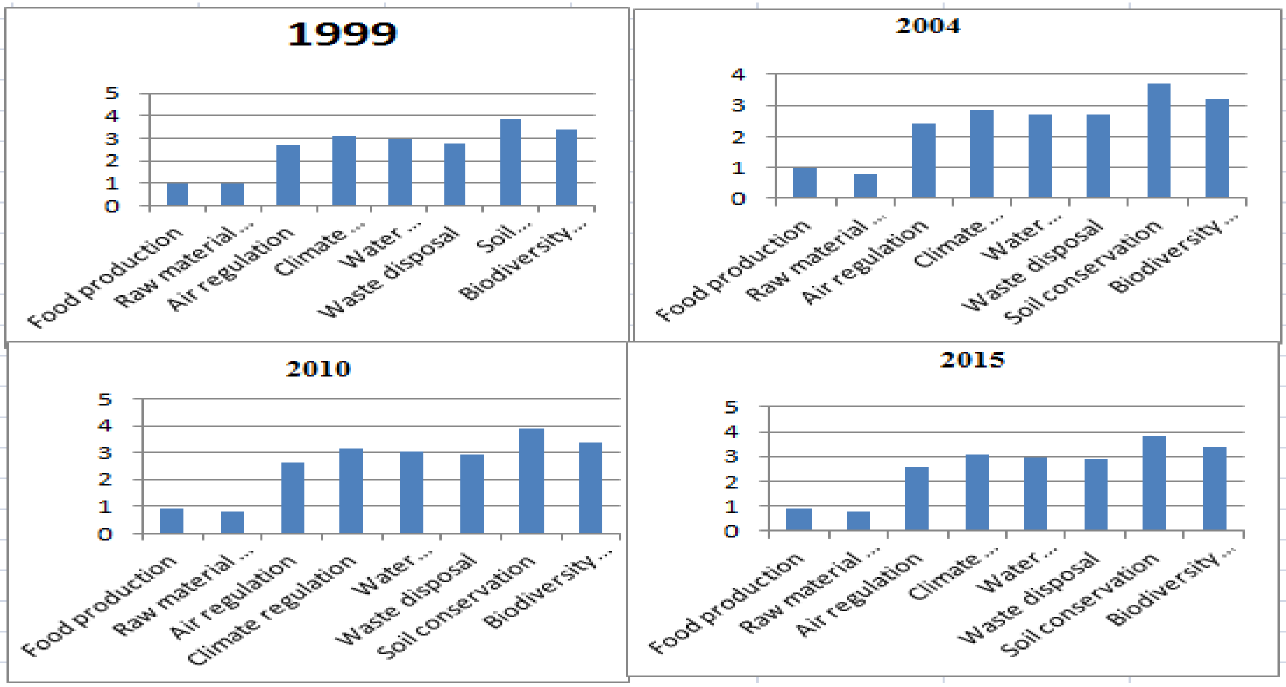

Figure 3. V_{ei} from 1999 to 2015.

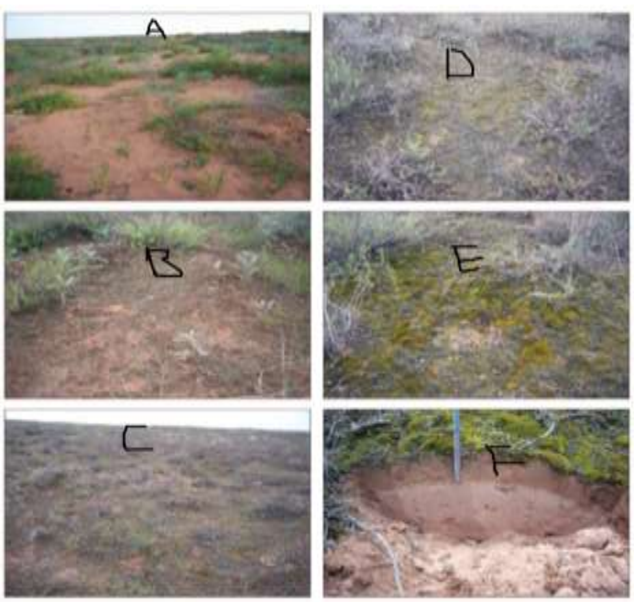

Photo 2. Appearance stage of soil crust in the different fencing period. **A & B:** Yanchi (taken in 2004), **C & D:** Yanchi (taken in 2015), **E & F:** Yanchi (taken in 2010).
Source: Belnap et al. (2003) and Anderson et al. (1982).

