

The Excellent Effect of Natural-Based Solutions in Blocking Sand and Conserving Water: A Case Study of Saihanba Mechanical Forest Farm in China

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Abstract: "Natural-Based Solutions"(NBS) refers to the environment-friendly way to meet the challenge of sustainable development through the combination of nature and technology. Various countries have carried out a series of explorations and practices in the field of NBS and provided many demonstration cases, including China. And land desertification is the natural enemy of ecological civilization construction, so in order to build ecological civilization, we must attach great importance to the prevention and control of land desertification, and focus on solving the problem of land desertification. Therefore, based on the case of Saihanba Mechanical Forest Farm Project in China, this paper analyzes its problems, measures and implementation plans, further explains how NBS practice in reality, and evaluates the benefits it brings. This will not only enable more people to see the contribution of China to NBS, but also make more people understand the role of NBS and improve the recognition of NBS from people. It will also provide a good case for blocking sand and conserving water for the benefit of countries affected by desertification globally.

Keywords: NBS; Saihanba Mechanical Forest Farm Project; Blocking sand; Water conservation

DOI: 10.62639/sspjinnss04.20250201

1. Introduction

With social progress, climate change, food security, water resources security, disaster risk and other challenges are emerging, threatening the sustainable development of mankind. However, traditional ecological methods, such as relying solely on engineering technology or nature itself to repair and manage ecosystems, have a very limited and single role to play in solving problems. Therefore, in order to promote the sustainable development of human society, it is necessary to explore a new way to deal with complex challenges from a comprehensive perspective, so as to comprehensively manage the social ecosystem^[1]. One of the themes of the UN Climate Action Summit, "Nature-Based Solutions," which took place in New York in September 2019, has received much attention. At present, in many interpretations, the European Commission^[2] defines the "Natural-Based Solutions" as a solution inspired and supported by nature, with being cost-effective and environmental, social and economic benefits, while helping to build resilient social ecosystems. NBS is not a process of "returning to nature", but rather an environmentally friendly approach to the challenges faced through a combination of nature and technology. Therefore, we can view it as a comprehensive approach to addressing the sustainable development challenges of the "social-economic-environment" combination by promoting harmony between man and nature and creating a new and

(Manuscript NO.: JINSS-25-1-1002)

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Funding

National Energy Group Jinjie Company: "Research Project on CO2 Source Sink Matching and CCUS Industrialization Cluster in the Energy Golden Triangle Region" (Contract No.: FW-SC-2022-057-03).

environmentally friendly ecosystem between historical and human ecosystems^[3].

In 2019, desertification land area in China amounted to 2.6116 million square kilometers, accounting for a quarter of the land area. Land desertification seriously restricted the development of the ecological civilization in China^[4]. Although desertification land area in China has been declining for more than 10 years after a long period of unremitting efforts, it must be soberly recognized that China is still one of the most seriously threatened countries in the world by desertification and the task of combating desertification remains arduous. Land desertification is the natural enemy of ecological civilization construction, so in order to build ecological civilization, we must attach great importance to the prevention and control of land desertification, and focus on solving the problem of land desertification. This is not just the case in China. Achieving the goal of zero growth in global land degradation by 2030, set by the United Nations, will require greater efforts by all humankind. Facing the grim situation of global desertification expansion, the experience in desertification control of China may provide reference for the world and contribute to the sustainable development of mankind^[5].

NBS advocates the harmonious symbiosis between man and nature, and attaches importance to the construction of ecological civilization. More than 150 action initiatives have been put forward by various countries and international organizations, compiled numerous demonstration cases on biodiversity protection and forestry protection. These initiatives and cases do not lack the contribution of China. NBS is in line with the idea of General Secretary Xi of "harmony and symbiosis between man and nature" and "lucid waters and lush mountains are invaluable assets"; so China has also carried out a series of exploration and practice in the field of NBS, and actively promoted the work such as biodiversity conservation, forestry protection and water resources security and so on^[6]. Therefore, this paper further explains how NBS is to carry out the practice and benefit evaluation in reality by combining the excellent case of Saihanba Mechanical Forest Farm Project of blocking sand and conserving water in China. It allows more people to see the contribution of China to NBS and make more people understand the role of NBS. This will not only increase the recognition of NBS from people, so that it can be accepted by different value-oriented groups in the process of promotion, but also provide a good case for blocking sand and combating desertification for the benefit of countries affected by desertification globally.

