Case Study Paper

Study on the Joint Construction of Ecological Control and Green Infrastructure in Desertification Area

-- a Case Study of Ulan Buh Desert Area

Jiamin Zhou, Beijing Forest University, China
Yun Qian, Beijing Forest University, China
Yunlu Zhang, Beijing Forest University, China
Keli Wang, Beijing Forest University, China

Abstract

The Ulan Buh Desert is located at the edge of the arid zone in the central Eurasian continent, which is one of the main sources of the Yellow River sediment and sandstorms in Northeast Asia. The project site, at the junction of the Ulan Buh Desert, the Hetao Irrigation District and the Yellow River Beach, has abundant groundwater source, unique geographical landscape and sensitive ecological environment. any changes in the regional ecological pattern may lead to significant impacts on the living environment of hundreds of millions of people within tens of millions of square kilometers in the middle and lower reaches of the Yellow River. However, in the past, ecological management, economic development and the construction of human settlements in local area have worked independently. Traditional grazing-based production ways and disorderly scattered settlements consume huge natural resources, leading to the continuous spread of desertification and the increasingly harsh human settlement environment. Therefore, through the construction of a comprehensive and sustainable desertification spatial management system, we can solve the contradiction between the abundant natural resources, the fragile ecological pattern and the need to improve the human settlement environment in this area.

Firstly, we construct the technical system of territorial spatial identification and landscape evaluation system. Then, we built three systems, an ecological landscape infrastructure system, an vertical circular agriculture system and an efficient and centralized human settlement environment construction system, to realize the sustainable development of local "ecology-production-life". Finally, we monitor the landscape performance of desertification control through the construction of a comprehensive, scientific, parameterized and multidisciplinary dynamic, "sky-air-ground" integrated ecological monitoring system.

The desertification spatial governance system achieves a high degree of integration of multiple landscape elements, which ensures the beautiful prospects can be realized mostly through a natural-driven sustainable process. What's more, this system connects the management system and ecological management of multi-scale and multi-level, to realizes the transmission and implementation of the planning results. Finally, the system achieves the joint promotion of socio-economic, ecological issues and living environment simultaneously in desert ecologically sensitive areas.

Keywords

Desertification Control, Eurasia, The Ulan Buh Desert, Green Infrastructure

1. Introduction

The Ulan Buh Desert is one of the eight major deserts in China, located at the edge of the arid zone of central Eurasian continent. the desert has the most abundant water resources in China. It's is one of the main sources of the Yellow River sediment and sandstorms in Northeast Asia as well as the main source of aeolian sand in Beijing-Tianjin-Hebei Urban Agglomeration.

The study area, Dengkou Inner Mongolia, locates at the northeast of Ulan Buh Desert, at the junction of the Ulan Buh Desert, the Hetao Irrigation District and the Yellow River Beach. Dengkou has rich groundwater resources, unique geographical landscape, strong solar radiation and strong wind energy resources. the total amount of available water resources is 810 million m^3, of which 60% is not utilized. The annual average total solar radiation is 1686 kwh, and the annual average wind energy resources is 150W/m^2. (Figure 1.)

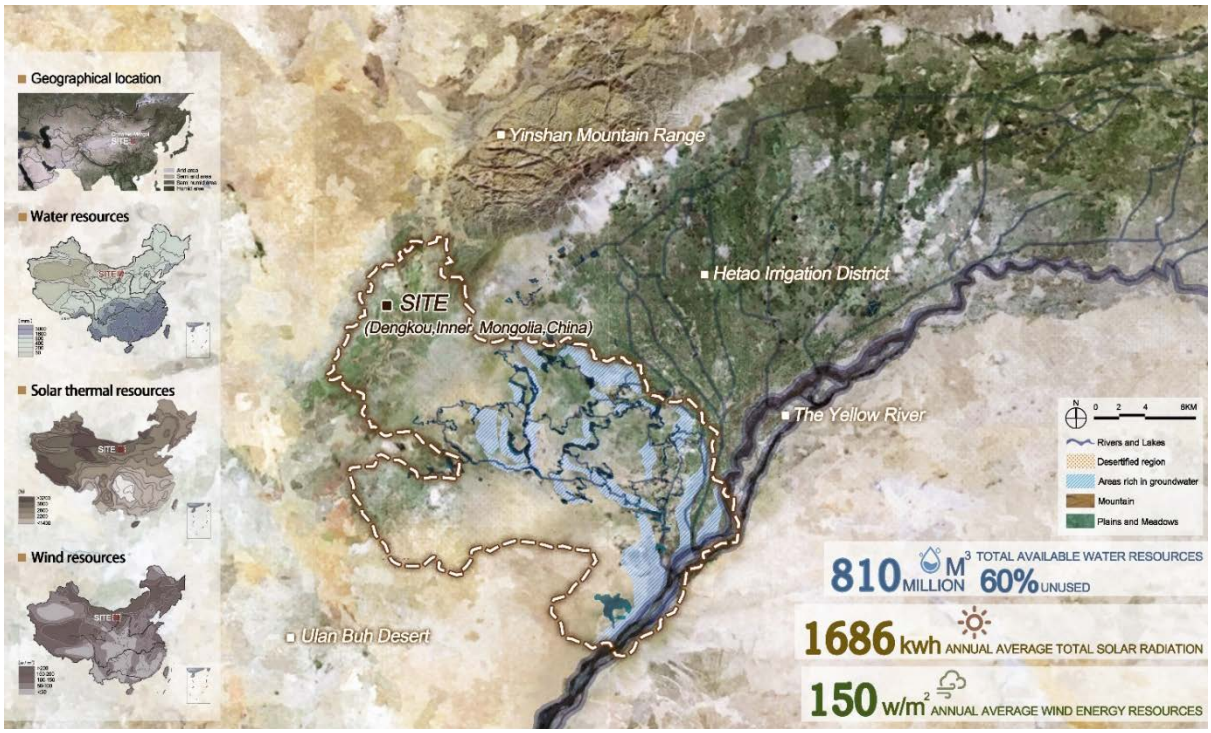

Figure 1. location map of the study area. Source: Author Drawing.

