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Governing a Large Country: Strategic Choices and Future Vision for Desertification Control in China (Postprint)

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Abstract

Over the past 70-plus years, China's continuous desertification control efforts have achieved tremendous accomplishments. Currently, China's desertification control has entered a new stage, still facing issues such as a large base area of sandy land and high difficulty in governance, and needs to comprehensively meet national strategic demands including ecological construction, rural revitalization, and the development and utilization of wind and solar power in desert, Gobi, and sandy areas. In the new era, China's strategic choice for desertification control is holistic improvement and prioritized breakthroughs, with the strategic core being comprehensive territorial governance, innovation-driven development, and technology integration. The institutional arrangement of classified policy implementation is the comprehensive implementation of the "One Desert, Four Systems" approach (conservation, prevention, treatment, utilization), striving to win the "Three Major Symbolic Campaigns" in the "Three-North" afforestation battle, prioritizing the layout of a batch of key demonstration projects, accelerating policy updates, and creating a new technological engine. These efforts aim to improve the quality and efficiency of desertification control, blueprint a beautiful vision of Chinese-style modernization featuring the integration of the "three lives" (production, living, ecology) and harmonious coexistence between humans and sand, and promote the "China Solution" for desertification control to go global and benefit the world.

Full Text

Preamble

Special Issue: Comprehensively Prevent and Control Desertification to Win the "Three-North" Battle

On June 6, 2023, during his inspection of Bayannur City in Inner Mongolia Autonomous Region, President Xi Jinping presided over a symposium on strengthening comprehensive desertification prevention and control and advancing key ecological projects such as the “Three-North” shelterbelt program, delivering an important speech. He emphasized that strengthening comprehensive desertification prevention and control and deepening the “Three-North” and other key ecological projects is vital to China’s ecological security, its development as a great nation, and the sustainable development of the Chinese nation—a noble undertaking that benefits both contemporary and future generations. Over the past 45 years, China has achieved remarkable success in desertification control and “Three-North” project construction: forest coverage in the project area has increased from 5.05% to 13.84%, more than 45% of manageable sandy land has been initially treated, 61% of soil erosion areas have been effectively controlled, and 450 million mu of farmland has been protected by shelterbelt networks, pioneering a path of sand prevention and control with Chinese characteristics. While past achievements have been substantial, future tasks remain arduous. Over the next decade, China urgently needs new scientific and technological engines to fight the “Three-North” project battle. Based on outcomes from multiple scientific programs—including the National Science and Technology Basic Resources Survey Special Project, the National Natural Science Foundation of China, and the Chinese Academy of Engineering’s Strategy and Consulting Project—the *Bulletin of Chinese Academy of Sciences* has organized this special issue on “Comprehensively Preventing and Controlling Desertification to Win the ‘Three-North’ Battle.” This issue presents China’s strategic choices and future vision for desertification control, as well as implementation pathways and strategic planning for the new phase of “Three-North” project construction, aiming to create new miracles in sand prevention and control with Chinese characteristics and provide new momentum for the “Three-North” battle. The issue was jointly guided by Chief Scientist Lu Qi from the Chinese Academy of Forestry and Researcher Lei Jiaqiang from the Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences.

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China’s Governance: Strategy Choice and Future Vision for Combating Desertification

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Abstract

China has achieved tremendous success in combating desertification over the past 70 years. Currently, China has entered a new stage of desertification control while still facing challenges such as a large base of desertified land and high difficulty in treatment. It must comprehensively meet national strategic needs including ecological construction, rural revitalization, and the development and utilization of wind and solar energy in desert, Gobi, and wasteland areas. The strategic choice for China's desertification control in the new era is overall improvement with key breakthroughs. The core of this strategy is whole-area governance, innovation-driven development, and technology integration. The institutional arrangement involves fully implementing the "one desert, four mechanisms" approach (cultivation, prevention, treatment, and utilization), striving to win the "three iconic battles" of the "Three-North" project, prioritizing the deployment of key demonstration projects, accelerating policy updates, and building a new engine of scientific and technological innovation. This will improve the quality and efficiency of desertification control, chart a beautiful vision of Chinese-style modernization featuring the integration of production, life, and ecology with harmony between humans and deserts, and promote China's desertification control solutions to the world for global benefit.