2. A Case Study of Saihanba Mechanical Forest Farm of China

(1) Identification problem

"Saihan" is a Mongolian language meaning beauty. Dam is Chinese, meaning kaolin. Historically, Saihanba is rich in forests with plenty of water and lush grass. At the end of the Qing dynasty, due to the decline of national strength, the Saihanba was opened for reclamation, and the original forest almost disappeared. In addition, fire and deforestation occurred year after year. So at the beginning of the founding of China, the ecological environment of Saihanba seriously deteriorated, becoming a rare wasteland, and the sandstorms from Inner Mongolia pressed Beijing(see Figure 1). In the 1950s, the average dust days in Beijing were as many as 56.2 days a year. The neighboring sandy, such as HunShanDaKe and Badan Jaran, invaded the capital like two hungry lions. However, Saihanba is in the northernmost autonomous county of Hebei, at the southern source of HunShanDaKe sandy land in Inner Mongolia and at a special geographical position that can block the sandstorm(see Figure 2). Some say Saihanba is to Beijing like someone standing on a rooftop and pushing sand towards the courtyard. At the same time, the area of Bashang is the birthplace and main catchment area of the four major rivers of Tidal River, the Luan River, Liao River and Daling River, among which Tidal River and Luan River are the two major water sources of Beijing and Tianjin, which are directly related to the living water safety of urban residents such as Tianjin, Chengde, Chifeng, Tieling, Tiefsa, Xinmin and Panjin^[7]. In 1961, the State Forestry Administration of China decided to set up a large mechanical forest farm in northern Hebei in order to curb the severe situation of the desert approaching Beijing and conserve water resources

in Beijing and Tianjin.



Figure 1. Saihanba in the 1950s



Figure 2. Geographical location of Saihanba

(2) Selection of measures

After the founding of China, the Ministry of Forestry submitted to the State Council the design plan of the Saihanba Mechanical Forest Farm, which had been fully investigated and proved and scientifically planned, and Premier Zhou attached great importance to it and make instructions personally, with a plan of 20 million yuan to complete the afforestation of 746,000 mu within 20 years. In February 1962, four missions were established for the construction of the Saihanba Mechanical Forest Farm^[8]:

- Build a large timber forest base
- Change the natural features of the area, conserve water and soil, and create conditions for changing the wind and sand hazards in the Beijing-Tianjin zone
- Study and accumulate experience in afforestation and forest cultivation in the alpine region
- Study and accumulate experience in the management of large-scale state-run mechanized forest farms

In order to complete the above tasks, Saihanba Mechanical Forest Farm has taken many measures, the following are the main measures.

1) Build a protective system to combat desertification

Beijing has a high latitude, and there is strong wind in winter. After the destruction of the Saihanba primeval forest, Beijing lost its green barrier, and the winter wind drove straight in, leading the wind and sand to invade south. And Beijing is only 180km away from the HunShanDaKe area, the northwest is high and the southeast is low, which will lead to the HunShanDaKe sandy area southward invasion. In view of this reality, Saihanba Mechanical Forest Farm attached great importance to the work of prevention and control of sand, started project for wind and sand source area control around Beijing and Tianjin in time, and took the task of "Change the natural features of the area, conserve water and soil, and create conditions for changing the wind and sand hazards in the Beijing-Tianjin zone" as the main goal. It also set up a special leading group for sand prevention and control, strengthened the special management of funds, and formulated corresponding management methods to form a relatively complete sand control work management system.

2) Increase forest resources and restore ecosystems

In the 1960s, Saihanba had a very harsh natural environment, with only 11.4% of the forest coverage at the beginning of its establishment and a severe destruction of the ecosystem. So, the first priority of Saihanba Mechanical

Forest Farm at that time was afforestation and doing well ecological environment construction. Therefore, Saihanba put forward the comprehensive management mode of combining artificial afforestation and forest closure in accordance with local conditions. Land preparation, tree species selection, seedling selection/ seedling breeding, afforestation, management and protection are all important. In afforestation, plant trees if appropriate, as do shrubs and grasses. And through the combination of tree, shrub and grass, a strong ecological shelter forest system is formed, so as to improve the coverage of forest and grass.

3) Combine production with scientific research to provide a strong technical support

The Saihanba combines the extreme environment of alpine, high altitude, gale, desertification and less rain, and the natural environment is bad. So the common afforestation technology is not suitable at all in Saihanba. Therefore, it combines production with scientific research according to local conditions, and pays attention to the development and utilization of human resources, so as to provide a strong technical support for the development of forest farm. More than 100 graduates are assigned to colleges and technical colleges at that time, and more are imported into forestry technical personnel one after another. They have the ability to solve the technical problems of seedling breeding, afforestation, forestry management and conservation, such as the reform of seedling breeding, land preparation and afforestation density mainly carried out in 1998, and in 1999, the classification of afforestation site types and the design of afforestation model were introduced on the basis of the original, and the technical and economic indexes of different afforestation models were determined by full investigation^①.

(3) Programme implementation

In order to stop the severe situation of the desert approaching Beijing, to conserve the water source in Beijing-Tianjin area, and to construct a solid ecological barrier for Beijing-Tianjin, the problem of afforestation should be solved in the final analysis. Therefore, the Saihanba according to local conditions, adopt the comprehensive management model. Based on the inspiration and support of its own conditions, through land preparation, tree species selection, seedling selection/ seedling breeding, afforestation, management and protection, Saihanba gradually set up a relatively perfect social ecosystem.

1) Land preparation

The purpose of land preparation is to change soil properties, improve soil water storage capacity, create a good growth environment for saplings, reduce the damage to the original ecology, and do not cause new soil erosion^[9]. In the process of land preparation, it is necessary to reasonably determine the way of land preparation and the direction of row spacing by combining the site conditions, terrain and topography.