The ecological environment of Dengkou is highly sensitive, and any change of ecological pattern within the region may have a significant impact on the living environment of 140 million people living along the Yellow River, including more than 50 large and medium-sized cities, 1.6 million hectares of cultivated land. But for a long time, ecological governance, economic development and the construction of human settlements in the region were separated. local ways of grazing and scattered living were inefficient in the use of natural resources, leading to severe desertification and harsh living environment. Deserted area increased by 143 km^2 within eight years and desert covers 72% of the area. However, the traditional way of ecological restoration is too simple to gain the ecology and the economic return.

In addition, infrastructure in the region is poor. Only 5.4% of the resident with pipe water and 12.7% of resident with heating. The average annual income of residents is only 60% of the national level.

The contradiction between the local abundant natural resources, the fragile ecological pattern and the demand of improving the human settlement environment is extremely intense. There is an urgent need for a scientific model and path to control desertification.

The global desert area accounts for 41% of the total land area[1], and desertification has spread to more than 110 countries and regions in the world. At present, there are several desertification control models: (Table 1.)

Table 1. Main Models of desertification control. Source: Author Drawing.

Types	Government-oriented	technology-oriented	industry-oriented
Content	Through promulgating a series of policy decrees and the law on land development and desertification control, the government provides strong policy , legal guarantee and a lot of financial support for the smooth implementation of the strategy of desert control.	The combination of advanced technology with applicable desertification control measures, within rational utilization of limited water and land resources, can promote the speed of prevention and control and obtain various benefits.	On the basis of improving the living and ecological environment, focus on the construction of industrial system to promote the regional economic development.
Features	Remarkable results with large capital investment.	The cost and the technical requirement is high.	Neglect the combination with desertification control technology. lack of perfect technical implementation path.
Represent countries or regions	The United States[2] , Canada[3] , Germany[4] and other developed countries.	Israel[5], Arabia[6], etc	Australia[7], Egypt[8], Iran[9] and China's Xinjiang[10]

Government-oriented and technology-oriented depend on high-input, high-cost technology system, while industry-oriented lack of perfect technology implementation path. But this project area needs a comprehensive desert space management system that can integrate various natural resources, joint promotion of socio-economic, ecological issues and living environment, and has perfect implementation path.

Therefore, this paper takes Dengkou as the study site, to explore the integration of the latest technologies in ecological monitoring, desertification control, green agricultural production and human settlement environment construction, forming a comprehensive desert space governance system. Finally realized the coordinated promotion of the social economy benefit, the ecology benefit and the human settlement environment construction in desert ecology sensitive area.

2. Materials and Methods

Based on the demand of ecological governance and green infrastructure construction, a planning system is constructed: Quantitative Science Identification Technology System + Green Development System + Dynamic Monitoring System (1 + 4 + 1 system). This system aim at realizing the coordination and integration of local ecological civilization and green development, and promoting the formulation of local norms and regulations. In addition, it can give birth to a number of green infrastructure planning projects and a set of desert management evaluation system. (Figure 2.)

