Post-Print: Effectiveness Assessment of the Protection and Construction of the Tibet Ecological Security Barrier

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Date: 2017-02-10T00:00:00+00:00

Abstract

Tibet constitutes the main body of the Qinghai-Tibet Plateau and the core of the Earth' s Third Pole, characterized by exceptionally unique geographical conditions and holding an extremely significant global ecological status. On February 18, 2009, the 50th executive meeting of the State Council reviewed and approved the "Tibet Ecological Security Barrier Protection and Construction Plan (2008-2030)" , proposing an investment of 15.5 billion yuan over nearly five "Five-Year Plan" periods to implement ten projects across three categories—protection, construction, and support and guarantee—with the goal of essentially establishing a national ecological security barrier. By 2015, the first-phase project had been successfully implemented and completed. Pursuant to the spirit of the CAS-Tibet Autonomous Region Science and Technology Cooperation Symposium, and with support from the CAS "Western Action" Program and the "Strategic Priority Research Program" , an effectiveness assessment of the first-phase project for Tibet' s ecological security barrier protection and construction was conducted. The results demonstrate that the first-phase project progressed smoothly and achieved its phased objectives; the alpine ecosystem structure remained generally stable, with an ecological pattern change rate of less than 0.15%; ecosystem services increased slightly and steadily, with a growth rate of 3%-5%. However, Tibet' s ecological environment remains fragile, and the task of consolidating the barrier continues to be arduous.

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Full Text

Assessment on Protection and Construction of Ecological Safety Shelter for Tibet

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Abstract

As the main body of the Tibetan Plateau and the core of the Earth' s Third Pole, Tibet possesses a unique geographical environment and holds extremely important global ecological status. On February 18, 2009, the State Council of China approved the "Protection and Construction Planning of Ecological Safety Shelter for Tibet (2008–2030)" . The plan aimed to construct a national ecological security barrier through nearly five "Five-Year Plan" periods, investing 15.5 billion Chinese Yuan to implement ten projects across three categories: protection, construction, and support. By 2015, the first-phase project was successfully completed. Following the spirit of the scientific and technological cooperation symposium between the Chinese Academy of Sciences (CAS) and the Tibet Autonomous Region, and with support from CAS' s "Action Plan for Western Development" and "Strategic Pilot Science and Technology Projects" , we completed the effectiveness assessment of the first-phase project. Results showed smooth progress with stage objectives achieved. The alpine ecosystem structure remained stable overall, with ecological pattern change rates below 0.15%. Ecosystem services remained stable with a slight increase of 3–5%. However, Tibet' s ecological environment remains fragile, and the task of building a robust barrier remains arduous.

Keywords: ecological safety shelter, effectiveness assessment, ecological engineering, Tibetan Plateau

DOI: 10.16418/j.issn.1000-3045.2017.01.004

Introduction

Tibet represents the main body of the Tibetan Plateau and the core of the Earth' s Third Pole. Its geographical environment is exceptionally unique, and its global ecological status is extremely important. The plateau' s dynamic and thermal effects constitute crucial factors in forming the non-uniform distribution of water vapor in the East Asian monsoon system, profoundly influencing the climate patterns of drought and flood distribution across China and Asia, as well as the evolution of ecological environments. Tibet serves as a "starter" and "regulator" for climate change in Asia and even the entire Northern Hemisphere. As the source of several major Asian rivers, Tibet is renowned as the "Water Tower of Asia," ensuring water security for over two billion people and nurturing both Chinese and Indian civilizations. The region encompasses all terrestrial ecosystem types, including many special types not found in other parts of China or even the world, and hosts unique wildlife species. Tibet represents the world' s primary center for mountain biological species differentiation and formation, earning it the designation of a cold-region biological germplasm repository and establishing it as a globally important biodiversity hotspot.

