Case Studies on Korea-China's Combating Desertification Cooperation Project in China

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• Abstract

The Korea-China joint research team of National Institute of Forest Science (NIFoS) of the Republic of Korea and the Institute of Desertification Studies, Chinese Academy of Forestry (CAF) of People's Republic of China, conducted a field study from 2017 to 2018, on 5 research sites in western China, which were set during the period of 2001-2005 as research site to combat desertification. The 5 sites are as follows: 1) Baiyin city (1,540 ha), Gansu Province, 2) Pingluo county (1,000 ha), Ningxia, 3) Tongliao city (3,000 ha), Inner Mongolia Autonomous Region, 4) Xiuwen (1,300 ha), Guizhou Province, and 5) Tulufan (1,200 ha), Xinjiang Province. On the above 5 sites, the joint team compared and analyzed the changes of the 1) major vegetation combination before and after the project, 2) land use aspects of the sites and surrounding areas, 3) social and economic aspects, and so on. Considered by the survival rate, the lowest was found about 52% (Pingluo county) and the highest is about 95% (Baiyin city). As for the NDVI (Normalized Difference Vegetation Index) and income sources, all the 5 sites were found to increase showing rising curves. The field study, however, also found some challenges to be addressed on the sites, including irrigation system, drainage management, density control and so on, which requires constant attention and further studies on these aspects. Also, more in-depth research should be conducted to systematize site characteristics by project sites as database, through continuous monitoring and evaluation of each project site, and to improve and advance restoration-related techniques that can fully address and cover all the potential challenges.

• Introduction, scope and main objectives

In Nov 2000, China's State of Forestry Administration and the Korea Forest Service exchanged opinions on the cooperation in the field of forestry between China and the Republic of Korea. Based on this, the State of Forestry Administration of China and Korea International Cooperation Agency (KOICA) signed the implementation agreement on "Cooperation in afforestation in the five provinces in the western part of China", this agreement marks the official launch of the project. According to the exchange of notes between China and the Republic of Korea, the ROK provided grants of 5 million U.S. dollars to the five western provinces (Xinjiang, Gansu, Inner Mongolia, Ningxia and Guizhou). This project, which with a period of 5 years and 8,040 hectares of afforestation, aimed to support the construction of the six major forestry projects and the strategy of the Western Development in China. It is an important to promote the technological development and academic cooperation in the field of forestry between the two countries, through experts' guidance and personnel training.

To scientifically evaluate the follow-up of the China-ROK cooperative afforestation project, the research team conducted investigation to Gansu, Ningxia and Inner Mongolia Autonomous Regions in Sep 2017, and to Guizhou and Xinjiang Uygur Autonomous Region in Jul 2018. Based on the ecological service and benefit evaluation techniques, combining forest investigating with remote-sensing imagines and other methods, the team also conducted a systematic investigation focusing on ecological and socio-economic benefits. The findings, which with significant social benefits, is expected not only to improve the ability of ecological investigation, observation and assessment in an all-round way, but also to help raise social and public awareness to protect the ecosystem quality. At the same time, improving the assessment of ecosystem quality and service in afforestation will provide a reliable basis for government departments to make ecological protection and management decisions, reduce the risk of decision-making, thus forming a huge social and economic benefits.

Main content is to scientifically evaluate the follow-up situation of the cooperation afforestation project, as well as to investigate the impact on the ecological environment and its socio-economic after the afforestation project which had been carried out in 2001-2005. The environment of the project area before and after reforestation was compared and analyzed according to the historical data and the newly acquired data. The comprehensive assessment was made from the aspects of the whole habitat change after afforestation, vegetation renewal and reproduction.