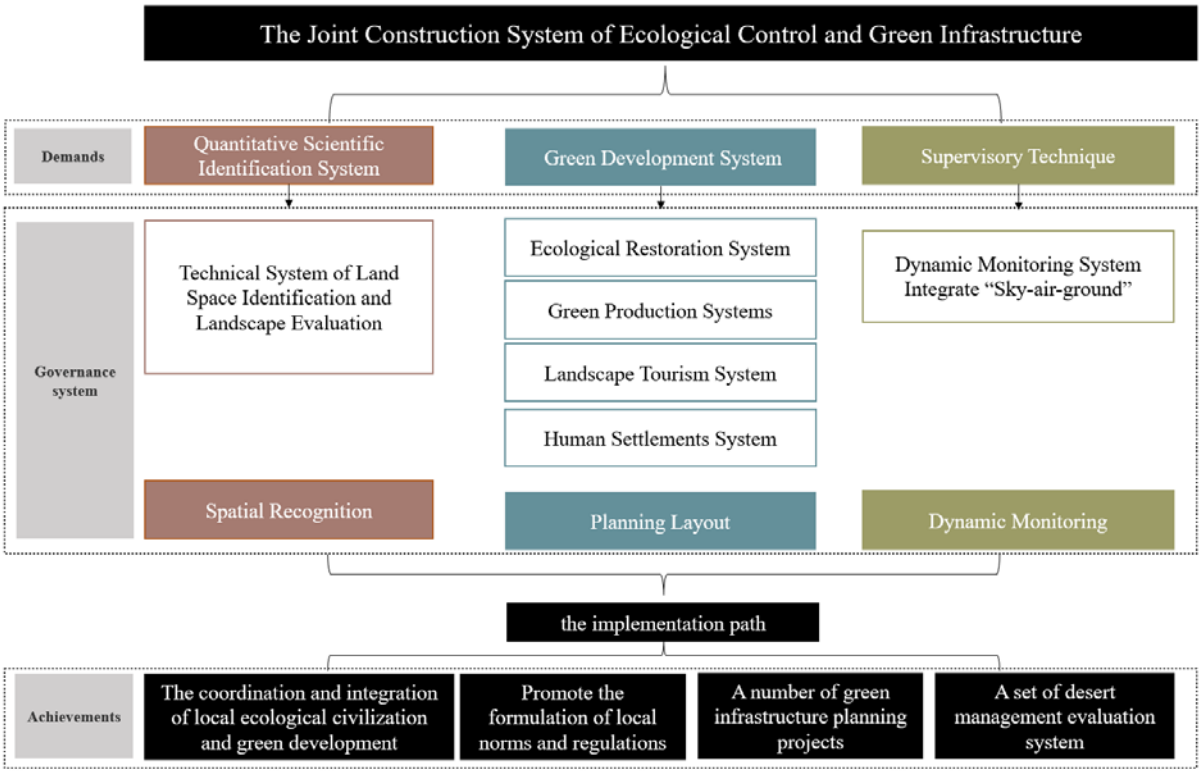

Figure 2.The Joint Construction System of Ecological Control and Green Infrastructure. Source: Author Drawing.

3. Results

3.1 Technical System of Land Space Identification and Landscape Evaluation

3.1.1 Acquisition of Indicator Information based on Remote Sensing Imagery and Large Data

By using the research data, includes basic geographic information data, land use data, Remote Sensing (NNP, NDVI) data, digital elevation (Dem) data, meteorological data, soil data, socio-economic statistics data, the Present Situation of Dengkou is systematically analyzed, including climate, land, vegetation, water systems, agriculture and tourist attractions.(Figure 3.) Totally account 16 indicators.

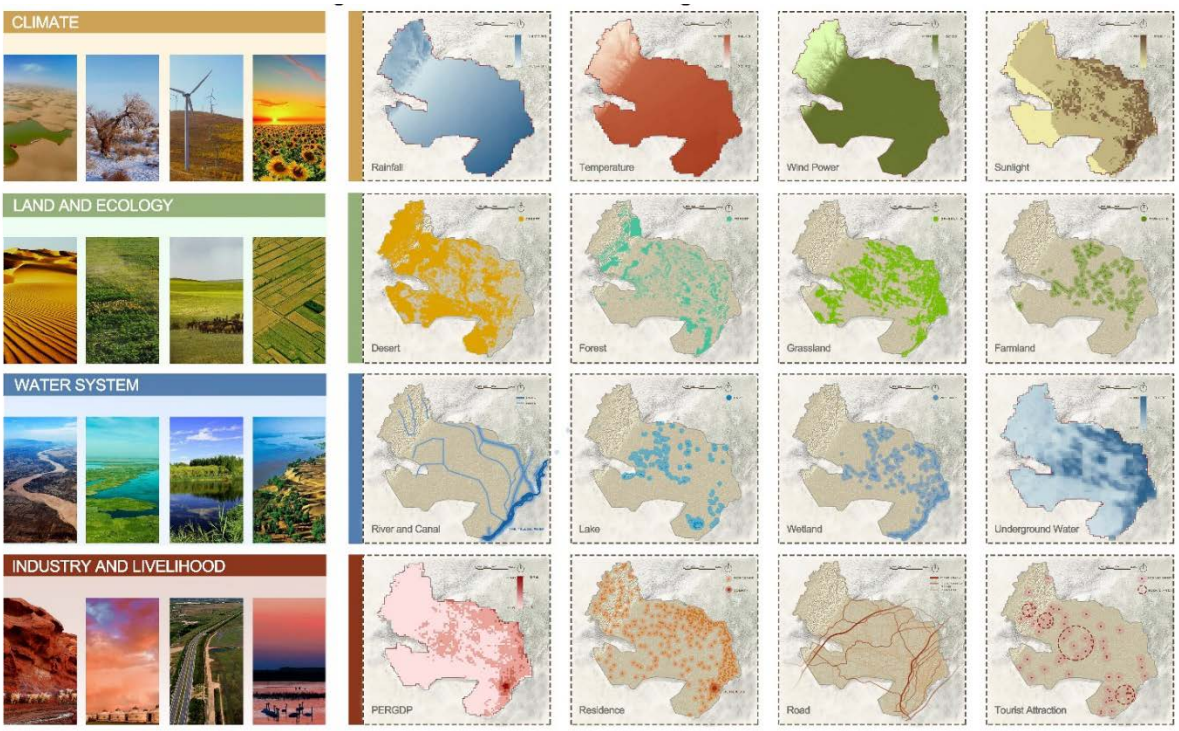

Figure 3. Analysis of Resources. Source: Author Drawing.

3.1.2 Quantifying Index based on GIS Platform and Constructing Applicability Evaluation System

Based on comprehensively consideration of the various natural ecological and socio-economic factors' present distribution characteristics, six evaluation indexes are determined from three aspects: Ecosystem Service Capacity Evaluation, Ecological Sensitivity Evaluation, Suitability Evaluation (Figure 4.). Then the corresponding weight ratio is determined by the expert scoring method[11], and the results are weighted and superimposed. Finally, according to the scores, we determined the ranges of the Desert Utilization Core Area, Desert Utilization Conservation Area and Desert Utilization Buffer Zone in the region (Figure 5.).