Over the past decade, CAS has strengthened scientific and technological cooperation with the Tibet Autonomous Region, completing a series of critical tasks including the planning of Tibet' s ecological security shelter protection and construction, establishment of an ecological monitoring system, and construction of the ecological safety barrier. These efforts have provided scientific support for building a national ecological security barrier and promoting ecological civilization in Tibet. Supported by CAS' s "Action Plan for Western Development" and "Strategic Pilot Science and Technology Projects," we have objectively evaluated the effectiveness of the first-phase project, scientifically publicized Tibet' s ecological protection and construction achievements, and provided scientific support for optimizing subsequent ecological projects. On October 26, 2016, the State Council Information Office held a press conference for CAS' s "Assessment on Protection and Construction Project of Ecological Safety Shelter for Tibet (2008-2014)," releasing important progress on the national ecological security barrier construction to the global community with detailed data that scientifically and objectively publicized Tibet' s ecological conservation achievements. This marked the first time in CAS history that research results were released at the State Council Information Office, demonstrating outstanding effectiveness in serving national objectives and driving regional development through scientific and technological innovation.

1 Ecological Safety Barrier Project

An ecological safety barrier refers to a regional ecosystem (primarily vegetation-based) whose ecological structure and processes remain undisturbed or minimally threatened, forming a stable pattern composed of multi-level, ordered ecosystems that provide material production and environmental services essential for human survival and development. The barrier function manifests as protection for the barrier zone, surrounding areas, and national ecological security and sustainable development capacity. During the Fifth Tibet Work Forum, the central government established Tibet as an important national security shield and ecological safety barrier.

On February 18, 2009, the 50th executive meeting of the State Council reviewed and approved the "Protection and Construction Planning of Ecological Safety Shelter for Tibet (2008-2030)" (hereinafter referred to as "the Planning"). The plan proposed investing 15.5 billion Chinese Yuan over nearly five "Five-Year Plan" periods to implement ten projects across three categories—protection, construction, and support—to essentially establish a national ecological security barrier. The first-phase project covered the period 2008–2015.

The ten projects include five key protection projects: natural grassland protection, forest fire prevention and pest control, wildlife protection and reserve construction, important wetland protection, and traditional energy substitution in agricultural and pastoral areas; four key construction projects: shelterbelt system construction, artificial grass planting and natural grassland improvement, sand control and desertification prevention, and soil erosion control; and one support project: ecological safety barrier monitoring engineering [2].

Based on principles of zonal vegetation differentiation, similarity of dominant ecosystem structure and function, geomorphological patterns and type similarity, relative consistency of ecological environment and socio-economic conditions, and watershed integrity, Tibet' s ecological safety barrier comprises three subregions: the northern Tibet plateau and western Tibet mountains dominated by meadow-steppe-desert ecosystems, the southern Tibet and middle Himalayas dominated by shrub-steppe ecosystems, and southeastern and eastern Tibet dominated by forest ecosystems [3] [Figure 1: see original paper].

2 Main Assessment Results

The Planning' s major projects have progressed smoothly, initially establishing the main framework of Tibet' s ecological engineering, with some key projects already demonstrating noticeable ecological and environmental benefits. Tibet' s ecosystems remain stable overall, with enhanced service functions in project areas and steadily improving plateau ecological barrier functions [4,5]. Specific results are as follows.

2.1 Overall Stability of Plateau Ecosystems with Increasing Vegetation Coverage

(1) Over the past two decades, the structure of various plateau ecosystems has remained stable overall, with ecological pattern change rates below 0.15%. Change rates for forest, grassland, wetland, farmland, and bare land were 0.01%, -0.13%, 0.14%, -0.01%, and -0.02%, respectively, with absolute values all below 0.15%, indicating overall stability in ecosystem structure.

(2) Vegetation coverage has increased slightly, with coverage improvement occurring across 66.5% of the region' s territory. Between 2008 and 2014, vegetation coverage showed an upward trend. Areas with coverage increases of less than 5% accounted for 731,200 km², representing 60.9%

of Tibet' s total land area. Areas with coverage increases exceeding 5% accounted for 68,000 km², representing 5.61% of Tibet' s total land area.