Specific work as follows:

(1) Investigation and Assessment of the Large-scale Afforestation Ecological Afforestation Project in Baiyin City, Gansu Province

(2) Investigation and Assessment of Demonstration Projects of Soil and Water Conservation Afforestation on Ningxia Pingluo Yellow River Beach

(3) Investigation and Assessment of Key Project of Forestry Ecological Management in Tongliao City, Inner Mongolia

(4) Investigation and Assessment of Afforestation Demonstration Project of Karst Rocky Mountain in Xiuwen County, Guizhou Province

(5) Investigation and Assessment of Solidification Afforestation Project in Turpan City, Xinjiang Uygur Autonomous Region

- **Methodology/approach**

In this paper, EOS-MODIS and Landsat TM images were used to study the growth of vegetation in the forest areas. As an important sensor on the TERRA/AQUA satellite, MODIS is a high spectral sensing instrument with a new generation of spectrum in the world, which has a high spectral resolution and temporal resolution compared with the commonly used sensors such as TM, ETM+ and AVHRR. The MODIS land standard data production MOD13Q1 from 2000 to 2016 (Path/Row: h26v04/h26v05, DOY: 193 & 209), provided by NASA) were ordered and processed. The spatial resolution of MOD13Q1 products is 250m x 250m and the time resolution is 16d. The selected time corresponds to Jul 11 to Aug 12 of each year, when vegetation growth is in the most vigorous phase of the year. Modis Reprojection Tool (MRT) was used for the MODIS titled land products to perform subset and projection transformation. The map projection employed was Albers Conical Equal Area (ellipsoid is Krasovsky, longitude of central meridian is 105°E, latitude of standard parallels are 25°N and 47°N). To further reduce the influence of cloud noise, Maximum Value Composites (MVC) is used.

The selected Landsat TM data (Path/Row: 121/29, 129/33, 130/35, 127/41 and 140/30) were respectively taken on Sep 16, 2006, Sep 18, 2007 Jul 1, 2005, May 8, 2007, and Jun 27, 2007, respectively, because at that time, vegetation was almost at the peak of the growth period of the year, with cloud-free and sunny conditions. Landsat TM images covered the Horqin Left Middle Banner, Tongliao, Inner Mongolia, Baiyin city Gansu, Pingluo county Ningxia, Xiuwen Guizhou and Turpan Xinjiang, respectively. And for Landsat TM image, according to the principle of control point mark clearly and evenly distributed, 1:50000 scale topographic maps were used to carry out geometric correction. The correction after the average error control within 0.5 pixels. Based on the distribution survey of afforestation in Sep 2017 and Jul 2018, we identified the distributions of afforestation regions in the five provinces from Landsat TM images.

Then the growth and change of vegetation growth in the afforestation area is represented by the spectrum, which is the physical basis for the remote sensing monitoring of vegetation growth using NDVI. To enhance the comparability and continuity of remote sensing data in the study of NDVI, MODIS data product MOD13Q1 was selected to analyze the characteristics of NDVI changes.

- **Results**

1. Baiyin Gansu Area

NDVI value was relatively low in the whole area, but the average value was significantly increased by 0.0108 per year. For the inter annual variation, average NDVI in the afforestation area in 2000-2016 was 0.2927. NDVI negative anomaly of the year for 2000-2002, 2004-2006 and 2004, of which 2000, 2001 and 2006 relative to the minimum, the NDVI anomaly were -0.0906, -0.0803 and -0.0737 respectively. NDVI positive anomaly of the year for 2003, 2007 and 2009-2016, of which relatively high levels in 2016, 2013 and 2014 and the NDVI anomaly is 0.1223, 0.0909 and 0.0842 respectively. As the projects were implemented in 2001 (150ha), 2002 (240ha) and 2003 (430ha), the corresponding NDVI value increased rapidly, and the NDVI from 0.2021 in 2000 to 0.2124 in 2001, 0.2577 in 2002 and 0.2999 in 2003 respectively. From then on, although NDVI had its ups and downs, with the further improvement of the supporting and management of drip irrigation water conservancy projects, the NDVI showed a significant increasing trend.