the relationship between the crust recovery and precipitation. The correlation linear equation describes a link between climatic factors and biological factors for land degradation restoration. In fact, the biological soil crust generated stabilizes the soil sand to resist air or water erosion. But the limit of this stabilization is on the economic income that is missed making it unsustainable. Although this correlation coefficient was feeble stating that there is less link between these two factors, it has been shown in practice (on field investigation) that the precipitation amount influences the biological crust production (Table 7 and Figure 7) so that the more wet a soil is, the more capable it is to generate biological soil crust.

From Figure 7 it can be seen that the correlation between the precipitation and the biological crust is slightly obvious and remarkable. This statement is shown by the correlation coefficient being very feeble less than 80% and the trend line of the crust variation. This graph which represents the precipitation and biological crust generated annually from 2003 to 2013 intended to portray graphically the variation of the land status on stabilization basis. It emphasizes the relationship between the amount of rain received every year and it influences on the capacity of that land to bear biological activity. In fact, the crust generated bound the sands and make the soil able to resist erosion, showing on one hand the good influence of fences establishment as well as the lack of an economic income for the local population implementing this policy.

DISCUSSION

The need to restore degraded environments especially

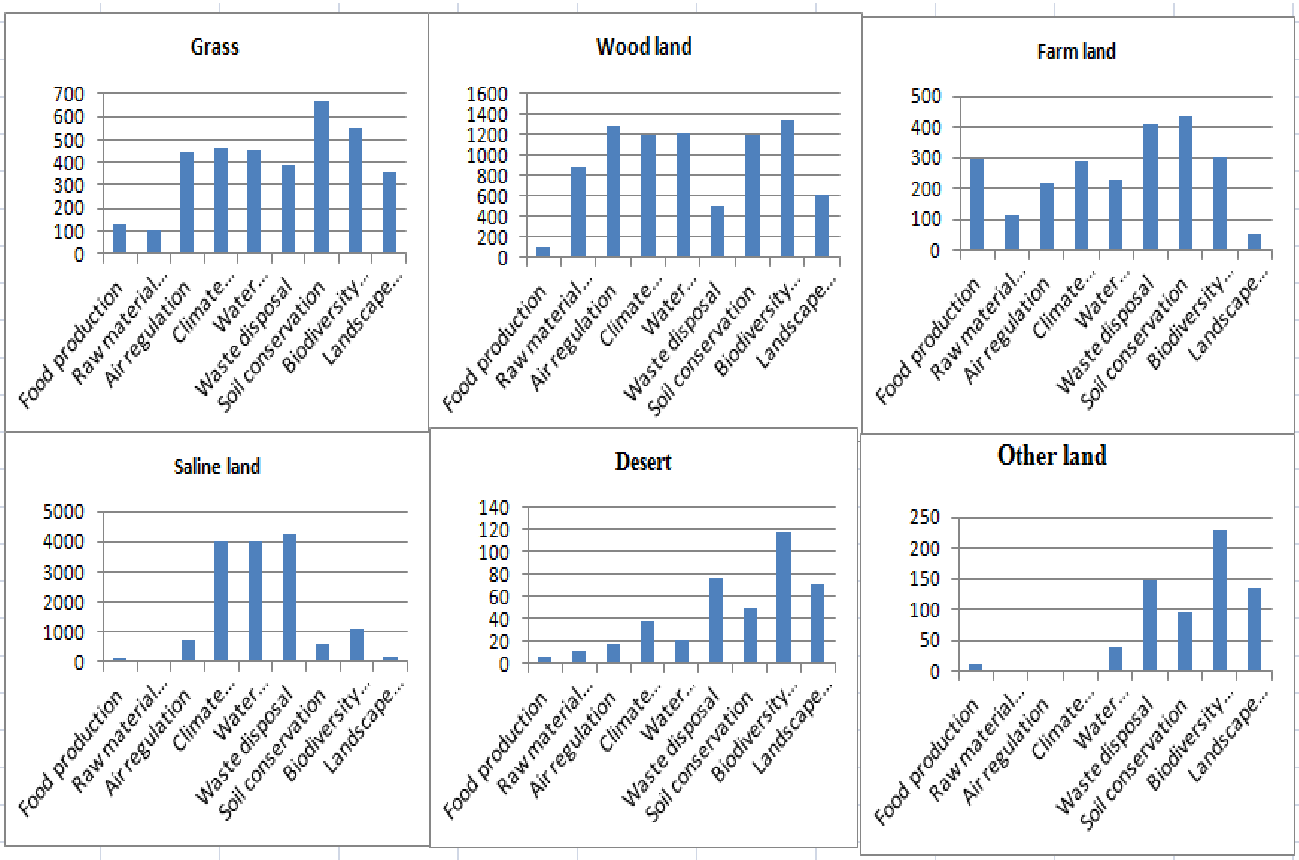

Figure 4. V_{ei} per unit area.

soil degradation has led the Chinese government to implement several projects which are influencing the grassland variation. These ecological projects are important and vital method to help ecosystem adaptation and restoration in response to environmental change and human interference and disturbance (Han et al., 2010) and for biological restoration. On the other hand, these techniques increase indirectly the capacity of the soil ecosystem to provide efficiently the ecosystem services for human welfare.

In order to analyze the influencing factors for both monitoring techniques such as enclosure method and ecosystem service provision in Yanchi, data has been collected from 1999 to 2015 by preferential sampling technique used as a sampling design and 50 plots measuring 1 m × 1 m (quadrat) were laid up for plant community characteristics assessment in different land use types and the ecosystem service values (V_{ei}) have been quantified in other hand.