In order to ensure the afforestation effect of different geology, the ways and time of land preparation are different. The area of Saihanba Forest Farm belongs to the Inner Mongolia Plateau and the excessive zone of Great Xingan Mountains, and the terrain is quite complex, among which the rocky mountain, sandy land and sand dune are the key targets at that time. Therefore, during land preparation, it is necessary to pay attention to the time and method of land preparation for different terrains. For example, the vegetation of sandy land and sand dune land is less and the soil is relatively loose, so it can use conventional hole-like land preparation, the specifications are 50cm×50cm×30cm or 70cm×70cm×30cm, showing the shape of the outer shallow inner depth small reverse slope. The lower edge depth of the hole surface must not be lower than 10cm, and all roots, stones, weeds must be cut off and cleared out of the cave. The land can be prepared during afforestation to reduce soil transpiration and quicksand erosion. As another example, using 80cm×70cm×30cm size fish scale pit or 70cm×70cm×30cm large size hole preparation for stony mountain. The depth of the lower edge of the hole shall not be less than 10cm, and then the small hole of 30cm×30cm×30cm (i.e., the large hole sleeve and small hole preparation method) shall be rectified in the large hole. The stony mountain land were prepared in the summer of the year before afforestation in order to facilitate water storage and moisture conservation and use rainwater to wash the soil in the cave^[10].

2) Tree species selection

Saihanba is a typical semi-arid and semi-humid cold temperate continental climate area. The elevation of Saihanba is 1010-1939.6m and the average annual temperature is -1.4°C. According to the reality of Saihanba, the selection of tree species is very important for successful afforestation. In order to make the afforestation tree species adapt to the forest land conditions and give full play to the forest land production potential, it is proved by investigation and experiment that the main tree planting in Saihanba area is to build arbors. For example, in the selection of tree species, it is preferred to choose *Pinus sylvestris* var. *mongolica*, larch and white birch as the main planting species, which have strong tolerance to drought, cold and barren (see Table 1). In addition, it is necessary to build a green ecological barrier with multiple tree species and combination of arbors and shrubs, so as to play a good ecological protection function, enhance the effect of soil improvement and stabilize the ecosystem.

Table 1. Main planting species in Saihanba

Main Planting Species	Type	Plant Characteristics	Advantage
Larch	Arbor	It is resistant to cold, drought, water and humidity. It has strong resistance to adverse weather and grows quickly.	It has the ability to maintain soil and water and prevent wind and sand. The growth performance is obviously better than that of other tree species, and it has good growth performance and economic benefit.
White birch	Arbor	It has the characteristics of light-loving, cold-tolerant, moisture-tolerant, and rapid growth.	Natural conditions such as climate and precipitation in Saihanba are more suitable for the growth of birch.
<i>Pinus sylvestris</i> var. <i>mongolica</i>	Arbor	It has strong cold tolerance, low temperature tolerance at -40°C or less. The temperature limit is not very sensitive. And it has strong drought resistance and adaptability.	Its root system is very developed, which can adjust its root distribution according to the soil water status, and it does not have high requirements for soil water and atmospheric humidity. It can grow on aeolian sand and sandy soil, and is very suitable for windbreak and sand fixation and soil and water conservation.
<i>Sabina davurica</i> / <i>Hippophae rhamnoides</i> / <i>Caragana microphylla</i> Lam/ <i>Salix gordejvii</i>	Shrub	Sandy shrub, which can survive in the open air in winter	They can grow well under local climatic conditions in Saihanba area.

3) Seedling selection/ seedling breeding

In the first two years, the trees planted under the green seedlings transferred from the northeast area were all dead because of the influence of geography and climate. Therefore, to complete the tree planting task, the Saihanba first figure out the reason for the death of trees: The exotic seedlings are not suitable to the soil and the resistance is too weak. To succeed in planting trees in the Saihanba area, it is necessary to use seedlings adapted to the local soil and environment. So the Saihanba began to tackle technical problems. They first overcame the problem of raising seedlings in the high and cold regions, and then succeeded in raising seedlings in the Saihanba area.

According to the different site conditions and the difficulty of planting, Saihanba afforestation is mainly produced by the tree farm nursery and locally cultivated container seedlings. The selected seedlings must be the "Big Beard" container seedlings with seedling height of more than 25cm, ground diameter of more than 0.4cm, cultivated for more than 2 years, with developed root system, thick trunk, full terminal bud, strong resistance and no diseases and pests. This kind of seedlings has a strong ability of drought resistance and stress resistance, which can improve the survival rate of afforestation^[9]. Specific requirements are shown in Table 2.