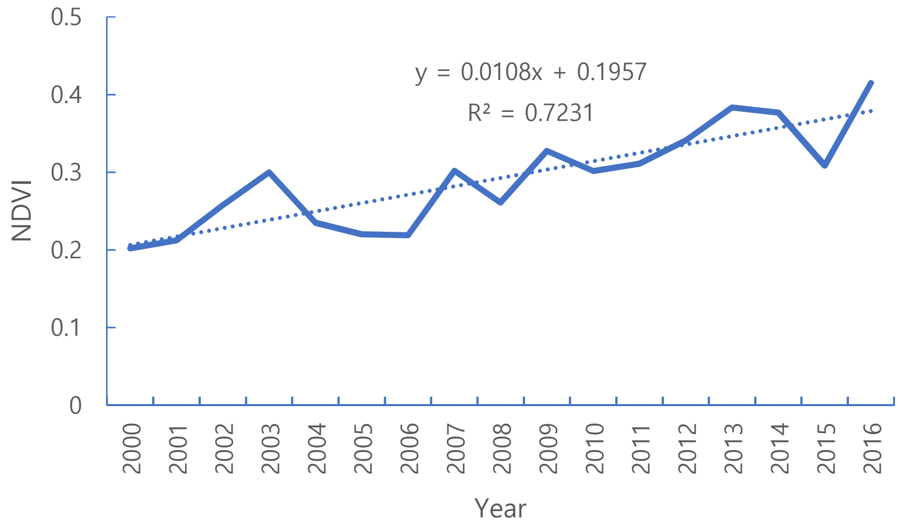

Fig.1 NDVI variations in Baiyin Gansu in 2000-2016

2. Pingluo Ningxia Area

From 2000 to 2016, the average NDVI of vegetation in the in the afforestation area of Pingluo Ningxia increased significantly by the speed of 0.0092 per year. For the inter annual variation, average NDVI in the afforestation area in 2000-2016 was 0.5825. NDVI negative anomaly of the year for 2000-2006. NDVI in 2000, 2001 and 2002 were relatively the lowest in 2000-2016 and the NDVI anomaly were-0.1118, -0.0855 and -0.0650, respectively. NDVI positive anomaly of the year from 2007 to 2016, and during the period NDVI values in 2016, 2013 and 2012 were relatively the highest. The highest NDVI anomaly is 0.06533, 0.633 and 0.0525, respectively. From 2003 to 2005, with the implementation of the afforestation project, NDVI in afforestation area was rapidly increased from 0.5175 in 2002 to 0.5810 in 2003, 0.5612 in 2004 and 0.5816 in 2005. But with the occurrence of the Yellow River flood for two consecutive years in 2004 and 2005, and the area of 1,000 ha in the afforestation area was completely submerged, which directly resulted in the occurrence of death of trees from 2004 to 2005.

With the implementation of the project in 2001 (150 ha), 2002 (240 ha) and 2003 (430 ha), the corresponding NDVI value increased rapidly, and the NDVI from 0.2021 in 2000 to 0.2124 in 2001, 0.2577 in 2002 and 0.2999 in 2003 respectively. From then on, although NDVI had its ups and downs, with the further improvement of the supporting and management of drip irrigation water conservancy projects, the NDVI showed a significant increasing trend. For NDVI variations, NDVI was 0.5612 in 2004, slightly lower than that in 2003 (NDVI was 0.5810), and the influence of the Yellow River flood in two consecutive years made NDVI (0.5328) in the afforestation area in 2006 significantly lower than that in 2005 (0.5816). Since then, with the development of reforestation and wetland forest farm construction, the NDVI in the afforestation area had shown an increasing trend.