Keywords: combating desertification, sand prevention and fixation, ecological governance, strategy choice, future vision

Over the past 70 years, China's continuous efforts in desertification control have yielded remarkable achievements. The trend of desertification expansion has been fundamentally curbed, achieving "double reduction" (both desertified and sandy land areas and severity decreased) across three monitoring cycles (national desertification and sandy land monitoring conducted every five years). A series of major national ecological projects have ensured ecological security in arid and semi-arid regions, generating certain ecological benefits. Research indicates that China's ecological restoration projects have made important contributions to achieving the UN Sustainable Development Goals (SDGs). Between 2000 and 2017, China contributed 25% of the world's "greening" with only 6.6% of global vegetation area, with ecological projects led by the forestry and grassland sector accounting for 42% of this contribution. Vegetation coverage in northern China increased significantly from 1981 to 2013, with the most notable improvements in the Loess Plateau, Northeast China, and central Xinjiang. This analysis suggests that ecological projects were the main driver of "greening" in northern China. Between 2000 and 2010, national major ecological projects contributed half of the carbon sequestration in project areas. Since 2000, China has ranked first globally in net land restoration area, contributing nearly one-fifth of the world's total. Over the past two decades, sandy land area in the Beijing-Tianjin sandstorm source region has continued to decrease, with research showing that ecological projects focused on desertification control

were the main driving factor, while natural factors accounted for less than 1% of changes, proving that ecological improvement in this region did not simply “depend on nature’s mercy.” The quality and functions of ecosystems in China’s desertification areas have steadily improved, with enhanced ecological services. Future conservation patterns in desert and desertified areas need to strengthen synergy with regional development.

On June 6, 2023, at the symposium on strengthening desertification prevention and control and advancing key ecological projects such as the “Three-North” program in Bayannur, Inner Mongolia, President Xi Jinping emphasized that “the current situation shows that desertification prevention and sand control in China remains severe. We must fully recognize the long-term, arduous, repetitive, and uncertain nature of sand control work, further raise our political stance, and enhance our sense of mission and urgency.” Currently, China’s desertification control technologies, models, and policies are basically well-developed and will be further promoted to countries along the “Belt and Road.” From humans retreating before sand to humans advancing and sand retreating, the future will achieve harmony between humans and sand, with institutional advantages, inclusive policies, and strategic choices serving as important guarantees. However, China has a large base of desertified and sandy land. According to the sixth national desertification and sandy land survey, by 2019, desertified land covered 2.5737 million km² (26.8% of national territory), and sandy land covered 1.6878 million km² (17.6% of national territory). The overall ecological environment in northern arid and semi-arid regions remains sensitive and fragile. The Horqin and Otindag sandy lands in the east remain important sand sources, the central Yellow River’s “Jiuzigou Bend” area faces compounded water, sand, and salinity hazards, and the western Hexi Corridor-Taklamakan Desert edge still has incomplete management of sandstorm passages and heritage site protection. Some technological gaps, funding shortages, and institutional deficiencies persist, and the supporting role of science and technology has yet to be fully realized. There is an urgent need to develop strategic designs for desertification control to achieve sustainable management of desertified areas.

The new era presents a strategic opportunity for China’s desertification control, requiring alignment with SDGs and shouldering the responsibility of China’s ecological civilization construction to provide a “Chinese solution” for global ecological governance. Through overall improvement and key breakthroughs, China will prioritize protection of pristine deserts, prevent and control hazards according to local conditions, and efficiently utilize resources to improve people’s livelihoods and achieve human-sand harmony. In terms of scientific and technological support, a comprehensive system for research, development, demonstration, extension, and popularization of desertification control technologies and models will be established. Based on these elements, this paper proposes strategic choices and a future vision for China’s desertification control.

1. State-Led Strategic Upgrading

Over the past 40 years, China has implemented a series of major ecological projects including the “Three-North” project, Beijing-Tianjin sandstorm source control, natural forest protection, returning farmland to forest and grassland, and integrated protection and restoration of mountains, rivers, forests, fields, lakes, grasslands, and deserts, leading to improved ecological conditions in northern China. A nature reserve system with national parks as the main component has been initially established, with large areas of natural desert incorporated into protected zones. Six cycles of desertification and sandy land monitoring have clarified China’s sand “conditions,” and a long-term observation and research network has been initially established in desert areas. Currently, the relationship between scientific desert management and desertified land development has been basically rationalized compared to 40 years ago, with production, life, and ecology achieving basic harmony in some areas. The concepts of whole-area and systematic governance have been scientifically developed, with integrated, high-quality green development of ecological security becoming a regional priority.

