

Coping Strategies with Desertification in China



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October, 2006, New Delhi, India

Desertification

“land degradation in arid, semi-arid or sub-humid dry areas resulting from various factors including climatic variations and human activities” (UNCED,1992)

About **two-thirds** of the countries of the world, **one-fifth** of the global population and **one-fourth** of the land of the earth are now affected by desertification with a direct economic loss about 42.3 billion US dollars every year.

Desertification is a source of poverty and constraint of socioeconomic sustainable development.

China is one of the countries with large area, wide coverage and heavy losses from desertification in the world.

With rapid increase of population and driven by economic benefits, various human activities deteriorate vegetation in sandy areas, such as over-grazing, wasteland cultivation, excessive firewood gathering, excessive gathering of plants of sandy land and irrational use of water resources.

The serious desertification has been threatening ecological security and sustainable socio-economic development in China.



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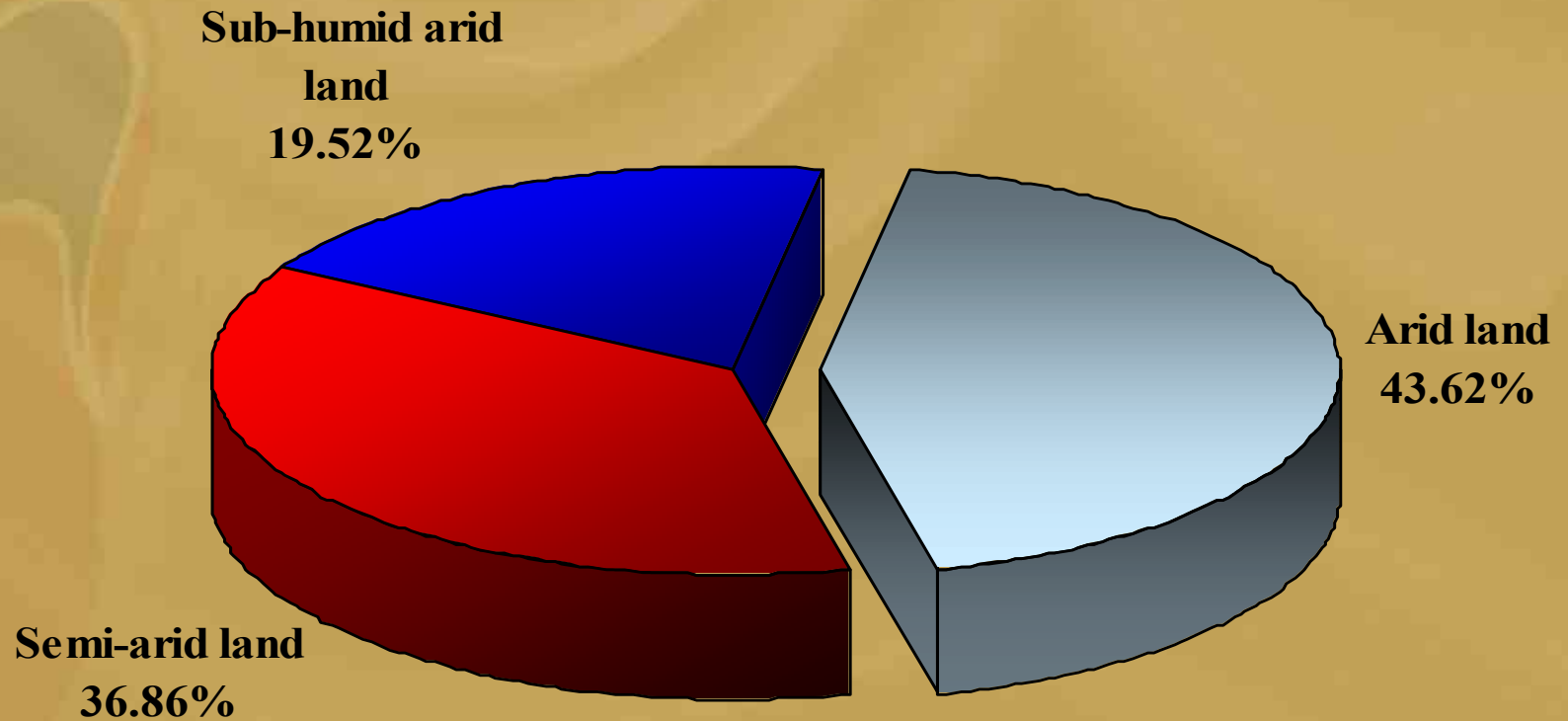
- **Status of Desertification in China**
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1. Status Quo of Desertification in China