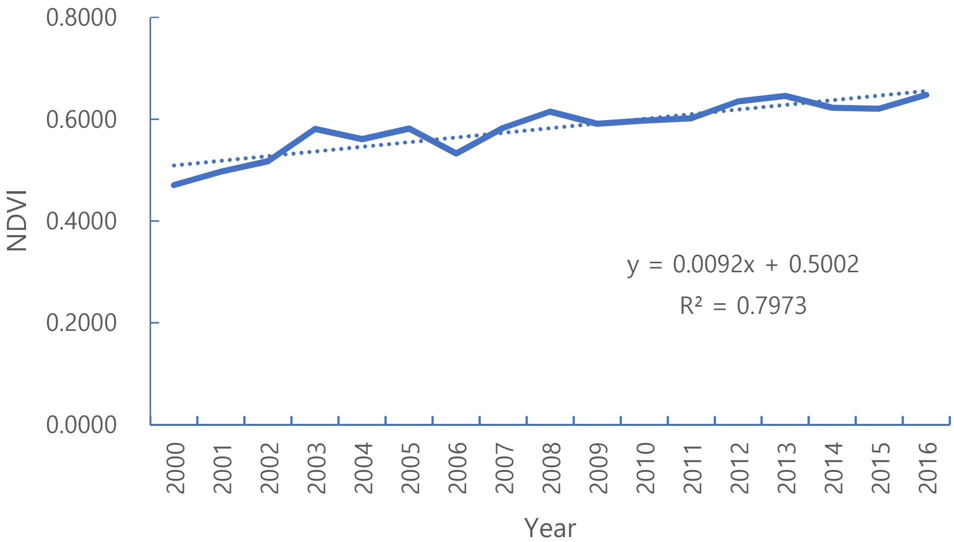

Fig. 2 NDVI variations in Pingluo Ningxia in 2000-2016

3. Horqin Left Middle Banner, Inner Mongolia

The change of vegetation in afforestation area from 2000 to 2016 was analyzed and we found NDVI value of vegetation increased by the average speed of 0.0054 per year, but the trend of increase was not significant. Hydrothermal conditions, especially precipitation, are the important factors that affect the growth of afforestation vegetation. In terms of inter annual variability of NDVI, the annual average NDVI in 2000-2016 was 0.5260, and the negative anomalies of NDVI were in 2000, 2001, 2004 and 2007-2010, with relatively the lowest NDVI in 2000, 2007 and 2009. The anomalies were -0.1106, -0.0910 and -0.0781, respectively. The NDVI positive years were from 2002 to 2003, in 2005, 2006 and from 2011 to 2016. Vegetation growth in 2005, 2003 and 2014 were good with NDVI anomalies of 0.1434, 0.0754 and 0.0727, respectively. With the afforestation project carried out in 2001, the NDVI values in this area also showed a continuous increase in 2000-2003. In 2004, the serious spring drought in eastern Inner Mongolia occurred in nearly 40 years, resulting in a significant drop in NDVI in 2004. In 2005, the afforestation project was further developed and its NDVI reached the highest value of 0.6693 for afforestation in 2000-2016. Severe spring droughts and summer droughts in eastern Inner Mongolia in 2006 and 2007, to a certain extent, caused the NDVI values in afforestation areas to decline.

