

## Hexi Corridor—Taklamakan Desert Edge Blocking Battle: Aeolian Sand Situation and Prevention and Control Tasks Postprint

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### Abstract

To implement the important spirit of General Secretary Xi Jinping's speech at the symposium on strengthening comprehensive desertification prevention and control and advancing key ecological projects such as the "Three-North" shelterbelt program, this article takes winning the blocking battle at the edge of the Hexi Corridor–Taklamakan Desert as its primary objective, and conducts in-depth research on the aeolian sand situation and prevention tasks at the edge of the Hexi Corridor–Taklamakan Desert. Based on the characteristics of desertified land and the aeolian sand activity situation at the edge of the Hexi Corridor–Taklamakan Desert, with the goal orientation of "preventing shifting sand from further spreading and effectively controlling dust sources" and the core topics of "wind prevention, sand blocking, and dust control," the strategic approach for the blocking battle at the edge of the Hexi Corridor–Taklamakan Desert is determined. By systematically identifying the source areas and pathways of "wind, sand, and dust," targeting key zones for sand prevention and control at the desert edge and focusing on prominent sand hazard management priorities, this study proposes key task areas and key tasks for sand prevention and control at the edge of the Hexi Corridor–Taklamakan Desert, aiming to provide scientific and technological support for fighting and winning the blocking battle at the edge of the Hexi Corridor–Taklamakan Desert.

### Full Text

#### The Battle on the Edge of Hexi Corridor–Taklimakan Desert: Wind-Blown Sand Situation and Prevention Tasks

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## Abstract

To implement the spirit of General Secretary Xi Jinping's important speech on strengthening comprehensive desertification control and advancing key ecological projects such as the "Three-North" Shelterbelt Program, this study focuses on winning the battle against desertification on the edge of the Hexi Corridor–Taklimakan Desert. We conducted in-depth research on the wind-blown sand situation and prevention tasks in this region. Based on the characteristics of desertified land and wind-blown sand activities along the Hexi Corridor–Taklimakan Desert edge, we established the strategic goal of "preventing drifting sand from spreading further and effectively controlling dust sources," with "wind prevention, sand blocking, and dust control" as the core focus. By systematically identifying the source areas and pathways of "wind, sand, and dust," and targeting key zones at the desert edge and critical areas for sand damage control, we propose key task areas and specific tasks for desertification prevention and control. This work aims to provide scientific and technological support for successfully winning this critical battle.

**Keywords:** Hexi Corridor, Taklimakan Desert, desertification combating, battle, strategic area, desertified land, wind-blown sand situation

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## 1 Desertification Status of the Hexi Corridor–Taklimakan Desert Edge Strategic Area

### 1.1 Overview of the Strategic Area

The Hexi Corridor–Taklimakan Desert edge strategic area (hereinafter "strategic area") is located in the core region of China's northwest arid zone and serves as the throat of both the ancient "Silk Road" and the modern "Eurasian Continental Bridge." The region features a dry and windy climate with low vegetation coverage, well-developed aeolian landforms, and a landscape dominated by deserts, gobi, and yardangs. Due to the extensive distribution of desertified land and large area coverage, with concentrated and contiguous drifting sand dunes and severely desertified land, this region represents China's most intense

wind-sand activity zone, the most severe wind-sand disaster area, the main battlefield for three iconic desertification control campaigns, and a critical zone for building the northern ecological security barrier.

The strategic area primarily includes the Hexi Corridor region (Jiayuguan, Jinchang, Jiuquan, Wuwei, Zhangye, and western Baiyin in Gansu Province) and five prefectures in southern Xinjiang (Aksu, Kashgar, Hotan, Bayingolin Mongol Autonomous Prefecture, and Kizilsu Kirghiz Autonomous Prefecture) [Figure 1: see original paper]. The total area of the strategic area is approximately  $82.78 \times 10^4$  km<sup>2</sup>, with a population of about 15.7657 million, average annual precipitation of approximately 97 mm, and total oasis area of about  $10.71 \times 10^4$  km<sup>2</sup>.