Following the hypothesis that vegetation characteristics were able to portray effectively by their behaviors the quality of the soil, the analyses of the results showed that likewise it is shown in the Figure 2 that the vegetation characteristics are insufficient to explore the land cover effectively. For this reason, other indexes including vegetation evenness, biodiversity and dominance indexes were calculated. The calculation of these indexes enables analyzing the structure of the vegetation on the soil, and vegetation shows that an abundant area can be "uneven" and an even area can be less diverse. In addition, the comparison between the different diversity indexes of all kinds of land use indicates that grassland diversity is the highest outside (E) of the fences than in the enclosure (Figure 2). In the enclosure, the growth of the dominant species competes with the other species; a fact that decreases the biodiversity inside the enclosure than outside. In addition, the outside is influenced by the animal grazing effects because the growth of the dominant species meets the animal passage, making the conditions fair for the other species, enriching the biological diversity in the unclosed area. Moreover, Figure 2, Figure 4, Table 4 and 5, shows that plant recovery varies according to the land management techniques and land type. In fact, when analyzing Figure 2, it was seen that the most even area is the seasonal enclosure area followed by the year round area and the unfenced area. The greatest values of evenness occur in this seasonal area. The seasonal area has a good soil recovery and can resist against erosion. This means that when implementing enclosure method, the purpose of the

Table 4. V_{ei} per Unit Area

	Farm land	Wood land	Grass	Saline land	desert	Other land
Food production	296.41	97.81	127.45	106.71	5.93	11.4
Raw material production	115.6	883.29	106.71	71.13	11.85	0
Air regulation	213.41	1280.47	444.61	714.34	17.79	0
Climate regulation	287.52	1206.37	462.4	4016.3	38.53	0
Water conservation	228.23	1212.3	450.54	3983.69	20.75	39.91
Waste disposal	412.01	509.82	391.25	4268.25	77.07	148.24
Soil conservation	435.72	1191.55	663.95	589.85	50.39	96.93
Biodiversity conservation	302.33	1336.79	554.28	1093.74	118.56	228.06
Landscape regulation	50.39	616.53	357.88	139.14	71.13	136.84