1.1 Whole-Area Governance and “Skin-and-Fur” Combined Treatment

China has creatively developed and enriched the new ecological construction concept of integrated protection and restoration of “mountains, rivers, forests, fields, lakes, grasslands, and deserts.” Based on differences among these seven elements, a “skin-and-fur” combined treatment system has been developed (Figure 1 [Figure 1: see original paper]). Here, “mountains, rivers, lakes, and deserts” constitute the “skin,” representing land carrying capacity attributes, while “forests, fields, and grasslands” constitute the “fur,” representing land productivity attributes. The “skin” includes the ground surface and below, serving as the matrix for “fur” growth, with emphasis on ecological land planning in ecological construction. The “fur” includes vegetation growing above ground, with resource optimization based on the “skin’s” carrying capacity.

The “skin-and-fur” combined treatment represents a simple summary of whole-area, comprehensive, and systematic governance, containing multiple layers of understanding. Within the “skin,” ecological security must be ensured internally, such as addressing the Ulan Buh Desert’s sand flow into the Yellow River (sand-water), Helan Mountain mining area ecological restoration (mountain-sand), and Dunhuang West Lake ecological management (sand-water-lake). Within the “fur,” high-quality integrated development must be achieved among forestry, grassland, and agriculture sectors, such as in returning farmland to forest and grassland and restoring degraded grasslands in farming-pastoral transition zones. Between “skin” and “fur,” optimal allocation of vegetation productivity must be based on land carrying capacity, such as in farmland/oasis shelterbelt construction and whole-area management of the Horqin sandy land/grassland.

In northwestern arid and semi-arid regions where desertification control tasks are heavy, “mountains, rivers, forests, fields, lakes, grasslands, and deserts” often present multi-element and multi-hazard 叠加 situations. Taking the Yellow River’s “Jiuzigou Bend” as an example, this area lies in both the Yellow River basin and the northern sand prevention belt, containing all seven elements (Yinshan and Helan mountains, the Yellow River, ten major tributaries, windbreak and sand-fixing forests, Hetao Plain grain base, Ulansuhai Nur, Urad grassland, and Ulan Buh Desert). It faces compounded water hazards (Yellow River’s hanging river), sand hazards (sandstorm disasters, coarse sand entering the river), and salinity hazards (salinization), with prominent contradictions among production, life, and ecology (ecological water and land use) that are highly overlapping regionally and consistent in nature, requiring integrated whole-area governance solutions. In arid oasis areas, water, sand, and field contradictions are prominent, with high risks of salinization threatening food security. Therefore, in desertification control, especially in ecological construction spatial layout, vegetation construction should be scientifically planned according to the natural endowment differences of the “skin.”

1.2 Conceptual Innovation and Learning from Nature

China’s desertification control philosophy has experienced three stages: the initial stage of mass mobilization and advancing into deserts; the development stage driven by national will and major projects; and the new stage of whole-area, comprehensive, and systematic governance. The most prominent challenges differed in each historical stage, with corresponding priorities. In the new era, China has implemented a series of conceptual innovations, emphasizing learning from nature. Current mainstream global ecological governance concepts such as sustainable development and Nature-based Solutions (NbS) are reflected in traditional Chinese culture. For example, the *Zhou Shu · Daju Pian* states: “In Yu’s prohibition, during spring’s three months, no axes in mountains and forests to allow grass and trees to grow; during summer’s three months, no nets in rivers and marshes to allow fish and turtles to grow,” corresponding to sustainable development. The *Zhanguo Ce · Qi Ce Si* concept of “returning to simplicity” and the *Tao Te Ching* principle of “Man follows Earth, Earth follows Heaven, Heaven follows the Dao, and Dao follows nature” correspond to NbS.

New-era scientific management of deserts and scientific desertification control concepts need updating. Ecological construction in sandy areas should strengthen synergy with regional high-quality integrated green development, ensuring both ecological security and driving regional green development. Desertification control should address not only ecological problems but also livelihood issues and green development challenges. Mining area ecological restoration, desert pollution control, and lake-wetland protection and restoration should be organically integrated with desertification control. Phase 6 of the “Three-North” project will launch 20 county-level scientific afforestation pilots, scientifically optimizing county-scale forest and grassland resource allocation

based on water resource constraints according to different site conditions.

1.3 Desertification Control “Prescriptions” and Complete Technology

Over the past 70 years, China has maintained state leadership in desertification control while encouraging participation from all sectors (forestry and grassland, science and technology, agriculture, water conservancy, finance, environmental protection) and social levels (sand control enterprises, models, forest farms, education and popularization), leveraging scientific support, local characteristics, and public wisdom to establish diverse desertification control models and technical systems for different bioclimatic zones. Drawing on traditional Chinese medicine concepts, desertification control technologies can be categorized into three “prescriptions” plus one “miracle prescription.”