Table 2. Specifications for seedlings

Varieties of Trees	Seedling Age (Year)	Height of Seedling (cm)	Ground Trail (cm)	Container Specifications (cm * cm)	Quality Requirement
Larch	2-3	35	-	-	Plump terminal bud, normal color, developed root system, complete needles, no damage, no multi-headed phenomenon.
Pinus sylvestris var. mongolica	2	25	0.6	12*20 15*20	
White birch	2-4	50	0.4	-	
Chinese pine	2	30	0.6	15*20	

4) Afforestation

After the completion of land preparation, seed selection and seedling breeding, the most core steps can be implemented--afforestation. The issues to be considered in afforestation include afforestation density, afforestation season and afforestation technology. When determining the afforestation density, it is necessary to proceed from the afforestation purpose, considering the site conditions, soil thickness, soil fertility, operation difficulty and other factors, to achieve local conditions and use all available space. Some especially difficult areas need to consider the actual situation to decide how to afforestation. For example, in mountainous areas with a high degree of surface exposure and unsuitable for planting trees, it is necessary to make full use of the small biological environment formed by natural conditions such as stony gully, stone pit and other natural conditions to be planted with the appropriate tree species^[11]. The white birch is growing faster and has a slight shade of light. So the afforestation density should not be too large when it is young. And because the birch branches are sprouting early, the afforestation should start as early as possible, so the afforestation time is best in spring^[12]. Other afforestation seasons choose the rainy season at the turn of spring and summer or the rainy season in autumn as the best because the wet environment can provide sufficient moisture for seedling roots^[11].

In addition to afforestation density and season, afforestation technology is more important to the Saihanba area. The geographical environment and climate environment of the Saihanba are relatively special, so the common afforestation technology is not suitable. So the Saihanba combine production with scientific research to innovate the tools applicable to Saihanba and explore their own afforestation technology according to local conditions.

A. Deep-planting technology

When planting, dig the planting hole in the center of the hole on the side of the mountain and cut the bottom to clear the disk root system at the bottom of the container barrel up about 1cm position using the knife or other sharp utensils. Then gently open the barrel skin from the side, straighten the seedlings, take the barrel to put in the hole, soil to 1/3 of the container seedlings, remove the container skin and squeeze with hand. Finally, the soil is divided into two times to fill 2/3 and slightly higher than the container seedling, and the surface of the water collection hole is compacted by hand. So the surrounding compaction is airtight, and the earth ball is upright, complete and not loose^[9]. Through this technology, soil or groundwater can be guaranteed to play a better role and further improve the survival rate of vegetation. Combined with the local situation of Saihanba, the depth is deeper when planting, and the shrub saplings will be planted to the outcrop depth of 5cm after cutting^[13].

B. Transplantation technology of frozen lump in early spring

Generally, the initial afforestation density of early naked root seedlings of *Pinus sylvestris* var. *mongolica* is 333 plants / mu. From 5 to 7 years later, in 3-4 months before soil freezing, take the frozen tree lump and carry it to the suitable forest according to each mu to retain 167 or 222 plants. The frozen tree lump below the ground 25cm or slightly deeper, with snow-mixed soil filling and compaction, then buried on the top of 10cm sand. This early spring frozen lump transplantation technology makes the transplanted *Pinus sylvestris* var. *mongolicum* with a survival rate

of more than 80%, which has become a precedent for afforestation in Saihanba, and has become a "Window Project" popularized and applied in the whole field^[14].

C. Container seedling technology

With the development of the times, container seedling afforestation technology has been adopted in Saihanba Forest Farm in recent years. Loading moist nutrient soil and planting seedlings at the same time by using the plastic cup with the upper mouth diameter of 15-18cm and the cup height of 25-28cm, and then domesticate them after compaction. Slow seedling proper watering, the next spring to suitable forest planting. When planting, deep-planting technology is adopted to ensure that the seedlings are erect, complete and not scattered. The density of container seedling afforestation is generally 167/mu or 111/mu, and the survival rate can reach more than 90%. This afforestation technology has become the typical of the national key shelterbelt project around Beijing and Tianjin, become the forerunner of fine demonstration forest project after entering the 21st century, and the qualified rate of afforestation is up to 95%^[14].

D. Tool reform

In order to solve the difficult problem of container seedling planting and high cost, Saihanba reformed the container seedling planting tools such as invented the afforestation compaction shovel and innovated the pit drilling machine bit. Before planting container seedlings used spades to dig pits, now instead of using a pit machine vertical pit, the depth is equal to the height of the container barrel. According to the actual production needs of Saihanba, the longitudinal cutter is installed at the tip of the bit to form a flat bottom hole, which is consistent with the bottom surface of the container barrel. According to the specifications of the container barrel, the drill bit of different specifications is made, and the diameter of the bit is larger than the diameter of the container barrel by 5cm, which ensures the reasonable space needed to squeeze the solid soil lump. And afforestation compaction shovel can be used to backfill the soil that is rotated by the pit drilling machine bit, squeeze the voids and level the hole surface and cannot damage the soil lump. The invention of afforestation compaction shovel and the innovation of pit drilling machine bit solve the difficult problem of container seedling afforestation with high difficulty and low efficiency, at the same time, it also greatly improves the survival rate of afforestation and brings great economic benefits^[15].

In conclusion, Saihanba reformed and updated afforestation methods and planting techniques for different site conditions, especially for the unique and difficult geology. For example, in sand dunes and wasteland with poor soil quality, the bare root planting is carried out by high-quality seedlings of 3-4 years, supplemented by the planting technology of root powder, water retaining agent and mud, which greatly improves the survival rate of seedlings. At present, the survival rate of naked root seedlings in Saihanba afforestation is above 90%. Another example is the use of large holes for soil barren stone mountain, with the method of soil back-filling to change the growth environment of seedlings. This approach is scientific and reasonable, so that the survival rate of afforestation are above 98%^[15]. According to its own environment, Saihanba constantly reformed and updated afforestation technology, one after another to overcome the difficulties, to complete the afforestation task.