Table 5. Vegetation indexes per land use type

Land type	Diversity index Sw	Ecological dominance Sp	Evenness index E
Natural grass land	2.64	10.32	0.51
quick sand or moved dunes	2.78	13.21	0.64
Artificial fencing	2.16	8.17	0.71
farmland convert to grass land	2.54	9.90	0.60
Abandoned land	2,44	10.35	0.49

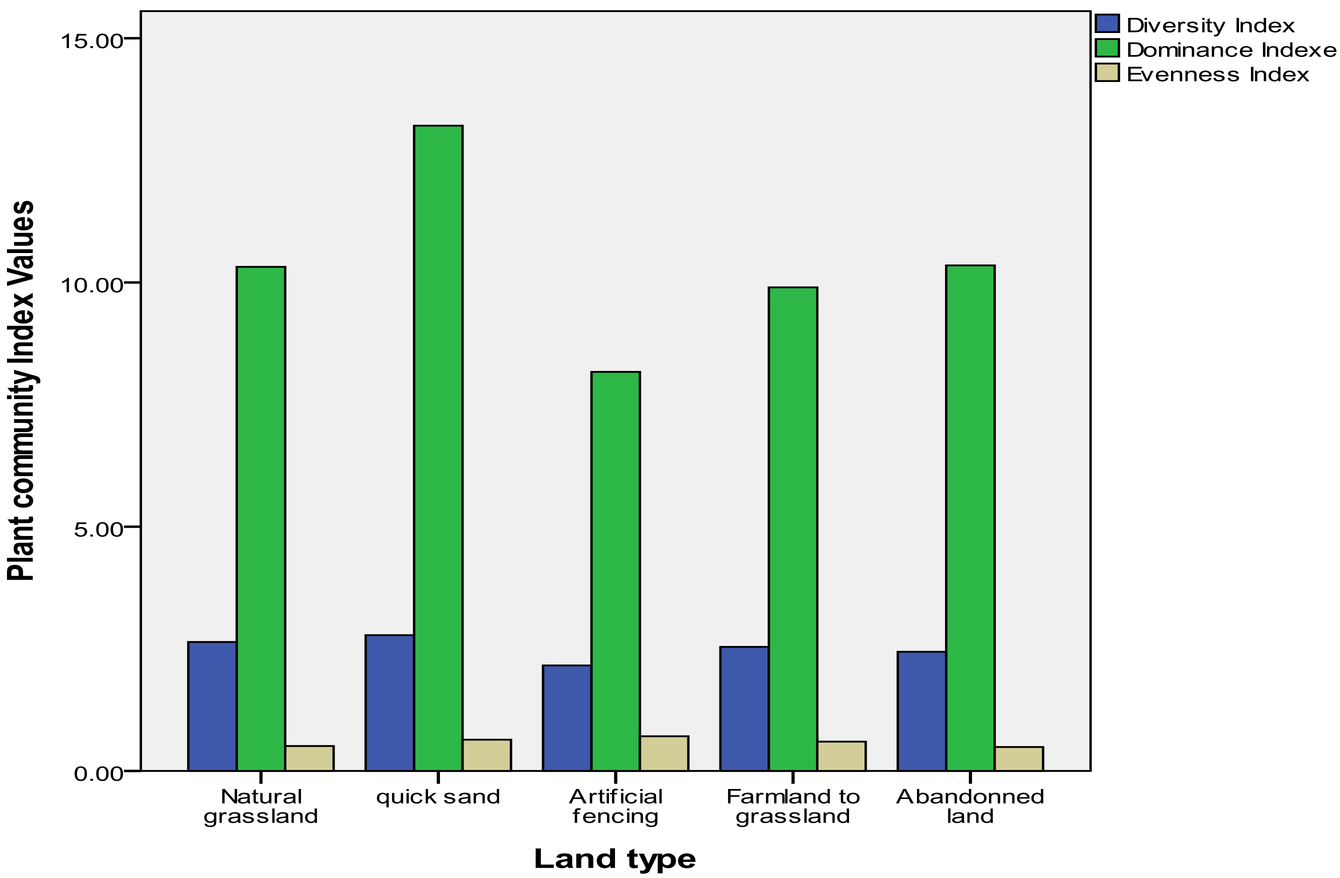

Figure 5. Plant indexes and land types.