The “single remedy” refers to using individual technologies for rapid sand hazard control. For example, the “straw checkerboard” mechanical sand barrier technology, known as the “Chinese Magic Cube,” was introduced from Soviet expert Petrov in the 1950s and improved, demonstrating excellent sand-fixing effects and still widely used in sandy areas today. Other examples include tree-planting initiatives like “Ant Forest” and “100 Million Haloxylon” launched by civil society organizations.

The “proven prescription” refers to integrated sand control technologies that have proven effective through years of practice, representing technological integration and innovation of individual techniques. Typical examples include the railway and highway sand control system “primarily fixing with combined fixing and blocking” based on sand transport research (such as the Baotou-Lanzhou Railway Shapotou section and Taklamakan Desert Highway comprehensive systems), and the “low-coverage sand control technology system” that achieves water-defined greening. China’s traffic artery sand hazard control models and applications have reached internationally leading levels.

The “specialized prescription” refers to comprehensive solutions developed for different climate and soil types and eco-economic needs across various eco-geographic regions. Current models include: “Hotan Model,” “Aksu Model,” “Dunhuang Model,” and “Ejin Model” for extremely arid regions; “Linze Model,” “Minqin Model,” “Shapotou Model,” “Dengkou Model,” “Kubuqi Model,” and “Eren Model” for arid regions; “Yulin Model,” “Youyu Model,” “Chifeng Model,” “Saihanba Model,” and “Zhanggutai Model” for semi-arid regions; and “Gonghe Shazhuyu Model,” “Guinan Huangshatou Model,” “Maqu Model,” and “Ruo’ergai Model” for special alpine habitats.

The “miracle prescription” for building new cities in deserts includes cities like Aral, Golmud, Kangbashi, Wuhai, Bayanhot, and Shapotou District. The Xinjiang Production and Construction Corps has shifted from “reclaiming and guarding borderlands” to “building cities and guarding borderlands,” developing towns and oases such as Aral City and Huyanghe City, all under corps jurisdiction and autonomous region administration.

1.4 Desert “Scenery” and Major Opportunities

In October 2021, at the 15th Conference of the Parties (COP15) to the UN Convention on Biological Diversity, President Xi Jinping announced that China would launch large-scale wind and photovoltaic construction in desert, Gobi, and wasteland areas. In January 2022, the National Development and Reform Commission and National Energy Administration jointly released the *Layout Plan for Large-Scale Wind and Photovoltaic Bases Focusing on Desert, Gobi, and Wasteland Areas* and *Opinions on Improving Institutional Mechanisms and Policy Measures for Green and Low-Carbon Energy Transition*, proposing policies to promote wind and photovoltaic development in sandy areas. In March 2023, the Ministry of Natural Resources, National Forestry and Grassland Administration, and National Energy Administration jointly issued the *Notice on Supporting Photovoltaic Industry Development and Regulating Land Use Management*, standardizing land use issues for photovoltaic industry development in desert, Gobi, and wasteland areas. Under strict ecological protection and regulated land and water use, wind and photovoltaic development in these areas will bring opportunities for “prevention, control, and utilization” in desertification control.

The wind and photovoltaic industry has become a major feature of future desertification control work, synergizing with local development. The establishment of comprehensive solutions like “photovoltaic + sand control” and social capital access mechanisms should be explored, accelerating the development of corresponding ecological protection technology systems. Desert wind and photovoltaic development will provide large amounts of clean energy. While most electricity will be transmitted externally for revenue, a portion will be used locally for industrial development, providing new momentum for high-quality development of new green industries such as plant factories, photosynthetic engineering, and facility agriculture in desert and desertified areas.

2. Overall Improvement, Key Breakthroughs

Desertification control concerns ecological construction, regional development, rural revitalization, and people’s well-being in vast desert and desertified areas. The strategic choices for desertification control have three starting points: ensuring the health of desert ecosystems to better serve humanity; strengthening desertification prevention, control, and assessment with enhanced preferential policy support; and actively aligning with national strategies to contribute to integrated “mountain-river-forest-field-lake-grass-desert” governance. China’s desertification control strategy must fully align with national strategies, meet international commitments, and respond to global initiatives. Following the governance approach of “integrated mountain-river-forest-field-lake-grass-desert comprehensive management” and “promoting green development to foster harmony between humanity and nature,” the strategy should use the “dual” planning as a starting point, focus on building national desertification control demonstration zones, consolidate the northern ecological security barrier, and achieve the

“dual beauty” goals (building a beautiful China and meeting people’s needs for a better life). It should align with the “dual carbon” goals and respond to the “dual convention” targets (SDGs and the UN Convention to Combat Desertification’s Land Degradation Neutrality “LDN” goal), building a community with a shared future for mankind in arid regions.