2.2 Sand Control and Desertification Prevention

(1) Sandy land area has gradually decreased, with improved ecosystem quality. Following implementation of sand control and desertification prevention projects, sandy land area decreased by 107,100 hm², with an average annual reduction of 15,300 hm² and an annual decline rate of 0.07%. Extremely severe desertified land has transitioned to severe or moderate desertification. In key treatment areas of Shigatse, Shannan, and southeastern Tibet, comparative analysis between project and non-project areas shows soil organic matter and moisture indicators increased by 88.5% and 104.4%, respectively, while plant total carbon and dry weight indicators increased by 9.08% and 58.6%, respectively. Main plant species increased from 29 to 49, and vegetation coverage rose from 5% to over 20% [Figure 2: see original paper].

(2) Forest-grass composite measures demonstrate effective sand fixation, with improved landscape ecology in the Yarlung Zangbo River valley. The Yarlung Zangbo River valley represents a key sand control engineering area. Early-planted trees in the valley have reached 2–3 m in height, with forest canopy density exceeding 0.5, significantly increasing surface roughness and reducing wind speed and erosion intensity near forest edges, thereby slowing sand flow. Ecological projects have improved regional environmental quality and, to some extent, ensured socio-economic security in the area. Statistical results from typical observation areas in the Yarlung Zangbo River valley (Quxu–Sangri section) show disastrous sand-dust weather decreased from 85 days in 2000 to 32 days in 2014, Gonggar Airport' s flight punctuality rate increased substantially, and direct economic losses from land desertification decreased from 120 million to 35 million Chinese Yuan.

2.3 Grassland Restoration from Grazing Withdrawal and Increased Farmer-Pastoralist Income

(1) Grassland coverage and biomass increased significantly in project areas, with improved forage yield. In northern Tibet's grazing withdrawal project areas, vegetation coverage increased by 9.9%–22.5% compared to outside areas, with an average increase of 16.9%. Grass height increased by an average of 2.04 cm (59.8% increase). Aboveground biomass increased by 2.67–13.3 g/m², with an average increase of 24.25%, equivalent to approximately 85.2 kg of dry hay per hectare, representing substantially improved forage yield [Figure 3: see original paper].

(2) Grassland carrying capacity improved, with increased policy-based income for farmers and pastoralists. The grazing withdrawal project promoted

rational grassland utilization, increased livestock off-take rates, accelerated livestock turnover, and improved economic benefits of animal husbandry. Meanwhile, through measures such as grazing prohibition subsidies, grazing withdrawal, and grass-livestock balance, the project implemented grassland ecological protection subsidy and reward policies, increasing policy-based income for farmers and pastoralists by 850 Chinese Yuan per capita annually, achieving a win-win situation for grassland animal husbandry quality improvement, ecological protection, and income growth.

2.4 Increased Clean Energy Usage in Agricultural and Pastoral Areas and Improved Living Conditions

(1) New clean energy usage reached 65.6%, reducing damage to forest and grassland ecosystems. The proportion of clean energy (primarily electricity, solar, and biogas) increased from 20.7% in 2008 to 65.6% in 2014, gradually achieving a transition from heavy reliance on traditional biomass energy to clean, low-carbon energy consumption. This saves over 800,000 tons of firewood, forage, and dried cow dung annually, reducing damage to forests, shrubs, and grasslands while increasing ecosystem carbon sequestration potential. Annual CO emission reductions and standard coal substitution reached 3.412 million tons and 1.255 million tons, respectively. Additionally, organic fertilizer return-to-field ratios increased from 21.6% in 2008 to 64.3% in 2014, strongly supporting green organic agriculture and animal husbandry development.

(2) Clean energy promotion improved living conditions for farmers and pastoralists. The promotion of biogas and solar energy in Tibet' s agricultural and pastoral areas saves households 620 Chinese Yuan annually. Clean energy promotion has changed long-standing household habits of direct contact with livestock manure, greatly reducing the risk of zoonotic disease infection. According to incomplete statistics from disease control departments, the incidence rate per 10,000 people decreased from 350 cases to 62 cases over the past decade.