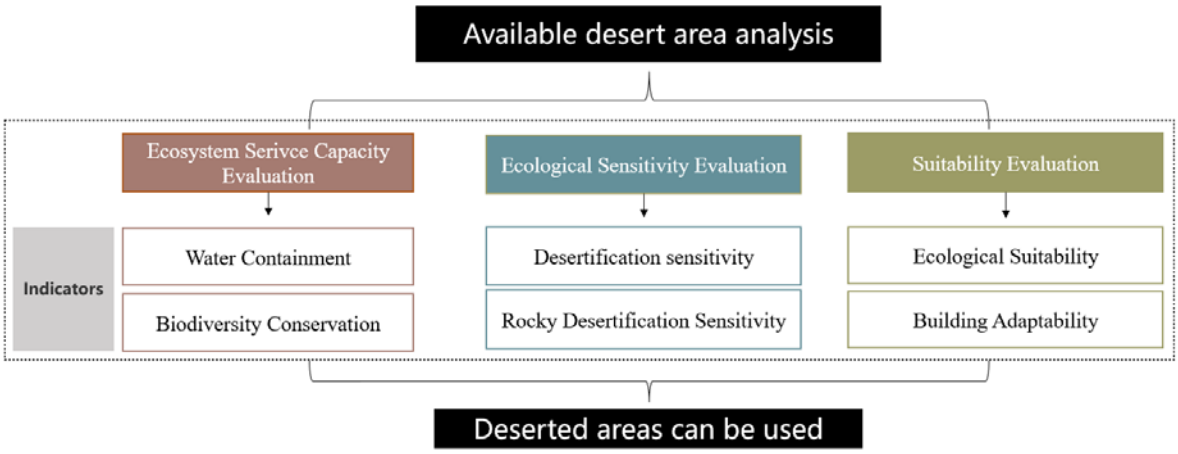

Figure 4. Deserted areas Evaluation System. Source: Author Drawing.

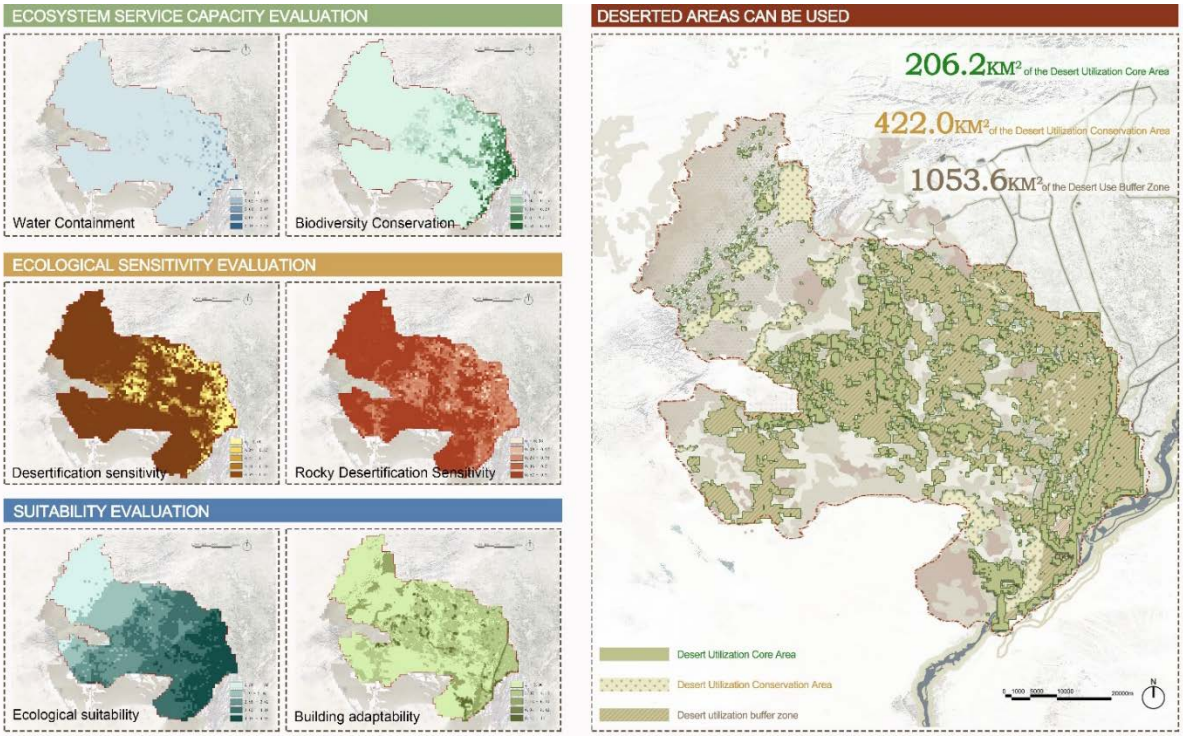

Figure 5. Deserted areas Evaluation Result. Source: Author Drawing.

3.2 Construction of Ecological Development System

Based on the practical problems in the fields of ecological restoration , agriculture and animal husbandry production, landscape tourism and human settlements, aimed at the four aspects of achievements: ecological management, landscape, vertical utilization of water resources, activation of cultural tourism and reconstruction of living space, in order to realize the sustainable development goal of “Ecology-production-life”, four systems are planned, including Ecological Restoration System, Green Production Systems, Landscape Tourism System and Human Settlements System. (Figure 6.)