The Hexi Corridor lies in western Gansu, extending from Gulang Gorge in the east to the Gansu-Xinjiang border in the west, bordered by the Qilian Mountains to the south and Inner Mongolia to the north. Spanning approximately 1,000 km east-west and up to 200 km north-south at its widest point, it covers  $27.6 \times 10^4$  km<sup>2</sup> of territory and supports a population of 3.5021 million [1]. The northern part of the Hexi Corridor contains the Badain Jaran and Tengger Deserts, while the southern part features the Qilian Mountains with significant topographic relief. The climate is arid with scarce precipitation, with many areas receiving less than 200 mm annually, creating a landscape pattern of coexisting deserts, dunes, and oases. Oasis expansion began rapidly during 1990–2000 and has continued to increase significantly since 2010 [2].

The Taklimakan Desert edge region features flat terrain surrounded by high mountains, connected to the Tianshan Mountains in the north and the Karakorum, Kunlun, and Altun Mountains in the south, integrating with the Qinghai-Tibet Plateau. The area contains the world's second-largest drifting desert—the Taklimakan Desert—spanning approximately 1,000 km east-west, 400 km north-south, with an area of  $33.76 \times 10^4$  km<sup>2</sup> [3,4]. Average annual precipitation is about 50 mm, with minimum values of only a few millimeters, while average evaporation reaches 2,500–3,400 mm [3]. The extremely arid climate and intense wind-sand activities severely impact the regional ecological environment.

## 1.2 Land Desertification Analysis

Using MODIS (Moderate Resolution Imaging Spectroradiometer) satellite remote sensing data from 2000–2022, we analyzed desertification conditions in the strategic area. The primary indicator was the Land Desertification Distance Index, which characterizes desertification degree by calculating the distance of all sample points from a reference point (1,0) representing the highest Modified Soil-Adjusted Vegetation Index (MSAVI) and lowest albedo (ALBEDO) in a two-dimensional feature space. MSAVI was calculated from MODIS MOD09A1 band values, while ALBEDO data were obtained from the MODIS MCD43A3 albedo product.

In 2022, total desertified land area in the strategic area was approximately

$79.42 \times 10^4$  km<sup>2</sup>, mainly distributed in the five southern Xinjiang prefectures, with relatively less distribution in the Hexi Corridor. From 2000–2022, desertification remained stable in most areas, with changes occurring only in small regions [Figure 2: see original paper]. Desertification intensified in approximately 18,694 km<sup>2</sup>, while it decreased in about 92,379 km<sup>2</sup>. Notable improvements occurred in southwestern Korla, southern Kashgar, and western/northwestern Alar (total area ~38,409 km<sup>2</sup>), and in southeastern Kashgar, Hotan, Dunhuang, Jiayuguan, Zhangye, and southeastern Wuwei (total area ~53,970 km<sup>2</sup>). However, desertification significantly worsened in scattered areas of northern southern Xinjiang prefectures, Bayingolin, and Wuwei (total area ~13,034 km<sup>2</sup>).

## 2 Wind-Sand Activity Situation in the Strategic Area

### 2.1 Strong Wind Intensity and Main Wind Gap Areas

The strategic area lies deep in the interior of the continent, featuring a special topography of alternating high mountains and depressions/basins. Influenced by westerly circulation below 400 hPa, winter monsoons, local circulation, and this unique terrain, the region contains numerous wind-prone areas such as canyons, river valleys, and passes, making it one of China's windy regions [5]. Strong winds are frequent, long-lasting, and powerful, posing significant threats to industrial/agricultural production, transportation, and human life and property.