2.1 One Desert, Four “Systems” Plus Assessment

For various types of desertified areas and different zones of desert ecosystems, a four-character principle of “cultivate, prevent, treat, and utilize” is proposed, establishing a strategic framework of “one desert, four systems” plus assessment (Figure 2 [Figure 2: see original paper]).

- (1) **“Cultivate”**—For natural ecosystems such as pristine deserts, sandy lands, and Gobi, designate key “cultivation” (protection) zones. Four major types of desert ecosystem cultivation (management) include national parks, nature reserves, desert nature parks, and protected closure zones.
- (2) **“Prevent”**—For “sub-healthy” areas, prevent potential desertification and sandification. This mainly includes edges of existing desertified and sandy lands prone to land degradation, as well as areas with obvious desertification and sandification trends, requiring key prevention and scientific management.
- (3) **“Treat”**—For “diseased” areas, scientifically promote key desertification control to slow deterioration and enable artificial restoration. According to the *Northern Sand Prevention Belt Ecological Protection and Restoration Major Project Construction Plan (2021-2035)*, various types and key prevention zones of sandy land in China should be treated through classified, concentrated, and contiguous management.
- (4) **“Utilize”**—For developable areas, adhere to the principle of “high input, high output, high efficiency, and high benefit” to manage and make good use of limited resources in sandy areas. While continuing to promote planting and breeding industries, develop green food and biopharmaceutical industries, utilize sand-based materials, and develop eco-tourism, efforts should be intensified to launch “four high” industries such as wind and photovoltaic power, factory-based facility agriculture, plant factories, and photosynthetic engineering projects. Management of land and water resources in sandy areas should be strengthened to promote efficient and intensive development.
- (5) **“Assess”**—For desert and desertified areas, conduct regular assessments of desert ecosystem quality, function, and services. Key monitoring and assessment indicators reflecting desert ecological quality and health should be established, utilizing integrated “satellite-air-ground” monitoring technology combining satellites, drones, and ground sensor networks to continuously monitor ecological functions at “point” and “area” scales, con-

ducting annual assessments of desert ecosystem quality, health, function, services, and ecological assets.

Based on natural endowment differences, especially water conditions, representative key areas should be selected for demonstrations: extremely arid regions like the Dunhuang Basin; extremely arid to arid regions like the Taklamakan periphery; arid regions like the Yellow River “Jiuzigou Bend” area; and semi-arid regions like the Horqin and Otindag sandy lands.

2.2 Priority Layout and Key Demonstrations

In future strategic tasks for China’s desertification control, five priority actions should be deployed in important and urgently needed areas.

1. **Desert Ecosystem Priority Protection Action:** Mainly includes fully promoting the establishment of desert-type national parks, conducting inventory and strengthening popularization of China’s deserts, sandy lands, and Gobi, and increasing interaction with media and society.
2. **Desert Sustainable Development Action:** Mainly includes strengthening disaster prevention and reduction, forecasting and early warning, curbing coarse sand entering the Yellow River in the middle and upper reaches, and managing the increasingly serious “hanging river” upward shift in the Hetao irrigation area (the Yellow River’s hanging river problem is trending upward from the lower to middle and upper reaches).
3. **Desert High-Quality Development Action:** Mainly includes promoting large-scale wind and photovoltaic new energy base construction in desert, sandy land, and Gobi areas, and accelerating the establishment of a financial support system for green industries in desert ecosystems.
4. **Desert “Dual Carbon” Action:** Mainly involves developing quality and efficiency improvement technologies for carbon sequestration in sand-fixing vegetation based on water resource carrying capacity.
5. **International Exchange and Technology Export of “Chinese Solution” for Desert Management:** Introduce China’s experience, measures, wisdom, and solutions for global desertification control, with priority support for the “Great Green Wall” construction in Pan-Africa, assistance for agroforestry management in Africa, and promotion of photovoltaic industry development in Africa’s populous but electricity-scarce regions.

2.3 Legislation, Regulation, and Institution-First Approach

- (1) **Initiate revision of the *Law of the People’s Republic of China on Prevention and Control of Desertification*.** The revised law should better adapt to new-era national ecological governance concepts and relevant national strategies, coordinate with other environmental protection

and natural resource laws, and provide a legal foundation for sustainable desert ecosystem development.