5) Management

A. Management and transportation of seedlings

The management and transportation of seedlings before afforestation is also the key. In the upper area of Saihanba, the windy weather is frequent in winter and spring, and the temperature is low. Therefore, it is necessary to prevent cold treatment of seedlings after afforestation^[11]. In addition, the seedlings planted in autumn are vulnerable to the harm of freezing and uprooting, which reduces the survival rate of seedlings. Therefore, in the spring of the second year after afforestation, when the soil freezing depth reaches the root, it should be trampled in time according to the order of soil moisture content from less to more. When the dead seedlings of afforestation

exceed a certain limit, in order to make the conservation rate of afforestation more than 95%, it is necessary to replant the afforestation land in the next afforestation season. The seedlings of the same species and specifications shall be used for replanting, and the seedlings of the same age shall be used as much as possible^[16].

In the process of transportation, the first thing is to give enough water. Two days before the seedlings leave the nursery, the foot bottom water must be poured in order to fully penetrate the water and keep the substrate in the container intact and not loose^[9]. In order to keep the moisture content of the seedlings, it is necessary to ensure that the seedlings do not lose water during the transportation, such as short-distance transportation using straw curtain packaging, and watering at any time to prevent the seedlings from drying, and long-distance transportation using plastic bags, transport vehicles using canvas shelter^[16]. Secondly, to prevent damage. In the process of seedling raising, the actions shall be standardized, and it is strictly prohibited to carry seedlings, so as to avoid container breaking, scattering and damage of seedlings. Finally, unified management. When the seedlings arrive at the site of the mountain farm, they should take the nearest centralized management, and the seedlings who spend the night in the mountain yard should be centralized placed, sprinkled with water, covered with grass curtain and so on, so as to avoid the exposure time is too long, the water evaporates, the low temperature is frozen, and the root system is damaged^[9].

B. Seedling tending

After afforestation, the seedlings are still in the seedling stage. In order to improve the survival rate of the seedlings, the staff should cover the seedling bed to reduce the water loss, and then remove the covering after the seedlings germinate. It is also necessary to correct the seedlings according to the actual situation, remove weeds by hand, and remember to protect the seedlings and their roots. Especially in alpine areas, because of the scarcity of precipitation, seedlings need to be watered regularly to ensure the water supply in the process of seedling growth. In case of rain, the state of seedlings should be timely checked after rain. If the seedlings are pressed by rain, they should be straightened in time and the hole surface should be arranged^[11]. For example, after the new planting of young *Pinus sylvestris* var. *mongolica* forest in Saihanba, in order to make the young forest spend a long winter, it is necessary to trample again and prevent cold. At the same time, when tending seedlings, we should pay attention to timely weeding on the site with large vegetation coverage, so as to fully expose the seedlings and let the sun shine directly. This can avoid the competition between weeds and afforestation seedlings for water, making afforestation seedlings grow normally, and can improve afforestation preservation rate^[14].

C. Other management work

In addition to the management and protection of seedlings, other management and protection work should be done well. At present, Saihanba has established a system of management, protection and allocation of afforestation achievements of young forest land, which not only makes clear the responsible land and meets the requirements of who is responsible for the management and protection, but also effectively avoids the harm of people and animals and consolidates the afforestation achievements^[9]. At the same time, combined with digging protective ditch, erecting fence and other sealing measures to prevent people and animals from entering the harm, Saihanba has strengthen the prediction and forecast of pests and the occurrence of rodent damage. In addition, it is necessary to cut shrub (grass) according to the growth of young trees in the afforestation land. Generally, All shrubs within 60cm around the seedlings or all shrubs in the afforestation land must be cut off, and the stubble height must be less than 10cm^[9]. Cutting shrubs and weeding is an effective way to promote the growth of trees. It is necessary to determine the intensity of weeding and cutting shrubs according to the composition of tree species and water conditions of young forest land. However, in the main larch plantations, without affecting the growth of larch, natural sprouts such as white birch, Mongolian oak, aspen and so on can be retained properly to cultivate coniferous and broad-leaved mixed forest^[16].

(4) Benefit assessment

The Saihanba Mechanical Forest Farm, which was established in 1962, now has 6 forest farms, 26 departments and 14 units directly under it, with a total operating area of 1.4 million mu. Over the past 58 years, several generations of forest people in Saihanba have been sticking to the plateau outside the Great Wall, enduring extremely hard work, life and natural conditions, overcoming all kinds of difficulties, making selfless contributions and unremitting efforts. Finally, in the inaccessible wasteland, a million acres of forest and a vivid world of beautiful mountains, birds and flowers have been built. Saihanba Mechanical Forest Farm has made remarkable achievements and benefits in various aspects^[17].