The Resultant Drift Potential (RDP) effectively characterizes regional wind-sand environments and represents regional wind energy features [6]. Based on RDP spatial distribution [Figure 3: see original paper] and field data, the main wind gaps include the Shule River Valley-Mazong Mountain gap, the downwind area of western Pamir Plateau airflow (western Kashgar and northern Kizilsu Kirghiz mountainous areas), and the eastern inflow wind gap of the Taklimakan Desert. High wind value zones are located in northwestern Hexi Corridor and the eastern edge of the Taklimakan Desert. The special terrain creates a funneling effect, making northwestern Hexi Corridor a famous wind gap and “wind reservoir” [7]. The Shule River Valley area, bordered by the Qilian Mountains to the south and Mazong Mountain to the north, serves as the entrance for northwest airflow and cold air. Due to topographic funneling, it experiences the most frequent strong winds, highest maximum wind speeds, and longest durations, with annual average strong wind days of 41.4 and maximum wind speed of 27 m/s. Mazong Mountain and surrounding areas also show high wind values, influenced by the strong wind area of Shisanjianfang in Hami, Xinjiang, which experiences up to 209 strong wind days annually with average wind speed of 8.6 m/s.

Wind intensity is closely related to topography, generally showing that high mountain areas have more strong winds than medium/low mountains; basin/depression edges have more than basin interiors; and high wind speed zones are mainly located in mountain gaps or gobi areas at desert edges. The

strategic area has distinct seasons with significant differences in wind distribution, strongest in spring, followed by summer, and weakest in autumn/winter. Prevailing winds are northwesterly in the Hexi Corridor and easterly in the Taklimakan Desert.

## 2.2 Dune Activity and Protection Gaps at Desert Edge

**2.2.1 Wind-Sand Passages Between Desert-Edge Oases** Wind-sand passages between desert-edge oases are active zones for wind-sand activity and prone areas for drifting sand invasion and dune activation. According to incomplete statistics, there are 16 wind-sand protection gaps in the Hexi Corridor–Taklimakan Desert region, including 5 in the Hexi Corridor and 11 around the Taklimakan Desert. In the Hexi Corridor, oases are scattered, resulting in widespread wind-sand passages, notably: Dunhuang’s Yangguan Town–Erduan Village passage, Yangguan Town–Qili Town passage, Mogao Town–Guazhou Town passage, Yumen City–Chijin Town passage, and Yumen Xiaohedong Town–Mingshan Township passage.

Around the Taklimakan Desert, wind-sand passages are mainly distributed along the southwestern edge (Yecheng–Pishan section), southern edge (Kunyu City–Ruoqiang section), and eastern edge (34th Regiment of Xinjiang Production and Construction Corps and Taitema Lake section), spanning approximately 1,400 km of wind-sand front. Major passages include: the Yecheng–Pishan gobi-covered area, Piashan Ranch–Piyalema Township gobi area in Pishan, the mobile dune and gobi area west of Cele County, the gobi area 15 km east of Yutian County, the gobi area between Yutian and Minfeng counties, the natural oasis area between 38th Regiment and Minfeng, the gobi area west of 37th Regiment, the gobi and mobile dune area west of Washixia Town, the natural oasis distribution area along Highway 218 south of 34th Regiment, and the sandy surface and mobile dune distribution area along Highway 214 from Taitema Lake to 36th Regiment.

**2.2.2 Dune Activation at Desert Edge** Driven by climate change and human activities, dune activation and drifting sand invasion at the desert edge constitute important wind-sand hazards. Unreasonable land development is the main cause of desert changes and activation of fixed/semi-fixed dunes. In the Hexi Corridor, risks of sand invasion, vegetation degradation, and dune activation exist from Minqin and Jinchang in the east, through Gaotai (Luocheng, Heiquan, Xuanhua, and Luotuo towns) and northeastern Yumen in the center, to Guazhou east of the western oasis, urgently requiring quality improvement of oasis shelterbelt networks. The areas around Minqin, northern Gaotai towns, and northern Linze are particularly severe. Additionally, unreasonable development of desert-oasis transition zones has created gaps in oasis protection networks, facilitating sand invasion and dune activation.