- (2) **Strengthen implementation of relevant plans.** Mainly includes the “dual” planning, national desertification control planning, forestry and grassland protection and development planning, soil and water conservation planning, agricultural sustainable development planning, and national desert park development planning.
- (3) **Continue to promote and improve the target responsibility system for desertification control.** Explore the establishment of a desert ecological damage accountability system, clarifying circumstances, forms, and procedures for accountability.
- (4) **Establish a desert ecosystem protection system.** Mainly includes establishing a sandy land closure protection system, implementing basic grassland protection systems, clarifying natural resource asset property rights, improving grassland contract management systems, and perfecting supervision systems for resource development and utilization in sandy areas.
- (5) **Establish a desert ecosystem protection compensation mechanism.** Based on existing forestry subsidies, grassland ecological protection subsidies, sandy land closure protection subsidies, and tax incentives, establish an ecological compensation mechanism for desert ecosystems. Actively explore diversified compensation methods and pilots, establish two-way compensation and penalty mechanisms, and accelerate the improvement of supporting systems for desert ecological compensation.
- (6) **Firmly fulfill treaty commitments.** Continue to fulfill the “Rio Three Conventions” (UNCCD, CBD, UNFCCC), establish cooperation mechanisms with the international community through these platforms, and contribute Chinese wisdom to global desertification control, particularly in developing countries. Promote global achievement of SDG 15.3 (land degradation neutrality) and respond to the G20 initiative to halve land degradation by 2040.

2.4 Scientific Support and Innovation-Driven Development

- (1) **Strengthen basic research and key technology development for desertification control.** Rely on research institutes, public-private enterprises, and technology extension units in desertification control and “Three-North” project fields to form government-enterprise-academia-research cooperation mechanisms, conduct joint research, encourage innovation, and achieve breakthroughs in basic scientific research, control technology development, and new product manufacturing and application.
- (2) **Strengthen promotion and application of desertification control**

technologies. Continue to improve national, provincial, and county-level technology extension networks, utilize various agriculture, forestry, animal husbandry, and water resources extension channels, and establish a sustainable technology and information sharing platform for desert ecosystems.

- (3) **Improve desertification monitoring, early warning, and observation research networks.** Establish a monitoring system with national, regional, and provincial monitoring centers as the backbone and positioning monitoring stations and fixed monitoring sample lines as the support, forming a long-term observation and research network integrating “observation-research-demonstration-extension.”
- (4) **Perfect the desertification control technical standard system.** Accelerate the formulation and revision of standards for desert ecosystem protection and desertification control, especially for emergencies like sandstorms, droughts, and strong winds. Actively participate in international desertification control standard formulation and promote the internationalization of technical standards.
- (5) **Establish a diversified financing system for desertification control.** Stabilize fiscal investment, encourage local and private investment in sand control, establish a mechanism for realizing desert ecological product values, and fully exploit the ecological value of desert products in tourism. Encourage social and private funds to actively participate in national and local desertification control projects, expanding financing channels.
- (6) **Strengthen basic surveys and clarify resource conditions.** Actively plan the second national desert scientific expedition and cross-border desert-Gobi resource surveys. Promote international cooperation, establish China-Mongolia and China-Arab desertification control cooperation centers, support Pan-Africa’s “Great Green Wall” construction, jointly implement Central Asian Aral Sea ecological restoration, and strive to participate in Saudi Arabia’s “10 Billion Trees Initiative” and other major international projects, encouraging domestic research units to conduct cross-border investigations.

3. Future Vision

3.1 China’s Desertification Control Goals for 2035

By 2035, China is expected to achieve decisive progress in desertification control. The modernization of governance systems and capabilities in desert and desertified areas will be basically realized, with substantially enhanced sustainable, high-quality, and green development capabilities. Manageable desertified and sandy land areas will continue to decrease, sandification severity will be significantly reduced, vegetation coverage in sandy areas will be basically stable, and the ecological environment will gradually improve. Key areas such as the four

major sandy lands, desert oases, the Qinghai-Tibet Plateau, the Yellow River basin, and the Beijing-Tianjin-Hebei periphery will see significantly improved ecological conditions, with the initial realization of a solid northern ecological security barrier. The national desert park system will be gradually perfected. The supporting capacity of green industries in sandy areas will be significantly enhanced, with a basically formed mechanism for rational resource utilization and a relatively complete green industrial system. While serving national ecological civilization construction needs, China will better support international treaty fulfillment and promote global achievement of SDG 15.3.