Table 6. Land type and crust

Land type	Crust thickness
Farm land to Grass land	0.5
Wet land	0.37
Artificial fencing	0.56

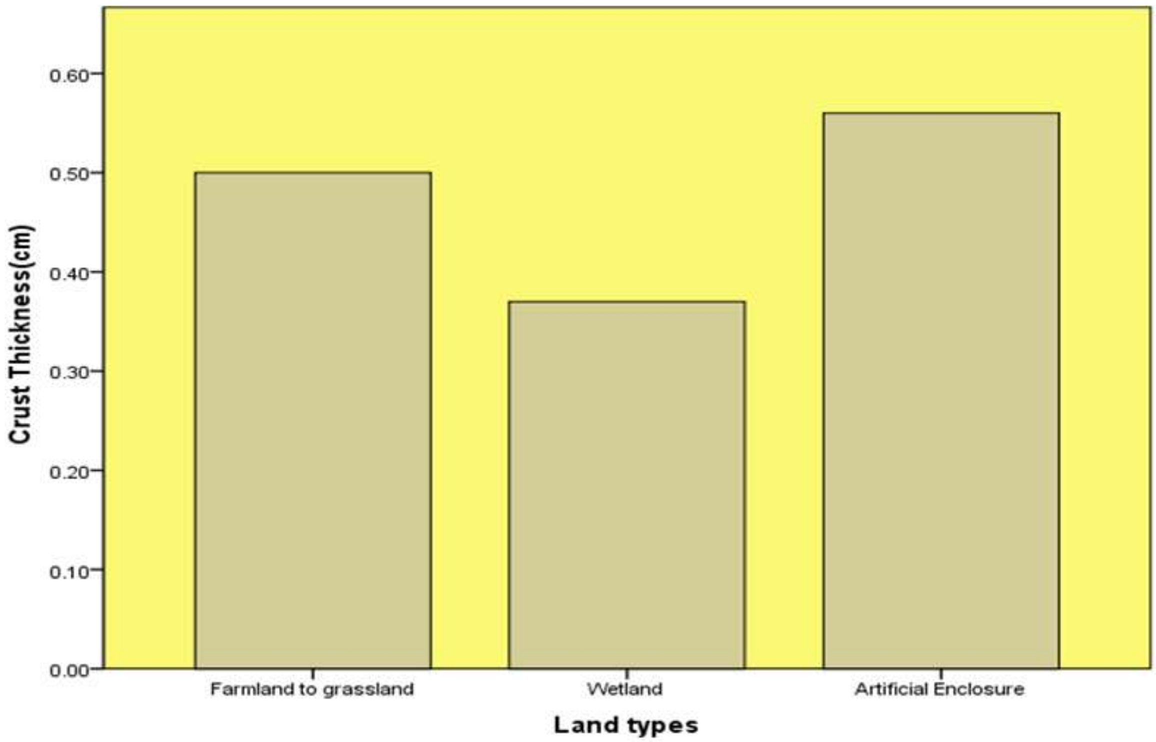

Figure 6. Biological crust and land types.

Table 7. Rain and Biological Crust correlation assessment in the fencing area (E1)

years	X= Rain(mm)	Y=Biological Crust $\times 10^{-2}$cm
2003	293.9	80
2004	262	60
2005	180	40
2006	212.1	30
2007	284.1	20
2008	266.7	50
2009	280.7	40
2010	248.4	20
2011	352.6	70
2012	308.4	80
2013	320	70

implementation and the length of fences period need to be taken into account. In fact, the biological life cycle of the species living in this area depends on these factors including temporal and spatial factors.