Around the Taklimakan Desert, large areas of degraded desert-oasis transition zones and scattered deserts remain. For example, the oasis delta between

Shache, Kashgar, and Tumushuke contains alluvial fan transition zones west of Kashgar, two major scattered desert-oasis transition zones between Jiashi and Maigaiti, and desert-oasis transition zones north of Tumushuke-Bachu. These areas, located downwind of the western basin wind gap and dominated by fixed/semi-fixed dunes or gobi, face high risks of soil and vegetation degradation due to climate change and human activities. In Aksu and parts of Bayingolin, issues include severely aging peripheral protection forest systems and serious vegetation degradation in desert-oasis transition zones.

Additionally, oasis expansion in the southern Xinjiang basin, primarily through cultivation of desert-oasis transition zones, poses problems. Key areas include new regiments of the Xinjiang Production and Construction Corps, such as Kunyu City (14th Division), 37th and 38th Regiments (2nd Division), and northern regiments of Alar City (1st Division). These regions, along with areas on the western, southern, and eastern edges of the Taklimakan Desert, have numerous wind-sand protection gaps between oases.

### 2.3 Dust Source Areas and Transport Paths

Dust storms in the Hexi Corridor–Taklimakan Desert region are characterized by significantly higher frequency along the Taklimakan Desert edge. From 1970–2007, Minfeng and Kalpin counties near the Taklimakan Desert had the highest dust storm frequencies, with annual average occurrence days of 36.92 and 28.16, respectively, followed by Minqin County in Gansu with 26.21 days [8]. Temporally, dust storms around the Taklimakan Desert mainly occur during April–August, while in the Hexi Corridor they appear primarily during March–May. The longest dust storm durations reach 10–26 hours along the southern Taklimakan Desert edge and 6–12 hours in the Hexi Corridor [9]. Over the past 50 years, dust storm frequency in northern China has generally shown a significant decreasing trend [10], but has increased since 2020, with spring 2023 experiencing the highest frequency in nearly a decade [11].

From 2000–2020, the average annual dust emission rate was 0–3,275 g/m<sup>2</sup> [Figure 4: see original paper], with the highest rates distributed mainly along the eastern and southeastern edges of the Taklimakan Desert and the Lop Nur area, followed by the lower reaches of the three major inland rivers (Shiyang, Heihe, and Shule) in the Hexi Corridor, such as Subei, Guazhou, Jinta, and Minqin. The strategic area’s total annual dust emission is  $1.14 \times 10^8$  t, accounting for over 60% of East Asia’s total dust emissions [12,13]. The Taklimakan Desert alone contributes approximately  $0.63 \times 10^8$  t annually (55% of the strategic area’s total). Quantitative studies of East Asian spring dust storms during March–April 2023 found the Taklimakan Desert contributed about 26% on average [11].

The Taklimakan Desert has three main spring dust transport pathways: cold air from the western Tianshan and Pamir Plateau entering the basin from the west, cold air from the north crossing the Tianshan Mountains, and strong

cold air from the east entering the basin's northeastern opening. Strong eastern inflow carries large amounts of dust, driving weak dust bands from western and northern pathways toward the southwestern basin. Blocked by the Qinghai-Tibet Plateau's southern topography, dust ascends along the plateau's northern slope and migrates toward the Hexi Corridor [14]. Dust from the Taklimakan and Kumtag Deserts, combined with dust from Guazhou, Yumen gobi, and the Badain Jaran and Tengger Deserts, continues eastward under the Hexi Corridor's funneling effect, affecting the Loess Plateau and North China Plain. Severe dust storms can even impact Wuhan, Changsha, Hangzhou, and Shanghai in the Yangtze River Basin [11].