Based on regional differences in natural endowment, especially water conditions, different regions should plan future desertification control priorities. China's terrain is traditionally divided into three major steps. This paper adds special consideration for marine territory and coastal zones (coastal dune distribution areas), proposing a new “four terraces” framework with blue territory and coastal zones as the “fourth terrace” to plan desertification control tasks accordingly (Figure 3 [Figure 3: see original paper]).

First Terrace: The first step of China's three terrestrial steps, including the Qinghai-Tibet Plateau region—a high-altitude, cold area with core tasks of grassland degradation and desertification control in the Three-River-Source region and freeze-thaw desertification control to ensure the ecological security of the “Asian Water Tower.”

Second Terrace: The second step, including northwestern inland areas, Inner Mongolia Plateau, Loess Plateau, Sichuan Basin, and Yunnan-Guizhou Plateau—China's main arid and semi-arid region and the main battlefield for the “Three-North” project's “three major battles.” Core tasks include fighting the Yellow River “Jiuzigou Bend” battle, focusing on sand control along the Yellow River banks and photovoltaic sand control to ensure Yellow River safety and maintain ecological security of grain bases; fighting the Hexi Corridor-Taklamakan Desert edge battle, focusing on sandstorm passage management and heritage site protection to maintain ecological security of key “Belt and Road” nodes; and strengthening ecological management in sand source and passage areas to ensure northern sand prevention belt security and improve farmland ecosystem services.

Third Terrace: The third step, including Northeast Plain, North China Plain, East China, and South China—mainly semi-arid, semi-humid, and humid regions with core tasks of fighting the Horqin-Otindag sandy land battle, focusing on high-quality forest and grassland construction to restore traditional grassland landscapes (such as sparse elm grasslands in the two sandy lands) and effectively cut off sand sources invading the Beijing-Tianjin region, implementing Beijing-Tianjin sandstorm source control and Northeast black soil management projects.

Fourth Terrace: Blue territory and coastal zones—coastal sandy land and marine distribution areas with core tasks of coastal sandy land desertification

and sandification control to ensure national blue territory ecological security.

While each terrace has its own priority tasks, all will contribute to national ecological construction and integrate into the national ecological governance framework, building a land-sea coordinated strategic plan.

3.2 New Mission for China's Desertification Control in the New Era

Facing the future, China's desertification control will achieve a major strategic transformation from sand prevention, control, and utilization to sand understanding, cultivation, and protection, extending from desert development and desertification control to ecological governance, whole-area governance, comprehensive governance, and public participation. The future vision for China's desertification control includes four main aspects (Figure 4 [Figure 4: see original paper]).

3.2.1 Integration of "Three Lives" and Holistic Development Ecological land should be scientifically planned. In desertification control areas, priority should be given to exploring substantive legislation and land classification management for ecological land. Based on future land ecological functions, ecological land in desertification control areas should be divided into three categories: permanent ecological land (natural), basic ecological land (artificial), and reserve ecological land (polluted/abandoned). Classified management should achieve sustainable use: for permanent ecological land, focus on "protection" with strengthened closure protection; for basic ecological land, focus on "management" ensuring ecological, production, and life functions through ecological projects; for reserve ecological land, strengthen treatment and restoration, balancing "management" and "utilization" to reserve land "increment" for future development.

Ecological water use should be scientific and efficient. Desertification control should achieve water-defined greening and production, scientifically optimizing forest and grassland resource allocation based on vegetation ecological water demand. In severely degraded areas with poor site conditions, active artificial intervention and ecological reconstruction should be implemented through major national ecological projects with enhanced water supply; in slightly degraded areas with better conditions, ecological restoration should rely mainly on near-natural restoration and closure protection with strict water supply control.

Desertification control should be coordinated with regional high-quality integrated development. It should closely align with national and local development strategies, especially accelerating green transformation in western regions, achieving modernization and intelligentization of agricultural production in sandy areas, encouraging integration of agriculture with photovoltaic and wind power industries, promoting conservation tillage (no-tillage), and developing organic agriculture to form new green, low-carbon, and environmentally friendly agricultural production models in sandy areas.