In addition, the fencing areas are influenced by some climatic factors such as amount of precipitation during the

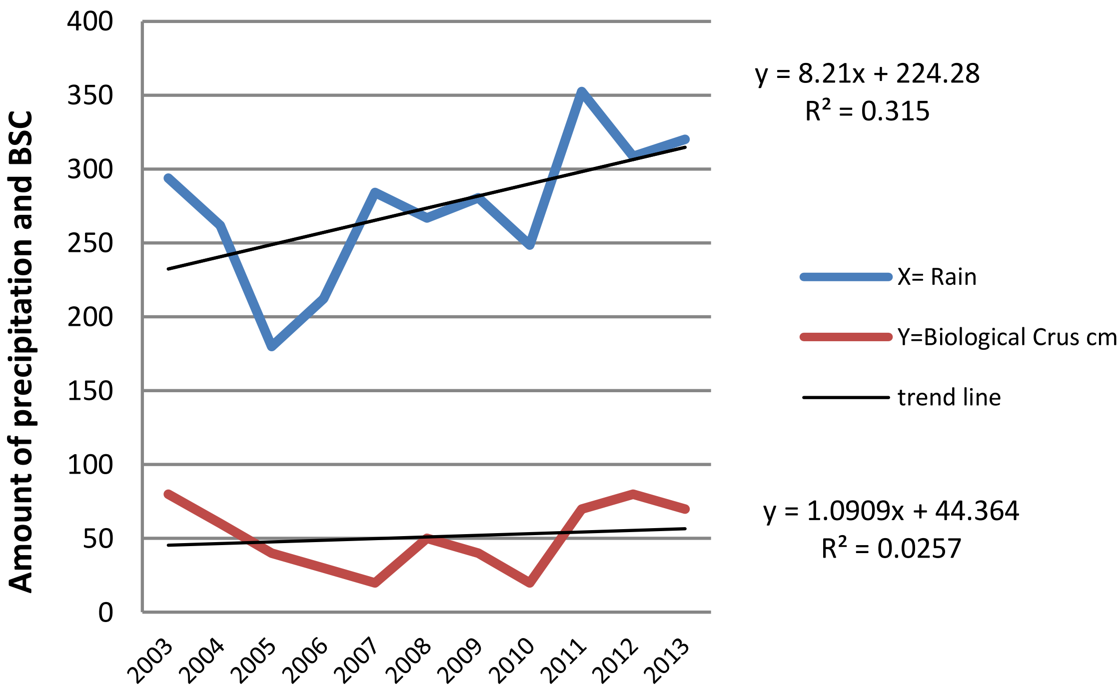

Figure 7. Precipitation and biological crust correlation graph.

year especially in the growing season. In fact, the link between soil activity and available water is shown by the biological crust measured during the field investigation. The most important biological soil crust is very thick and abundant in the artificial fencing than in the ancient farmland and in wetland. In fact, the soil crust is very important for soil sand fixation and desertification combating (Schwartzman and Volk, 1989). Referring to it as cryptogrammic, crypto biotic or micro biotic, biological soil crust are mainly dominated by cyanobacteria, lichens and or mosses and increases the soil pH, retains the moisture longer, can trap dust as well as increase the soil fertility and water holding capacity (Matthies et al., 2015). In addition, the farmland converted to grassland contains a crust more than a wet land. This observation shows also that this method impacts positively the soil even though the link between the biological crust and precipitation is not very obvious.

Moreover, the quantification of the services provided by the environments and using the Chinese Land Classification System, the land use was classified into six types: farmland, woodland, grass, saline land, desert, and other type of land use. Therefore, measures have been done and it has been seen that from 1999 to 2015 there was first a decrease and then an increase of the ecological services values. From 1999, 2010 and 2015 an increase of 6.75, 7.28 and 5.55%, respectively has been noticed. The V_{ei} was the highest for the grass zones, which represents 68.47% of the total amount, followed by agricultural land which is 13.25%, wooded area 9.03%, salt land 7.25%, other land 1.05% and desert 0.94%. This increase of the ecosystem services can probably be the result of the projects implemented to manage the grass land especially the protected areas.

Conversely, for primarily services, average annual rate control services, support services, supply services and cultural services were 52, 33 and 8%, respectively. Among secondary services, climate regulation, water conservation, waste disposal and air regulation were included in the regulatory services, with an average annual rate of 27 and 26%, respectively. In support services, the average annual soil conservation rate was 53%, which was higher than biodiversity conservation (47%). In ecological services, the average ratio of food production to raw material production was 54.79%, respectively. In the cultural services, the regulation of the landscape has changed slightly from one year to another. The average annual value of soil conservation, biodiversity conservation and climate regulation accounted for the largest proportions of all secondary services: 3.82 × 10^8 Yuan, 3.35 × 10^8 Yuan and 3.06 × 10^8 Yuan, respectively. These results indicated the positives impacts of the enclosure technique for arid and semi-arid areas restoration in the study area especially the fencing techniques. In fact, the capacity of the soil ecosystem to provide primary or secondary services such as biodiversity conservation and soil conservation has been improved by the artificial fencing which generated biological soil crust for erosion avoidance and soil fertility for food production (Schwartzman et al., 1989).