1) Economic benefits

“Plants make a country rich”. To protect the ecological environment is to protect the productive forces and to improve the ecological environment is to develop the productive forces. In 2019, the area of artificial larch forest created by Saihanba ranked first in China. The value of trees is over 4 billion yuan, and the annual growth volume of trees increases by about 800,000 cubic meters, with a value-added of 300 million yuan. According to the accounting evaluation of the Chinese Academy of Forestry, the economic benefits created by the forest farm also reached 20.2 billion yuan, with seedlings and tourism driving the total local social income of more than 600 million yuan a year. At present, the commercial forest management of Saihanba Forest Farm mainly focuses on cultivating medium and small-diameter timber stands, providing the country with a total of 1.92 million cubic meters of medium and small-diameter timber stands, and will gradually increase the size of large-diameter timber stands in the future. It is preliminarily estimated that the forest farm will produce economic benefits of about 72 million yuan per year. Through the construction of seedling base and the rational management of the existing nursery, the annual economic benefits of selling improved seed seedlings will be about 5 million yuan^[17-21].

In August 2016, the first batch of carbon sequestration projects in Saihanba Forest Farm was issued by the National Development and Reform Commission for 182,800 tons, which has become the largest voluntary emission reduction project of forestry carbon sequestration in China. In the first half of 2017, Saihanba Forest Farm opened an account on the Beijing Environmental Exchange and began trading in forestry carbon sinks. According to the market situation and price trend of carbon sink trading, the first batch of carbon sink afforestation and forest management projects of Saihanba Forest Farm can bring over 100 million yuan of revenue after the transaction is completed^②. By December 2017, Chengde cooperated with Beijing to carry out domestic cross-regional carbon emissions transactions, and had completed 13 carbon sink transactions with a volume of 69,000 tons and a profit of 2.541 million yuan, becoming the first city in the country to carry out cross-regional carbon sink projects. At the same time, the local also actively explores cross-regional energy rights, water rights, emission rights and other ecological products transactions, and has completed 158 emissions trading, the proceeds of 23.9 million yuan^[19].

In addition, through the construction of the project, the ecological environment quality of the forest farm has been greatly improved, and the attraction to tourists is constantly improving. Preliminary forecast shows that the current average annual ecotourism revenue is about 84 million yuan. The construction of Saihanba National Forest Park, with the state-owned forest management unit as its brand, has brought great economic advantages, formed a considerable brand of Saihanba, and created a brand value of more than 730 million yuan. And through the economic construction under the forest, Saihanba can provide the society with wild flowers, wild vegetables, fungi and livestock and other ecological organic products. Preliminary forecast, annual economic income under the forest is about 5.5 million yuan^[21-22]. Forest farms provide more than 150,000 temporary social workers a year, creating more than 20 million yuan in labor income, which has led the farmers around them to develop rural tourism, farming, green seedlings, mountain and wild specialty collection, marketing, handicrafts and other industries. Each year, the total social income can reach more than 600 million yuan, which plays an important role in promoting poverty alleviation and green development.

2) Ecological benefits

The miracle of Saihanba Forest Farm is the true portrayal of “Green Rich Country, Green Benefiting People “. According to the accounting and evaluation of Chinese Academy of Forestry in 2007, Saihanba can generate 12 billion yuan of ecological service benefits every year. Nowadays, the forest quality and ecological value of Saihanba are still increasing, which benefits Beijing and Tianjin and the local people. It is known as “the emerald of North China”^[20].

A. The forest resources have been greatly increased, and the artificial forest ecosystem has been rebuilt

At present, the total operating area of Saihanba is 1.4 million mu, of which there are 1.12 million mu of forest land, 80% of forest coverage and 10.12 million cubic meters of forest volume, which is the largest artificial forest farm in North China(see Figure 3)^③. In addition, the territory of Saihanba also contains 5A class scenic spots, which covers an area of 93,300 hm², and is also a national forest park and a national nature reserve^[18]. Saihanba cultivated forest resources that accounted for 35% of the total state-owned forest stock in Hebei province with the forest land that only accounted for 13%. The forest stock per unit area is 2.76 times of the national average level of plantation and 1.58 times of the national average level of forest. Forest carbon reserves exceed 8 million tons, and the total value of forest assets reaches 20 billion yuan. More importantly, the biodiversity of Saihanba has been effectively restored, with 293 species of wild animals and 625 species of plants, forming an ecosystem of forests, meadows and wetlands, which has built a solid green barrier for the Beijing-Tianjin region and effectively organized the sandy land invasion to the south^④.



Figure 3. Plantation in Saihanba

B. Blocking the source of sand, protecting the source of water and maintaining the ecological security of Beijing and Tianjin

Forest is the “lung” of the earth and the continuation of life on the earth. Saihanba National Forest Park is an important green treasure house of Chengde City and even Beijing-Tianjin-Hebei region, which contains rich wealth. Saihanba National Forest Park has dense forests, and various trees can effectively regulate the local ecological environment. On the one hand, forests can effectively regulate precipitation; on the other hand, they can reserve water resources. At the same time, Saihanba Forest Farm is located in the north of Beijing and the south of Hunshandak Sandy Land in Inner Mongolia. The forest sea on Saihanba has formed a solid green barrier, which effectively blocks the invasion to Beijing by wind and sand, blocks the southward invasion of Hunshandak Sandy Land, and avoids soil erosion and desertification of sandy land(see Figure 4)^[17].