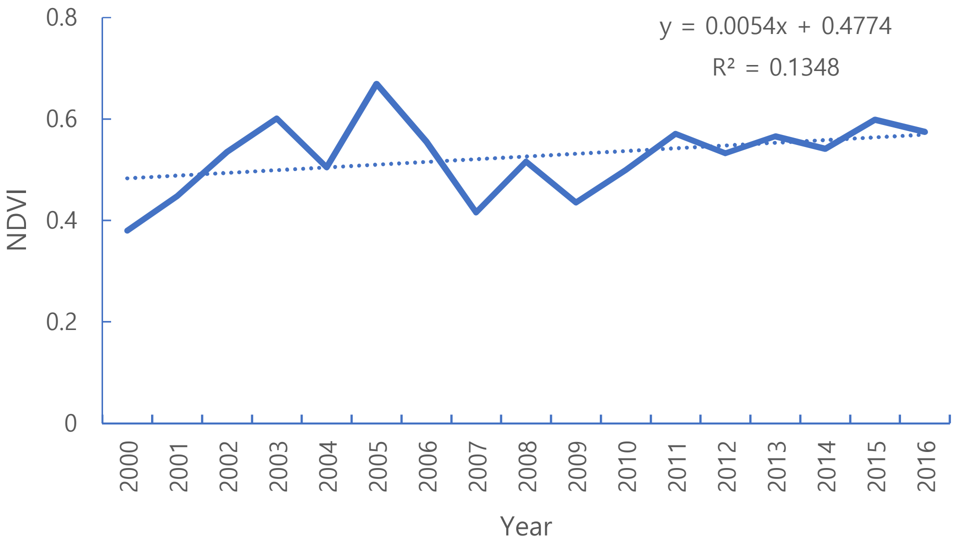

Fig. 3 NDVI variations in Horqin Left Middle Banner Inner Mongolia in 2000-2016

4. Xiuwen Guizhou Area

It was found that the NDVI value of surface vegetation increased at an average rate of 0.0046/a. Due to the same period of local rain and heat, vegetation grew well in general. The average annual NDVI of the afforestation area in 2000-2016 was 0.7353. the annual positive anomaly of NDVI was 2003, 2005, 2006, 2008-2012, 2014 and 2016. Among them, the highest NDVI values in 2016, 2012 and 2011, with the NDVI anomaly of 0.0755, 0.0711 and 0.0564, respectively. The negative anomaly years were 2000-2002, 2004, 2007, 2013 and 2015. Among them the lowest NDVI values mainly distributed in 2000, 2001 and 2015, and the anomalies were -0.0867, -0.0667 and -0.0616, respectively. For the implementation period of afforestation project in 2003, the NDVI value in the area also increased rapidly. In 2003, the NDVI value was 0.7541, which was significantly higher than the corresponding NDVI (0.6486 in 2000, 0.6686 in 2001 and0.7262 in 2002). Along with the completion of afforestation project in 2005, the NDVI value in afforestation area reached 0.7376 and 0.7502 in 2005 and 2006, respectively. And the NDVI in the afforestation area showed an obvious increasing trend from 2008 to 2012. In 2013, the vegetation index in afforestation area decreased rapidly. Combined with the monitoring of meteorological disasters in the same year, there was a serious drought in Guizhou Province from Jun to Aug 2013, which occurred in 80 counties (cities and districts) about 1224 townships of Guizhou province. The drought affected about 151.13 million people and temporary drinking water difficulties occurred in 2.466 million people. Accordingly, the Guizhou Provincial Meteorological Observatory issued a red alert and high temperature yellow warning. In 2013, extreme drought occurred in Xiuwen County. The high temperature and low rainfall drought greatly affected the normal growth of vegetation in the afforestation area, and showed lower NDVI values than before. In the following years, with the relief of drought and the increase of precipitation, NDVI showed a rising volatility and showed a higher NDVI in 2016.

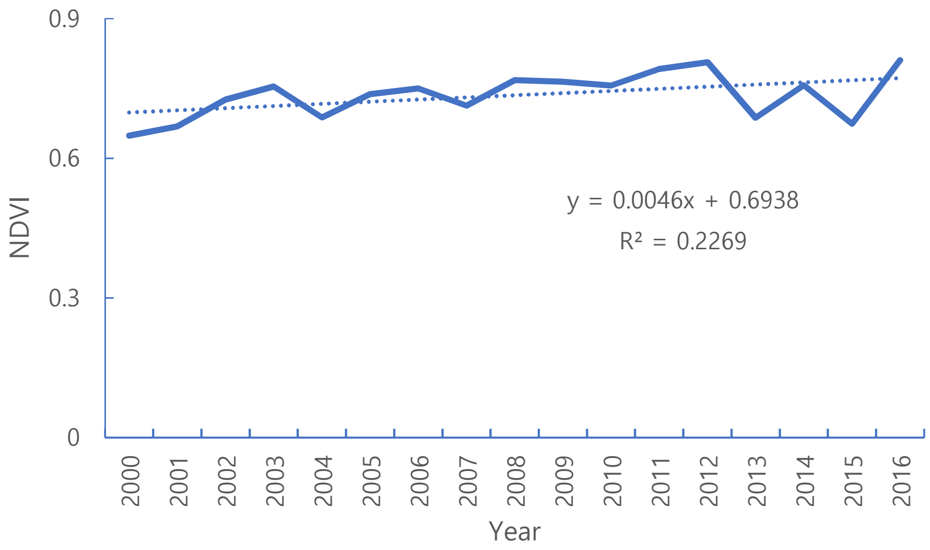

Fig. 4 NDVI variations in Xiuwen Guizhou in 2000-2016

5. Turpan Xinjiang Area

The surface vegetation changes in the afforestation area from 2000 to 2016 were analyzed and we could see that the NDVI value of the surface vegetation was relatively low. The average annual NDVI value was 0.1283. However, the average NDVI value of afforestation area increased at the rate of 0.0013/a, and the trend of vegetation growth improvement was obvious. From 2000 to 2016, the positive anomaly years of NDVI in afforestation area were 2006-2008 and 2010-2016, among which the corresponding ones were 0.0224, 0.0134 and 0.0067 in 2012, 2006 and 2010, respectively. The negative anomaly years were mainly 2000-2005 and 2009, and the corresponding ones were relatively low in 2002, 2000 and 2001. And the corresponding NDVI anomalies were -0.0188, -0.0163 and -0.0160 respectively. Corresponding to the implementation period of afforestation project, the afforestation area in 2000-2005 was mainly located in the upper reaches of the Aydingkol Lake. The surface vegetation was sparse, the afforestation species were mainly *Haloxylon ammodendron*, short fleshy leaves of plants, which reflected in the remote sensing images mainly showed that the corresponding NDVI value was low, which was also an important factor for the negative NDVI anomaly in the afforestation area from 2000 to 2005. With the end of the afforestation project and the growth of trees in the afforestation area, the NDVI value of the afforestation area had been increasing since 2006, which showed an improved trend of vegetation growth to a certain extent in the afforestation area.