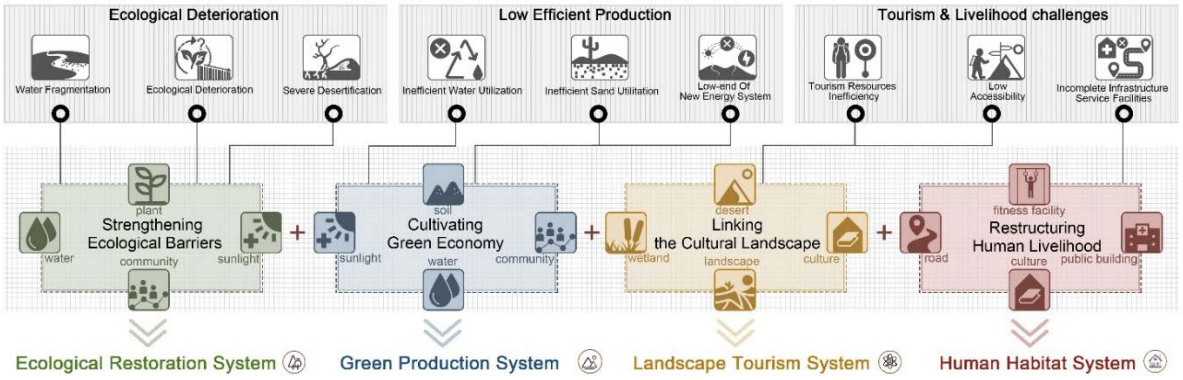

Figure 6. Planning Objectives. Source: Author Drawing.

3.2.1 Ecological Restoration System

Along the foot of the mountain, the water channel system and the river bank wetland, “Two belts, three veins, two nets ”and seven cores consist a landscaping forest system are established for sand prevention, including Sand-blocking forest belt, Landscape revetment forest belt（Table 2.）, forest veins along the

hills grass square base/the roads/canals(Table 3.), shelter forest net for farmland/grassland/residential area(Table. 4), which established a sustainable network pattern.(Figure 7.)

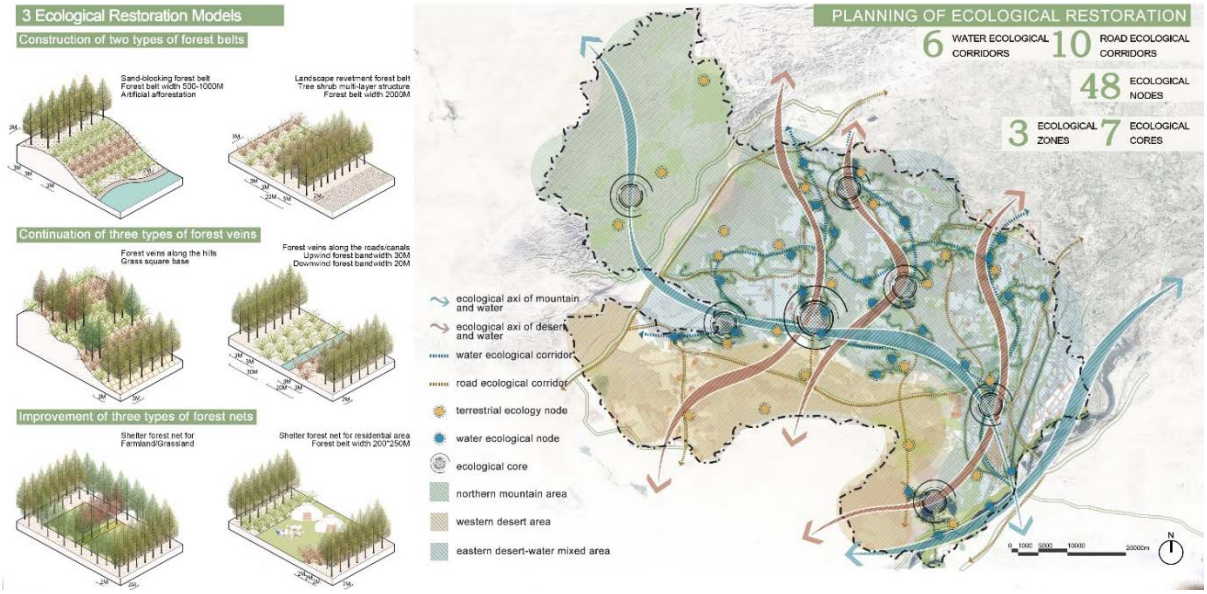

Figure 7. Ecological Restoration System. Source: Author Drawing

Table 2. Types of Forest Belts. Source: Author Drawing

Types of forest belts	Width(m)	Planting pattern	Irrigation pattern
Sand-blocking forest belt	500-1000	The combination of arbor and shrub	Water saving measures of drip irrigation
Landscape revetment forest belt	2000	The combination of Artificial shrubbery with arbor and shrub	Water saving measures of drip irrigation

Table 3. Types of Forest Veins. Source: Author Drawing

Types of forest nets	Width(m)	Spacing in the rows
Forest veins along the hills grass square base	/	Trees: 2m* 3m Shrubs: 3m * 3m
Forest veins along the roads/canals	Upwind direction: 30m Downwind direction: 20m	Trees: 2m* 3m Shrubs: 3m * 3m
Forest veins along the canals	Trees: 20m Shrubs: 10m	Trees: 2m* 3m Shrubs: 3m * 3m

Table 4. Types of Forest Nets. Source: Author Drawing

Types of forest nets	Specifications	Spacing in the rows
Shelter forest net for farmland	200m×250m	2m*2m
Shelter forest net for grassland	200 m×300m	2m*2m
Shelter forest net for residential area	200m×250m	2m*2m or 2m*3m

3.2.2 Green Production Systems

On the land with superior solar thermal soil conditions, a vertically distributed “new high-efficiency agricultural and animal husbandry production system” is constructed, including 5 modes of photovoltaic agriculture (Figure 8.). We planed Preservation Technology Lab, photovoltaic agricultural experimental area, Mongolian-chinese Herbs Lab, other related industries, and supporting infrastructure such as rapid transport routes. Finally, a photovoltaic agricultural landscape will be formed, promoting land productivity by 60 per cent.