According to the calculation of the State Forestry Administration, the amount of water conservation and regulation in Saihanba forest area is equivalent to the capacity of a large reservoir. According to the annual water consumption of 120 tons for a common family of three, the annual water conservation and regulation capacity

of Saihanba National Forest Park can be used by nearly 1.05 million families^[22]. In addition, according to statistics, Saihanba currently conserves and purifies water 238 million cubic meters annually, and delivers 137 million cubic meters of purified water to Beijing and Tianjin every year, ensuring the safety of drinking water for residents and serving as an important ecological barrier to guard Beijing and Tianjin^⑤.



Figure 4. Satellite map of the Saihanba area

C. Adjusting the climate, preventing and reducing disasters

Forests have an important function of regulating ecological climate. Densely forested areas tend to have more moisture, more rainfall, and distinct climate differences from areas without forests. According to the actual situation of Saihanba National Forest Park (see Figure 5), it is found that Saihanba National Forest Park effectively changes the local rainfall, temperature and microclimate. Saihanba National Forest Park has significantly more rainfall than surrounding areas.

According to the analysis of NASA website pictures and TM satellite image data, the temperature of Saihanba National Forest Park in summer is significantly lower than that of the surrounding areas, and the temperature difference reaches 10-15°C. The average temperature in Saihanba forest region is 5.8-10.8°C lower than that in the surrounding areas after removing the influence parameter of elevation 4.2°C^[22]. Compared with the initial period of construction, the average annual frost-free period in Saihanba area increased by 14 days, the average annual precipitation increased by 100 mm, and the number of gale days decreased by 28 days (see Table 3). Meanwhile, in the past 58 years, the temperature in Saihanba area has only increased by 0.2°C, and the drought and flood disasters have also been significantly reduced^[17].



Figure 5. The landscape in Saihanba forest

Table 3. Comparison of the situation before and after the establishment of Saihanba Mechanical Forset Farm

Period	Forest Land Area/ million mu	Percentage of Forest Cover/%	The Number of Gale Days Per Year/ Days	Annual Precipitation/ mm	Frost-free Period/ Days
Before	0.24	12	83	<410	52
After	1.12	80	53	460	64

D. Fixing carbon, releasing oxygen and purifying air

It is estimated that Saihanba Forest Farm can provide 137 million cubic meters of clean water for Beijing and Tianjin every year, fix 747,000 tons of carbon dioxide, and release 544,000 tons of oxygen, which can be used for 1.992 million people to breathe in one year. The total carbon sink of the entire ecosystem is about 7 million tons per year^[17]. Anion in the air has the functions of sterilization, dust reduction, air cleaning, etc., which is known as “air vitamin and auxin”. The total number of anions that can be released in Saihanba National Forest Park is 1.15061×10^{24} each year. The average concentration of anions in the air of the forest is $2000-3000/\text{cm}^3$, and the highest value can reach $84600/\text{cm}^3$ ^[22].

3) Social benefits

Saihanba Forest Farm insists on exploring the development of green industry and forming a diversified economic model. Their experience strongly proves that forest is a reservoir, bank and grain bank, as well as an important natural resource supporting economic and social development.

A. Creating a large number of jobs and driving regional economic development

Through fully exploiting the forest potential and increasing the economic benefits of the forest, Saihanba also combines forestry construction with precision poverty alleviation, vigorously develops the green industry, and helps more poor people to achieve employment income and stably shuck poverty. Over the years, Saihanba has contributed nearly 100 million yuan of profit tax for the country, providing a large number of jobs for the surrounding farmers. Especially in recent years, the increasingly developed forestry industry and the booming forest tourism industry create tens of thousands of jobs for the local area every year, and realize the total social income of more than 600 million yuan^[17].

B. Playing a leading role in demonstration

Over the years, Saihanba Forest Farm adheres to large-scale development and has become an area with rich biodiversity, perfect forest structure, beautiful forest environment and powerful forest functions in China. Saihanba Forest Farm has given full play to its important advantages of specialization, organization, scale and intensification in promoting land greening, green development and improvement of people’s livelihood, and has become an important model for the development of state-owned forest farms.

Under its demonstration function, it has successively launched many projects such as “Bashang Eco agriculture Project” and “Reconstruction of three Saihanba Forest Farm Project”, published many professional books and completed many forestry scientific research achievements, among which many technical achievements have been popularized and applied^[17]. At present, the task of afforestation and ecological protection and restoration in China is very arduous. The 60% of the remaining barren mountains and wastelands suitable for afforestation are distributed in arid and semi-arid areas such as Saihanba, which are the hardest hard bones to gnaw[®]. Therefore, the success of Saihanba Forest Farm has set up a banner in China, has been affirmed and praised by the state and leaders at all levels, and has also been generally recognized by the whole society. Saihanba Forest Farm has also become a successful model for the construction of state-owned forest farms in China. According to the experience of Saihanba, all over the country are also striving to build a number of large-scale forest farms with an area of more than one million mu, striving to rebuild several Saihanba, forming a large area of “Green Lung” and “Green Kidney”, and truly building a solid green Great Wall in North China^[17].