### 3 Wind-Sand Disaster Risk in the Strategic Area

Wind-sand disasters are meteorological disasters caused by wind-sand activities that affect human living environments and socio-economic development [15]. Manifesting as soil erosion, sand burial, dune encroachment, and air pollution, they pose major threats to residents in desert and surrounding areas. The Hexi Corridor-Taklimakan Desert edge experiences strong wind-sand activities, with widespread drifting sand invasion hazards that severely damage oasis farmland, towns, industrial/mining bases, and ecological environments. Frequent dust weather causes serious air pollution, while soil wind erosion reduces land productivity.

From 2000–2020, overall wind-sand disaster risk in the strategic area declined, with extremely high-risk area proportion decreasing from 12.7% to 8.0%. By 2020, risk levels at desert-edge oases were significantly higher than in desert hinterlands [Figure 5: see original paper]. In environmentally fragile and densely populated desert-edge oasis areas, disaster-causing factors easily damage vulnerable assets, resulting in extremely high disaster risk. High and extremely high-risk zones are widely distributed around the Taklimakan Desert edge and along the Hotan and Keriya Rivers penetrating the desert interior. In the Hexi Corridor, such zones are mainly distributed along the southwestern edges of the Badain Jaran and Tengger Deserts. Economic activities and high population density further increase the risk of significant economic losses. Consequently, all major cities in the strategic area are exposed to high or extremely high wind-sand disaster risks.

## 4 Key Tasks for the Hexi Corridor–Taklimakan Desert Edge Battle

### 4.1 Strategic Thinking

Winning the battle on the Hexi Corridor–Taklimakan Desert edge is a systematic project requiring coordination across resources, environment, society, and economy. It must implement the overall requirements of desertification control in the new era while highlighting the ecological and geographical characteristics of arid zones. The approach should: (1) maintain systematic thinking to

identify source areas and pathways of “wind, sand, and dust”; (2) highlight key governance areas by focusing on critical desert-edge zones; and (3) apply scientific sand control through integrated planning of “wind prevention, sand blocking, and dust control.”

Based on the spatiotemporal patterns of “wind, sand, and dust” in the region, combined with desertified land distribution and wind-sand disaster risk assessment, the strategic goal is “preventing drifting sand from spreading and effectively controlling dust sources,” with “wind prevention, sand blocking, and dust control” as the core focus [Figure 6: see original paper]. By identifying regional wind gaps, strong wind intensity zones, sand invasion patterns, and oasis protection gaps, key governance areas are prioritized. The wind-sand protection gaps between oases along the edges of the Taklimakan, Tengger, and Badain Jaran Deserts are designated as priority areas. Through dust source delineation and transport pathway tracking, major dust source wind erosion is controlled. This study has identified four key task areas and 15 major tasks [Figure 7: see original paper].

Given abundant sand sources and strong winds, frequent wind-sand activities severely threaten infrastructure safety. Based on complex and spatially variable regional wind-sand environments, setting appropriate engineering measures is crucial. To ensure long-term infrastructure effectiveness, we must grasp the main contradictions in regional wind-sand environments and formulate specific measures under the guidance of “prevention based on hazard characteristics.” Each key task area requires two specific engineering approaches: (1) quality improvement of oasis protection systems, and (2) protection engineering for major infrastructure and industrial/mining areas.

## 4.2 Key Task Areas

### 4.2.1 Hexi Corridor Oasis Sand Blocking and Fixation Key Task Area

The Hexi Corridor oasis sand blocking and fixation belt, composed of oases, surrounding shelterbelts, and peripheral protection zones, is distributed along three major inland rivers (Shiyang, Heihe, and Shule) with a total area of approximately 30,000 km<sup>2</sup> (including 21,400 km<sup>2</sup> of oasis and 9,000 km<sup>2</sup> of desert-oasis transition zone). It plays a critical role in blocking sand invasion, maintaining oasis ecosystem stability, and ensuring food security in the Hexi Corridor, forming an important component of the northern sand prevention belt in China’s “Two Screens and Three Belts” ecological security framework.