Conclusion

The economic estimation of the ecosystem services is effective in drawing the attention of the policy makers to addressing the challenge of land degradation in the World and especially in China. Therefore, analysis of this research shows that the Chinese Government has set the environmental protection and restoration as main priorities for sustainable development by actions and national plans implemented. Thus in the Northwest, several methods were implemented among which fencing method can be quoted as an effective method for vegetation restoration and ecosystem services provision in the arid and semi-arid areas especially in Yanchi County. These good incomes of the artificial fencing are also hindered by (1) the natural or climatic factors (precipitation rhythm and mount and soil crust) and (2) artificial factors especially human disturbance by animal grazing or soil cultivation. As a result, the enclosure technique should be periodically managed for a complete efficiency; and by the numerical knowledge of the services provided by a specific ecosystem and according to the contribution of each land use type to ecosystem services, the following rank order can be found (3); woodland, grass land, farmland, saline land, desert and other lands.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

This research has been financed by the National 13.5th Research Projects: Technical Integration and Demonstration of Ecological Animal-Husbandry and Degraded Sandy Land in Northeast of China (No. 2016YFC0500908) and National Desertification Monitoring Program in Yanchi County of Ningxia, which is funded by State Forestry and Grassland Administration of China. Thanks to the Chinese and Togolese Government for the cooperation scholarship and to my Supervisor for his generous help in the field investigation and improvement.

REFERENCES

Anderson DC, Harper KT, Holmgren RC (1982) Factors influencing development of cryptogamic soil crusts in Utah deserts. Journal of Range Management 35:180-185.

Cao S (2008). Why large-scale afforestation efforts in China have failed to solve the desertification problem. Environmental Science and Technology 42:1826-1831.

Cao S (2011). Impact of China's Large-Scale Ecological Restoration Program on the Environment and Society in Arid and Semiarid Areas of China: Achievements, Problems, Synthesis, and Applications'. Critical Reviews in Environmental Science and Technology 41(4):317-335.

Carpenter SR, Mooney HA, Agard J, Capistrano D, DeFries RS, Díaz S, Dietz T, Duraiappah AK, Oteng-Yeboah A, Pereira HM, Perrings C, Reid WV, Sarukhan J, Scholes RJ, Whyte A (2009). Science for managing ecosystem services: beyond the Millennium Ecosystem Assessment. Proceedings of the National Academy of Sciences 106:1305-1312.

Chytrý M, Otýpková Z (2003). Plot sizes used for phytosociological sampling of European vegetation. Journal of Vegetation Science 14:563-570.

Costanza R (2008). Ecosystem services: multiple classification systems are needed. Biological Conservation 141:350-352.

Dierschke H (1994). Pflanzensoziologie: Grundlagen und Methoden (Uni-Taschenbücher L) Gebundene. Verlag Eugen Ulmer, Stuttgart 683 p.

Bridges EM, Oldeman LR (2010). Global Assessment of Human-induced Soil Degradation (GLASOD) https://www.researchgate.net/publication/261696553_Global_Assessment_of_Human-induced_Soil_Degradation_GLASOD?ev=auth_pub

European Commission (EC) (2013). Organization for Economic Co-operationand Development, United Nations, World Bank. System of Environmental-Economic Accounting 2012 – Experimental Ecosystem Accounting. United Nations, New York. USA. Framework Design and Policy Application. United States Environmental.