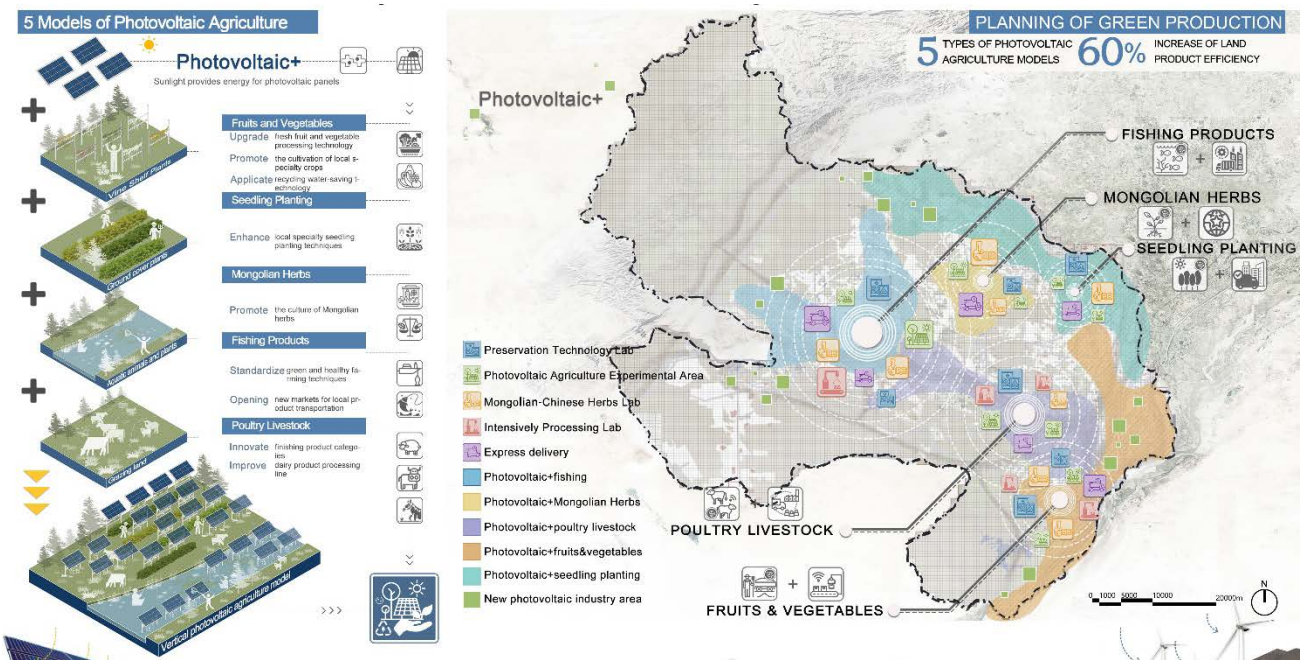

Figure 8. Green Production Systems. Source: Author Drawing

3.2.3 Landscape Tourism System

By full re-organize various lakes, wetlands, sand-bearing agriculture and other historical relics into four theme scenic tourist routes: wetland ecological experience, desert ecological landscape, desert sports and leisure, traditional culture sightseeing. A total of 26 tourist destinations and 254 km scenic routes has been built, forming a rich level of experience-based landscape tourism system. (Figure 9.)

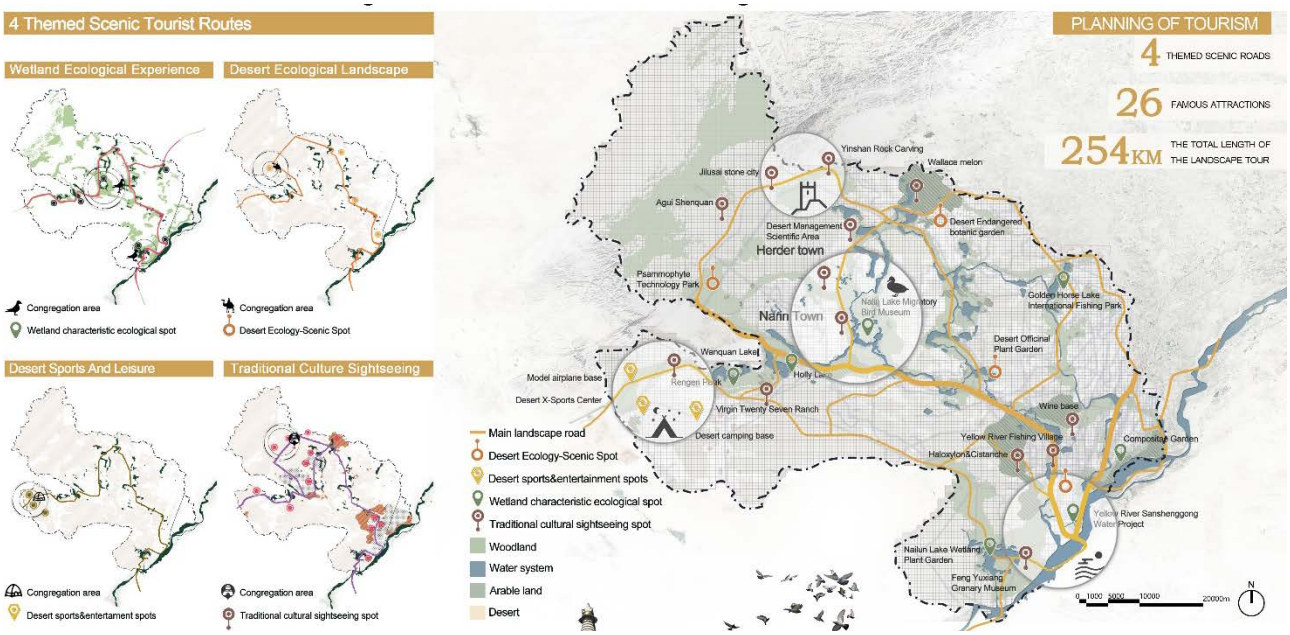

Figure 9. Landscape Tourism System. Source: Author Drawing

3.2.4 Human Settlements System

By restructuring local human livelihood environment into three new towns， building three industrial parks and gradually forming numbers of rural settlements, residents are guided to take up employment in three main modes: Travel-services, Green-planting and Ecology-engineering. Promote the efficient use of infrastructure for residents to achieve poverty alleviation. (Figure 10.)