C. Promoting ecological civilization and scientific and technological innovation

Saihanba has made great achievements in “Wasteland into a Forest, Sand into an Oasis”, but also has created the “Saihanba Spirit” of “Hard work, Selfless devotion, Scientific integrity, Exploiting& innovating and Devotion to work”. The spirit of Saihanba has transcended the boundaries of region and industry and become the spiritual motive force and precious wealth of the people to build ecological civilization^[17]. And with the rise of the forest eco-tourism industry, the number of visitors to Saihanba every year is about 500,000, and every visitor here has received a profound ecological education, which has enhanced the awareness of environmental protection and forest protection. Saihanba, therefore, has become the education base for hard work and entrepreneurship of Hebei forestry, the only normal education base of reconstructing beautiful mountains and rivers set up by the State Forestry Administration and the ideological education base of the working committee of the central state organs. In addition, in the case of material and technology almost blank, Saihanba insists on solving technical problems by relying on science, combines scientific theory with the specific reality of Saihanba and makes bold innovation to continuously carry out scientific and technological research and complete more than 60 scientific research projects in 9 categories, breaking a successful model of scientific and technological innovation to promote the sustainable development of forest farms^⑦.

The Saihanba Forest Farm has played an important role in personnel training, science and technology promotion and demonstration, ecology and ideological education, effectively spreading ecological culture and promoting ecological civilization^[17]. The great achievement of Saihanba Forest Farm, which vividly explains the inherent unity of development and protection, is a strong proof of General Secretary Xi’s scientific judgment that “lucid waters and lush mountains are invaluable assets”, which playing an exemplary and leading role in firmly establishing the new development concept and the consciousness of “lucid waters and lush mountains are invaluable assets”, and actively participating in the construction of a beautiful China^[20].

3. Results

NBS is in the exploration stage. As a solution to the challenge of sustainable development from a comprehensive perspective, China is constantly testing its effectiveness through practice. The success of Saihanba Mechanical Forest Farm Project is just proof of the excellent effect of NBS in blocking sand and conserving water. Saihanba put forward the comprehensive management mode of combining artificial afforestation and forest closure in accordance with local conditions. In afforestation, Saihanba adheres to planting trees if appropriate, as do shrubs and grasses. During land preparation, Saihanba is designed for specific terrain and soil conditions, such as sandy land preparation and stony mountain land preparation. Because the Saihanba Mechanical Forest Farm is greatly affected by the geographical and climatic environment, the drought resistant and sand resistant tree species, such as *Pinus sylvestris* var. *mongolica*, Larch and White birch, were selected and successfully bred in the alpine area of Saihanba. In addition, Saihanba adapted to local conditions, innovated the tools suitable for Saihanba, and explored their own afforestation technology. NBS of Saihanba Mechanical Forest Farm Project not only forms a strong ecological protective forest system with the organic combination of arbor, shrub and grass, greatly increases the forest resources, rebuilds the artificial forest ecosystem and completes the ecological tasks of blocking sand, conserving water, maintaining the ecological security of Beijing and Tianjin, but also brings huge economic and social benefits. More importantly, NBS of Saihanba Mechanical Forest Farm Project not only has excellent effects in blocking sand and conserving water, but also shows its advanced nature in engineering afforestation, forest management, pest control, wildlife protection and utilization in high altitude areas. Among them, the far-reaching technologies include Saihanba Forest Farm, through research and demonstration, explores how to manage the trees according to the tree species and forest species, so as to make the tree species and forest species design more scientific^[23]; Through repeated exploration, the systematic management technology of seedling raising and afforestation in alpine and

high-altitude areas has been explored, which has filled in the blank of all-light seedling raising in domestic alpine areas, making the local forestry seedling raised and afforestation technology market-oriented and large-scale become a reality and being promoted and applied; Saihanba Forest Farm summarized the afforestation technology of afforestation technology of *Pinus sylvestris* var. *mongolica* in sand wasteland, technology of windbreak and water conservation by covering soil, container barrel afforestation, big seedling transplantation and other technical measures for afforestation in sandy land. The adoption of these measures greatly improves the survival rate and preservation rate of afforestation and greatly accelerates the progress of sand control in Saihanba area^[24].

In conclusion, although NBS is currently in the exploration stage, we can see the role of NBS in blocking sand and conserving water through the case of Saihanba Mechanical Forest Farm Project, and also see the contribution of China in the field of NBS. As early as 2003, General Secretary Xi put forward the important argument that "If ecology prospers, civilization prospers; if ecology declines, civilization declines". From the royal hunting grounds 300 years ago, to the sandy wasteland 58 years ago, and to the green forest sea now, China has always adhered to the spirit of Saihanba, and constantly created a miracle of the world that the wasteland becomes a forest sea. With practical actions, it interprets the green development concept of "lucid waters and lush mountains are invaluable assets".

Acknowledgments: We are grateful to the teacher Rong Kang, Beibei Shi and Nan Li for their guidance and help in the process of writing.

Conflicts of Interest: The authors declare no conflicts of interest.

Notes

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