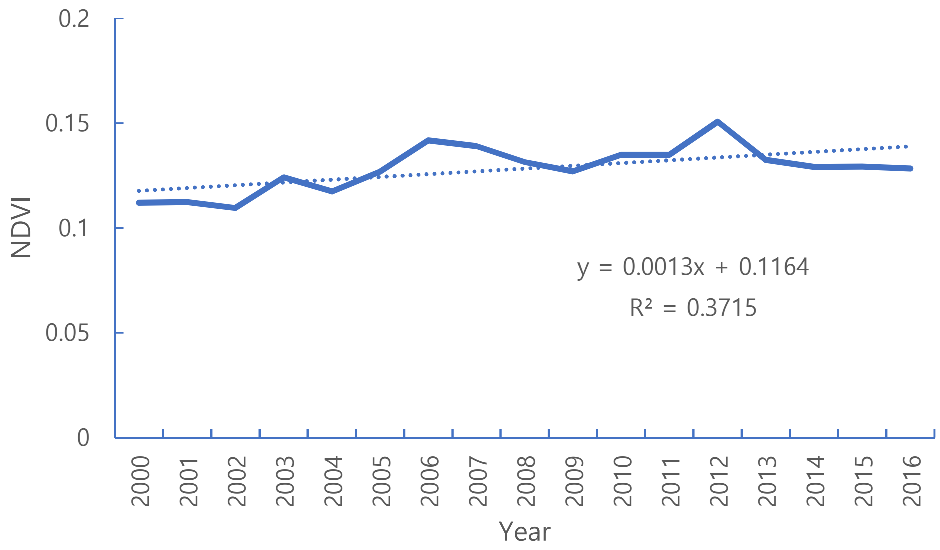

Fig. 5 NDVI variations in Turpan Xinjiang in 2000-2016

- **Discussion**

The study evaluated the social and economic benefits resulted from the five Korea-aided plantation projects. As these projects were implemented more than 13 years ago, it is difficult to separate the contribution of these plantation projects to local social and economic development from other contributors (e.g., investment, technological advancement, policy), Therefore, the team focused on analyzing local social and economic development in the five counties at a general level by using the official statistic data from 2001 to 2015. During this period, the five counties have experienced faster economic development, agricultural development and income increase. The Korea-Aided plantation projects indeed contributed to these achievements in social and economic development. In specific, the plantation in Horqin-zuoyizhong Banner was helpful to increase local crop production; the plantation in Xiuwen County was helpful to develop fruit industry (such as kiwi); and the plantation project in Pingluo County promoted the development of local ecotourism. These developments of agriculture or forestry contributed a lot to the increase in income of local farmers. Although the plantation projects in Baiyin District and Gaochang District only produced ecological benefits rather than economic benefits, they indeed enhanced environmental awareness of local people. It needs to point out that China have implemented several huge ecological engineering programs (e.g., the Three-North Shelterbelt Program, the Natural Forest Conservation Program, the Beijing-Tianjin Sand-Dust-Storm Source Control Program), which provided great ecological benefits as well as socioeconomic benefits. It is difficult to separate the contribution of these plantation projects on social and economic development from other contributors.

- **Conclusions/wider implications of findings**

It is the common goal to control the soil and water loss, as well as improving the ecological and social environment. Therefore, by introducing advanced equipment, Better technologies and superior tree species, we will be able to create a high-quality of ecological forests and Windbreak sand forests, so that we can effectively improve the living environment, promote the development of agriculture and animal husbandry, improve the production and living conditions of local people and mitigate the occurrence of natural disasters.

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