3.2.2 Whole-Area Sand Control and Real-Time Monitoring Multi-dimensional whole-area sand control should be achieved. Spatially, coverage of “whole watershed, whole mountain area, whole sandy area” should be realized, coordinating mountain-alluvial fan/gully-oasis transition zone-desert chain management, focusing on “whole oasis upstream-downstream” sand control in oasis transition zones at desert edges. Temporally, coverage of “whole process, whole duration, whole cycle” should be achieved, implementing classified measures according to different time scales required for ecological reconstruction (geological time scale, ecosystem succession scale, human ecological construction scale), realizing the principle of “whoever destroys, restores; whoever pollutes, manages; whoever benefits, pays.” Academically, coverage of “whole discipline, whole direction, whole field” should be achieved, using the upgrade of soil and water conservation and desertification control to first-level disciplines as an opportunity to integrate natural sciences including forestry, ecology, geology, geography, environmental science, biology, and water science into desertification control, strengthening international cooperation, fulfilling treaty commitments, emphasizing strategy and policy formulation, and encouraging research on sand industries and desert economics.

Real-time desert(ification) dynamic monitoring should be achieved. Currently, national forestry and grassland authorities conduct national desertification and sandification monitoring every five years. In the future, annual and eventually real-time dynamic monitoring capabilities for desert ecosystems and desertification will be gradually realized. Annual assessments of desert ecosystem quality, health, function, services, and ecological assets will be implemented. China’s ecological benefit contributions to desertification control will be explored and assessed annually.

3.2.3 Human-Sand Harmony, Greening and Carbon Sequestration
Prioritize protection of pristine deserts. The ecological value provided by desert ecosystems will steadily increase, ecological products will gradually enrich, and biodiversity in sandy areas will continuously improve. Under combined natural conditions and ecological projects, long-term greening and carbon sequestration will be achieved in sandy areas, with desert ecological carbon sink capacity scientifically recognized and steadily increasing. Natural deserts, sandy lands, and Gobi will be strictly protected through closure, preserving pristine landscapes for future generations.

Prevent and control hazards according to conditions. By 2035, key areas such as the Yellow River basin and Beijing-Tianjin-Hebei periphery will see gradual ecological improvement, with effective control of coarse sand entering the Yellow River and irrigation district salinization. Ecological conditions in domestic sand source areas will significantly improve (indirectly reducing frequency and hazards of sandstorms in northern China), and the northern ecological security barrier will become effective, healthy, and sustainable.

Efficiently utilize resources to improve livelihoods. On desertified land

with production functions that has been or is being treated, ecological industries will develop rapidly. Modern ecological agriculture (promoting conservation tillage, plant factories, photosynthetic engineering), characteristic Chinese herbal medicine cultivation (near-natural cultivation to improve medicinal quality), renewable energy development (wind, photovoltaic, biomass), and characteristic eco-tourism (relying on the nature reserve system with desert parks as the main component) will flourish. The rapidly developing wind and photovoltaic industry in desert areas, already internationally leading, will use part of its electricity locally through modern ecological agriculture methods, promoting ecological industry development and rural revitalization in sandy areas and achieving high-quality green development transformation.

3.2.4 Chinese Prescription, Global Win-Win Technology transfer, collaborative innovation, and mutual benefit. Future Chinese desertification control experiences, technologies, and new materials will support Africa's "Great Green Wall" construction. China's nearly 40 years of desertification control experience, especially the "Three-North" project known as the "Green Great Wall," can directly support Africa by contributing Chinese wisdom and solutions. Technology transfer in agroforestry management, where China has rich experience and mature models, and photovoltaic industry development, particularly suitable for Africa's populous but electricity-scarce regions, will be prioritized. It is hoped that future Chinese desertification control will provide technology, decision-making support, and think tank services for global desertification control, contributing to the "Belt and Road" ecological security and well-being of people in desertified areas along the route.

Promote cross-border whole-area governance. At the end of 2022, China proposed establishing a China-Mongolia Desertification Control Cooperation Center and a China-Arab International Research Center for Drought, Desertification, and Land Degradation to contribute to cross-border whole-area governance and jointly safeguard well-being in desertified areas along the "Belt and Road." Building on long-term international cooperation in desertification control technologies and models, future cooperation based on these two centers will enable China to actively participate in cross-border governance, providing scientific support, decision-making support, and think tank services for global desertification control. Facing deteriorating ecological trends in overseas sand source areas, China should conduct detailed surveys of cross-border Gobi and desert sand sources and promote China's solutions, wisdom, and contributions for "great nation sand control" and even "great nation governance" to relevant countries. Support should be provided for international cooperation and technical assistance at the national and social levels for Pan-Africa's "Great Green Wall," the Central Asian Aral Sea ecological restoration plan, Mongolia's 1 billion trees program, and Saudi Arabia's 10 billion trees initiative, effectively promoting ecological security and well-being in desertified areas along the "Belt and Road."

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