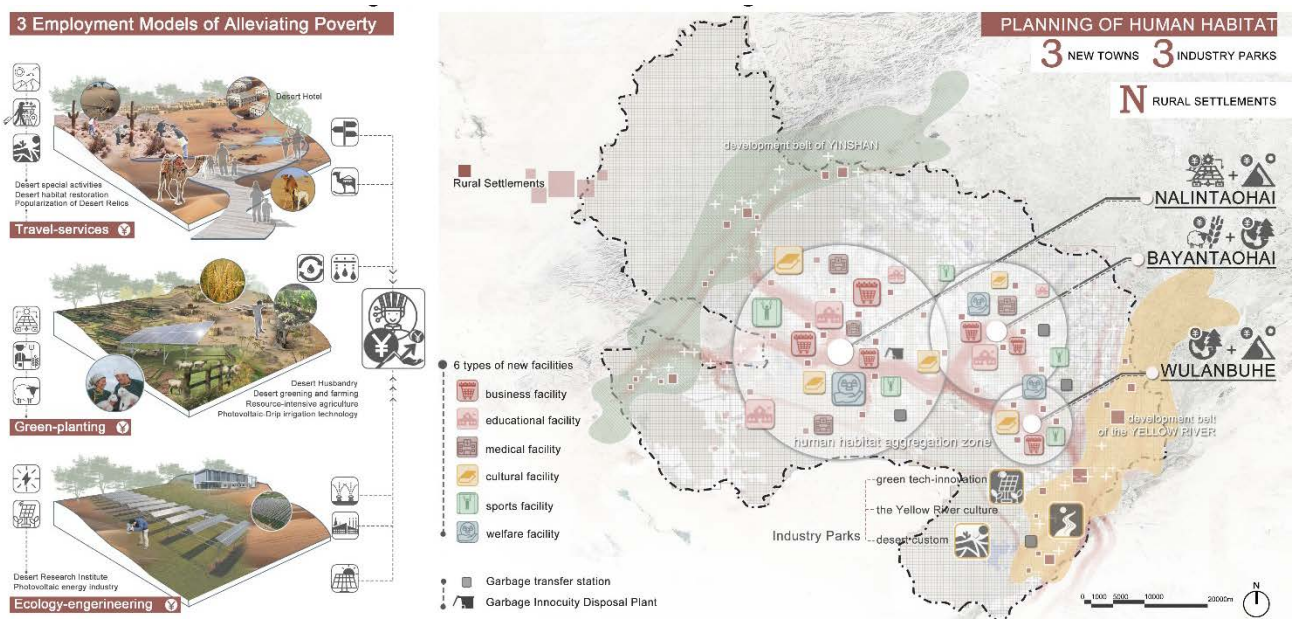

Figure 10. Human Settlements System. Source: Author Drawing

3.3 Dynamic Monitoring System

It is one of the most important contents for desert disaster prevention to identify, discover and monitor the potential hazard of land desertification and dune movement. Based on using a variety of techniques, we propose a dynamic monitoring system:

1. we use satellite remote sensing to survey and identify the project area in a large-scale: monitoring and analysis of space movement by multi-source satellite data, and then gain automatic comparison between new satellite images and historical satellite images in the recording system to generate change patterns. Finally we build sub-meter, meter, 1-30 meters, 250-1000 meters and MODIS database to check every year, and form the database of the desert movement spatial distribution map in the region.

2. we carried out a detailed survey of the areas prone to desertification: we use the UAV drone routes with multi spectral sensors to obtain view images of the area and desertification images, and then extract the change of deserted area by model calculation.

3. we establish the ground monitoring stations to monitor the desertification point: use the automatic ecological monitoring station and a variety of monitoring equipment to monitor the desertification point in real time. The detection data includes many monitoring technical index data, which can be transmitted to the terminal cloud platform for data management.

By using of remote sensing, drone routes, and the establishment of ground monitoring stations, a “Sky-air-ground” integrated, scientific, parameterized and multi-disciplinary dynamic monitoring system of desertification control planning performance has been formed.

3.4 planning the implementation path

To ensure that planning can be well implemented. We build a comprehensive governance and operational pattern by constructing a Multiple-stockholders partnership (Figure 11.). Planning designers, local government, local residents, enterprises, brand holders and other multi-role can participate in the implementation of planning, to achieve multi-participation and multi-benefit.