However, rapid oasis expansion has intensified water resource contradictions, lowered groundwater levels, reduced ecosystem stability, and increased desertification risks. The expansion primarily involves converting desert-oasis transition zones (sand blocking belts) into farmland, destroying transition zone stability and increasing sand invasion risks. Key tasks include: (1) enhancing Hexi Corridor oasis stability, (2) optimizing sand blocking belt functions at oasis edges, and (3) protecting “rain-fed vegetation” in peripheral desert areas.

#### **4.2.2 Kumtag Desert–Lop Nur Wind-Erosion Dust Source Control**

**Key Task Area** This task area is bounded by the Altun Mountains to the south, Beishan to the north, Kuruk Desert to the west, and Lop Nur to the east. Most of the area belongs to Ruoqiang County, with eastern parts in Dunhuang City and southeastern parts in Aksai Kazakh Autonomous County. Spanning approximately 360 km east-west, the land consists mainly of desert, gobi, and saline-alkali soils. Wind-sand hazards from Kumtag Desert–Lop Nur dust sources primarily manifest as gobi wind-sand flows, such as those affecting the Mogao Grottoes in Dunhuang. Recent discovery of potash and coal deposits has led to extensive road and railway construction, exacerbating wind-sand hazards. Key tasks include: (1) protecting gobi wind-erosion dust sources and desert ecosystems, and (2) constructing wind prevention systems for major infrastructure and industrial/mining areas.

#### **4.2.3 Southern Taklimakan Desert Edge Wind Prevention and Sand**

**Blocking Key Task Area** This area extends from Ruoqiang in the east to Pishan in the west, involving 7 counties and 1 city in Bayingolin Prefecture and Hotan region, spanning approximately 1,200 km. Land types include desert, gobi, grassland, artificial oasis, and saline-alkali soils. The southern Tarim Basin edge is a strong wind-sand activity zone and major dust source area, known as Xinjiang’s “Thousand-Mile Wind-Sand Line,” with oases distributed like prayer beads along the line. Despite expanding artificial oases and improving protection systems, cultivated transition zones have increased wind-sand hazards, with protection gaps between oases becoming main channels for sand invasion. The desertified land is highly mobile, severely desertified, and poses extremely high disaster risk. Key tasks include: (1) vegetation restoration and reconstruction in desert-oasis transition zones, (2) wind prevention and sand blocking in protection gaps between desert-edge oases, (3) optimization and functional enhancement of peripheral protection systems, and (4) sealing protection for desertified land not suitable for treatment.

#### **4.2.4 Tarim River Desert Riparian Vegetation Conservation Key Task**

**Area** This area extends from the downwind area of western Pamir Plateau airflow, including middle-lower reaches of the Yarkant, Kashgar, and Gez Rivers, through Xiaoqiaoke/Aral, Xinquman, Yingbaza, middle reaches of Wusiman and Aqike, to downstream areas of Qiala, Yingsu, Alagan, and Taitema Lake. The Kashgar-Shache-Tumushuke delta, located downwind of Pamir airflow, is strongly affected by wind-sand, salinization, and human disturbance. The Tarim River main stream wind-erosion dust source area is distributed on the Tarim River plain. Land types include desert, gobi, oasis, grassland, and saline-alkali soils.

The middle-upper Tarim River is a wandering river that historically formed extensive channels. Reduced water flow from upstream reservoir construction and water consumption has weakened flooding, significantly decreasing channel migration, causing *Populus euphratica* forest decline and creating dry, exposed

riverbeds that become important dust sources. Although ecological emergency water delivery over the past 20 years has restored corridor functions, groundwater levels remain low and the oasis corridor ecosystem remains fragile. Under eastern inflow winds, this area is one of the basin's strongest wind-sand activity zones. Key tasks include: (1) controlling wind erosion in dry exposed riverbeds and lakeshore areas, (2) establishing sealed protection zones for concentrated desertified land in the lower Tarim River, (3) constructing integrated river-lake-road protection systems, and (4) improving saline farmland and comprehensively treating saline-alkali soils.

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

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