Gong P, Wang J , Yu L, Zhao Y, Zhao YY, Liang L, Niu ZG, Huang XM, Fu HH, Liu S, Li CC, Li XY, Fu W, Liu CX, Xu Y, Wang XY, Cheng Q, Hu LY, Yao WB, Zhang H, Zhu P, Zhao Z, Zhang HY, Zheng YM, Ji L, Zhang Y, Chen H, Yan A, Guo JH, Yu L, Wang L, Liu XJ, Shi TT, Zhu MH, Chen YL, Yang GG, Tang P, Xu B, Giri C, Clinton N, Zhu ZL, Chen J, Chen J (2009). Finer resolution observation and monitoring of global land cover: first mapping results with Land sat TM and ETM+ data. International Journal of Remote Sensing 34(7):2607-2654.

Han Z, Wang T, Yan C, Liu Y, Liu L, Li A, Du H (2010). Change trends for desertified lands in the Horqin Sandy Land at the beginning of the twenty-first century. Environmental Earth Sciences 59:1749-1757.

Harper KT, Marble JR (1988). A role for nonvascular plants in management of arid and semiarid rangeland. In: Tueller, P. T. (ed.): Vegetation Science Applications for Rangeland Analysis and Management. Kluwer Academic Publishers, Dordrecht pp. 135-169.

Belnap J (2003). Biological soil crusts in deserts: a short review of their role in soil fertility, stabilization, and water relations. Algological Studies P 109.

Fandjinou K, Fousseni F, Wala K, Batawila K, Akpagana K, Zhang K (2016). Efficiency of an Artificial Fencing Method for Combating Desertification in the Northwest of China, the Case of Yanchi County of Ningxia Hui Autonomous Region. Nature Environment and Pollution Technology 15:2.

Malinga R, Gordon LJ, Lindborg R, Jewitt G (2013). Using participatory scenario planning to identify ecosystem services in changing landscapes. Ecology and Society18:59-63.

Matthies BD, Kalliokoski T, Ekholm T, Hoen HF, Valsta LT (2015). Risk, reward, and payments for ecosystem services: a portfolio approach to ecosystem services and forestland investment. Ecosystem Services 16:1-12.

Millennium Ecosystem Assessment (MEA) (2005). Ecosystems and Human Well-being. Island Press, Washington, D.C..

O'Mara FP (2012). The role of grasslands in food security and climate change. Annals of Botany 110:1263-1270.

Ouyang ZY, Wang RS, Zhao JZ (1999). Ecosystem services and their economic valuation. Chinese Journal of Applied Ecology 10:635-640. (in Chinese).

Poplasky S (2008). What's nature done for you lately: Measuring the value of ecosystem services. Choices: The Magazine of Food, Farm and Resource 23(2):42-46.

Qian L, Wang H, Zhang K (2014). Evaluation criteria and model for risk between water supply and water demand and its application in Beijing. Water Resources Management 28:4433-4447.

Schwartzman DW, Volk T (1989). Biotic enhancement of weathering and the habitability of Earth. Nature 340(6233):457-460.

Scurlock JMO, Hall DO (1998). The global carbon sink: a grassland perspective. Global Change Biology 4:229-233.

Sheng W, Lin Z, Gaodi X, Yu X (2017). Determining eco-compensation standards based on the ecosystem services value of the mountain ecological forests in Beijing, China. Ecosystem Services 26(B):422-430.

TEEB (2010). The Economics of Ecosystems and Biodiversity, Ecological and Economic Foundations, Routledge Abingdon, UK. 410p. https://en.wikipedia.org/wiki/The_Economics_of_Ecosystems_and_Biodiversity

Wang G, Liu Q, Zhou S (2003). Research advance of dried soil layer on Loess Plateau. Journal of Soil and Water Conservation 17(6):156-169.

Xie GD, Xiao Y, Zhen L, Lu CX, Xiao Y, Chen C (2008). Expert knowledge based valuation method of ecosystem services in China. Journal of Natural Resources 23(5):911-919.

Yan QL, Zhu JJ, Hu ZB, Sun OJ (2011). Environmental impacts of the shelter forests in Horqin Sandy land, northeast China. Journal of Environmental Quality 40(3):815-24.

Zhang P, Shao G, Zhao G, Le Master DC, Parker GR, Dunning JB, Li Q (2000). China's Forest Policy for the 21st Century. Science 288:2135-2136.