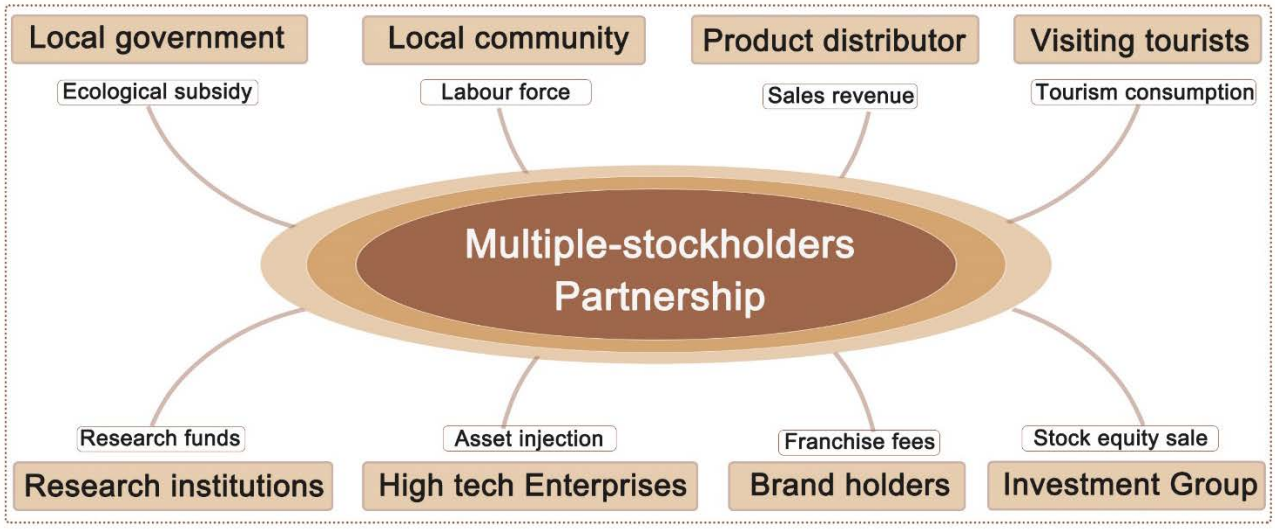

Figure 11. Operational Pattern. Source: Author Drawing

4. Conclusion & Discussion

Relying on this project, a lot of research and practice have been carried out in the area, and many ecological restoration technology centers and sand vertical high-efficiency planting demonstration areas have been built. From 2018, the afforestation area is 800 km^2. 490 km^2 of forest quality improved. 650 km^2 of vertical agriculture and animal husbandry projects has been constructed. 12 key tourism projects has been built, including desert towns, National Desert Park Cluster, etc. The efficiency of agricultural output increased by 60 per cent, and the area of deserted areas was reduced by 168 km^2. The coverage of water supply, electricity supply and heat supply reached 100 per cent. The local per capita income level increased by about 135 per cent, and all local people were out of poverty in 2019.

The study is issue-oriented and takes full account of the current ecological environment and living space in the ecologically fragile areas in the Ulan Buh Desert, and coordinates the development goals of ecological, economic and human settlement environment. The desertification spatial governance system achieves a high degree of integration of multiple landscape elements, which ensures the beautiful prospects can be realized mostly through a natural-driven sustainable process. What's more, this system connects the management system and ecological management of multi-scale and multi-level, to realizes the transmission and implementation of the planning results. Finally, the system achieves the joint promotion of socio-economic, ecological issues and living environment simultaneously in desert ecologically sensitive areas.

An integrated desert management system, suitable for the Ulan Buh Desert and similar ecologically fragile areas, will be formed to realize the "Ecology-production-life" promotion.

References

[1]Li Wenlu, Tan Jianxiong, Zhang Jiangfeng. 'Study on the coupling and coordination of rural tourism development, rocky desertification control and rural revitalization —— based on the case of karst area in Qiannan Prefecture', *Agricultural Resources and regionalization in China*,2021-09-14, p1-11.

[2]Gregory S. Okin, Bruce Murray, William H. Schlesinger. 'Desertification in an Arid Shrubland in the Southwestern United States', *Land Degradation,* p53-70

[3]Zanchetta, A., Bitelli, G. & Karnieli, A. 'Monitoring desertification by remote sensing using the Tasselled Cap transform for long-term change detection', *Nat Hazards,* 2016(83), p223–237

[4]Zhao Sen,Wu Xiuqin,Zhou Jinxing,Pereira Paulo. 'Spatiotemporal tradeoffs and synergies in vegetation vitality and poverty transition in rocky desertification area', *Science of the Total Environment*,2021,752, p56-63.

[5]Li, D., Xu, D., Wang, Z. et al. Ecological compensation for desertification control: A review. J. Geogr. Sci. 28, 367–384 (2018). https://doi.org/10.1007/s11442-018-1478-9

[6]Abdallah, S.M., Massoud, E.E. Land degradation risk assessment in Al-Sawda terraces, Kingdom of Saudi Arabia. Arab J Geosci 11, 599 (2018). https://doi.org/10.1007/s12517-018-3956-x

[7]Ning Baoying, Ma Jianxia, Jiang Zhide. 'Influencing factors and conceptual model for suiTableility assessment of eco-control Technologies: A Case Study of desertification control technologies', *China desert*, 2020,40(02) ,p9-16.

[8]Ahmed. 'Desertification in Egypt: Current Status and Trends'. Conference Proceedings Kubuqi International Desert Forum, 2015/08/01

[9]Farshad Amiraslani, Deirdre Dragovich. 'Combating desertification in Iran over the last 50 years: An overview of changing approaches', *Journal of Environmental Management*,2011,92, p1-13,

[10]Guo Zecheng, Wei Wei, Shi Peiji, Zhou Liang, Wang Xufeng, Li Zhenya, Pang sufei, Jie Binbin. 'Spatio-temporal pattern of land desertification sensitivity in arid region of northwest China', *Journal of Geography*, 2020,75(09), p1948-1965.

[11]Hanchen Duan,Tao Wang,Xian Xue,Changzhen Yan. 'Dynamic monitoring of aeolian desertification based on multiple indicators in Horqin Sandy Land, China', Science of The Total Environment,2019,650,10 February, p2374-2388