2.5 Initial Success in Natural Forest and Ecological Area Protection with Recovering Wildlife Populations

(1) Forest coverage in project areas increased slightly. The first-phase natural forest protection project (2000–2014) completed 82,500 hm^2 of ecological public welfare forest construction, increasing forest coverage in project areas from 38.6% to 39.5% (0.9% increase rate). Following the logging ban, total forest resource consumption decreased from 1.505 million m^3 to 694,000 m^3, a reduction of 53.9%.

(2) Nature reserve area reached 413,700 km^2, with significant increases in rare wildlife populations. Tibet has established 47 nature reserves of var-

ious types, covering 33.9% of the region' s territory, including 9 national-level, 14 autonomous region-level, and 24 prefecture/county-level reserves. These protect 125 nationally protected wildlife species and 39 nationally protected plant species. Tibetan antelope populations have increased annually to approximately 150,000 individuals. Black-necked crane numbers reached about 7,000. Wild yak populations increased to approximately 10,000. The Tibetan red deer, considered extinct by international animal research communities, has been rediscovered with an expanding population of about 1,000. The Yunnan snub-nosed monkey, a first-class national protected animal, has grown to over 700 individuals, representing approximately 33% of the national population.

(3) Protected wetland area reached 4.308 million hm^2, with effective protection of alpine wetlands. By 2014, two wetlands—Mapang Yungtso and Medog—were included in the List of Wetlands of International Importance. Tibet established 19 wetland nature reserves at various levels, including nine autonomous region-level or above reserves, and 13 wetlands listed as nationally important, including Qiangtang Lake Basin, Yamdrok Yungtso, Dagai Yungtso, Pangong Yungtso, and Dazhuka marsh wetlands. Additionally, ten national wetland parks (pilot) were established, including Duoqing Yungtso, Galang, Yani, and Nianchu River. This has created a wetland protection system with nature reserves as the main body, supplemented by national wetland parks and wetlands of international and national importance [Figure 4: see original paper].

2.6 Gradually Enhanced Ecosystem Service Capacity and Steadily Improving Ecological Safety Barrier Function

(1) Water regulation functions of ecosystems improved amid fluctuations, with forest water conservation remaining stable. The annual water conservation capacity of forest, grassland, and wetland ecosystems in the region is 91.62 billion m^3, with a unit area water conservation capacity of 750 m^3/hm^2, representing a 2.65% increase after project implementation.

(2) Windbreak and sand fixation functions began to take effect, with reduced intensity in major sandy areas. Before 2008, Tibet' s average annual soil wind erosion was 2.004 billion tons/year, decreasing to 904 million tons/year during 2008–2014. In key sandy areas of the Yarlung Zangbo River valley, prevention and control projects focusing on sand fixation, grass planting, and tree planting have reached scale, with ecosystem windbreak and sand fixation functions beginning to operate. Over the past two decades, wind field intensity in Tibet has weakened, also benefiting ecosystem windbreak and sand fixation functions.

(3) Total ecosystem carbon sequestration increased, with stable and rising carbon fixation functions. Primary productivity of various ecosystems in Tibet showed a slight increasing trend, with total carbon fixation in forests

and grasslands rising slightly. Total carbon fixation in vegetation and soil increased by 16.5 million tons, representing a 2.56% increase.

Conclusion

Building a solid ecological safety barrier represents a major initiative related to Tibet’ s future development. The key ecological projects implemented over the past six years have achieved a good start, with ecological benefits gradually becoming apparent. However, we must fully recognize the long-term and arduous nature of ecological construction. Future efforts will require continued high-level attention and strong support from national and local governments at all levels, strengthened organizational leadership for projects, accelerated implementation of the Planning, vigorous development of ecological Tibet and beautiful Tibet, and ensuring the achievement of the Planning’ s goals by 2030: “effective protection, successful governance, stable improvement, and ecological security.”

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Note: Figure translations are in progress. See original paper for figures.