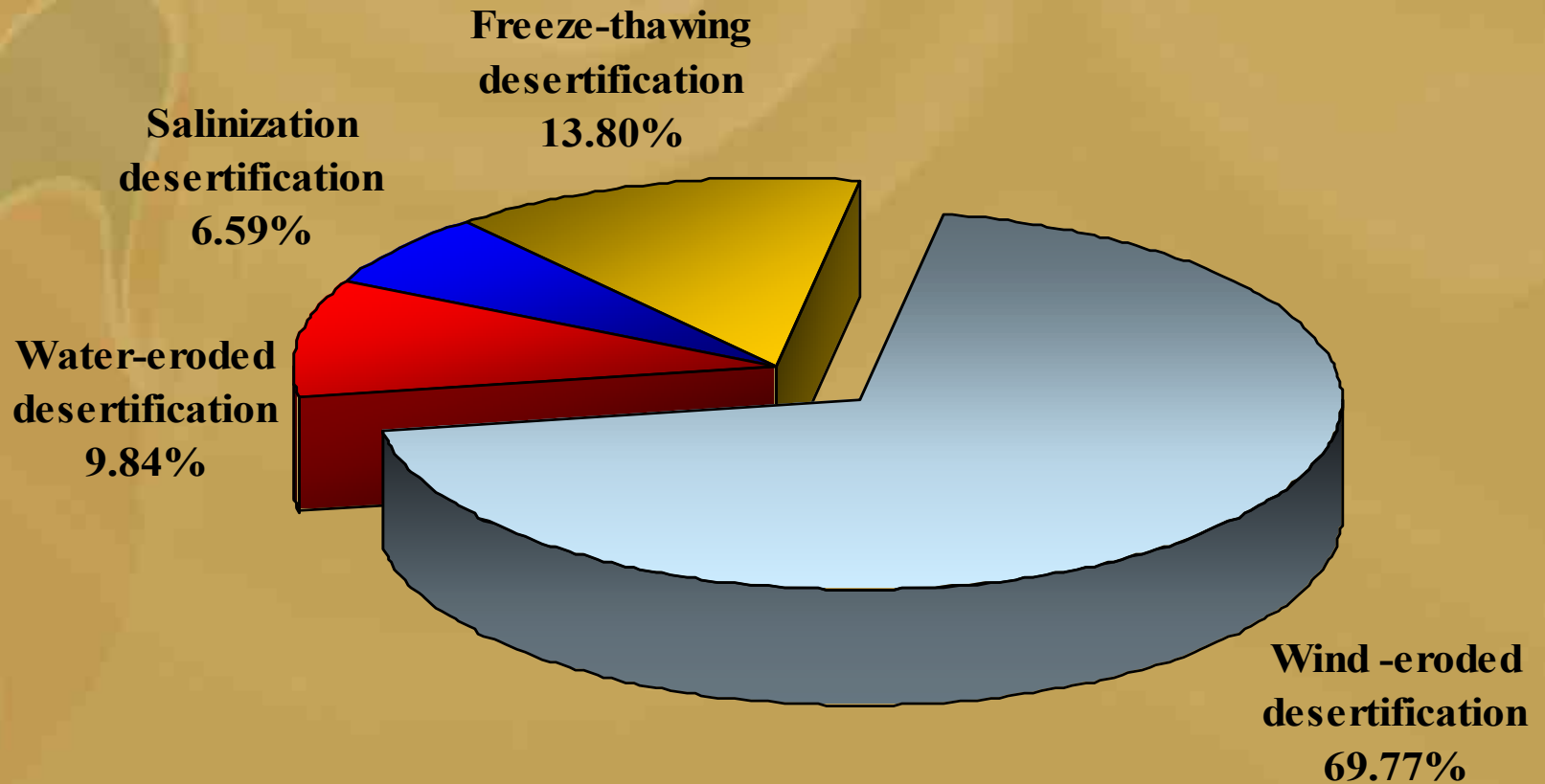
Status Quo of Desertified Land

The land suffering desertification nationwide in 2004 was **2.6362** million km², taking up **27.46%** of the territory, located in **498** counties of **18** provinces.

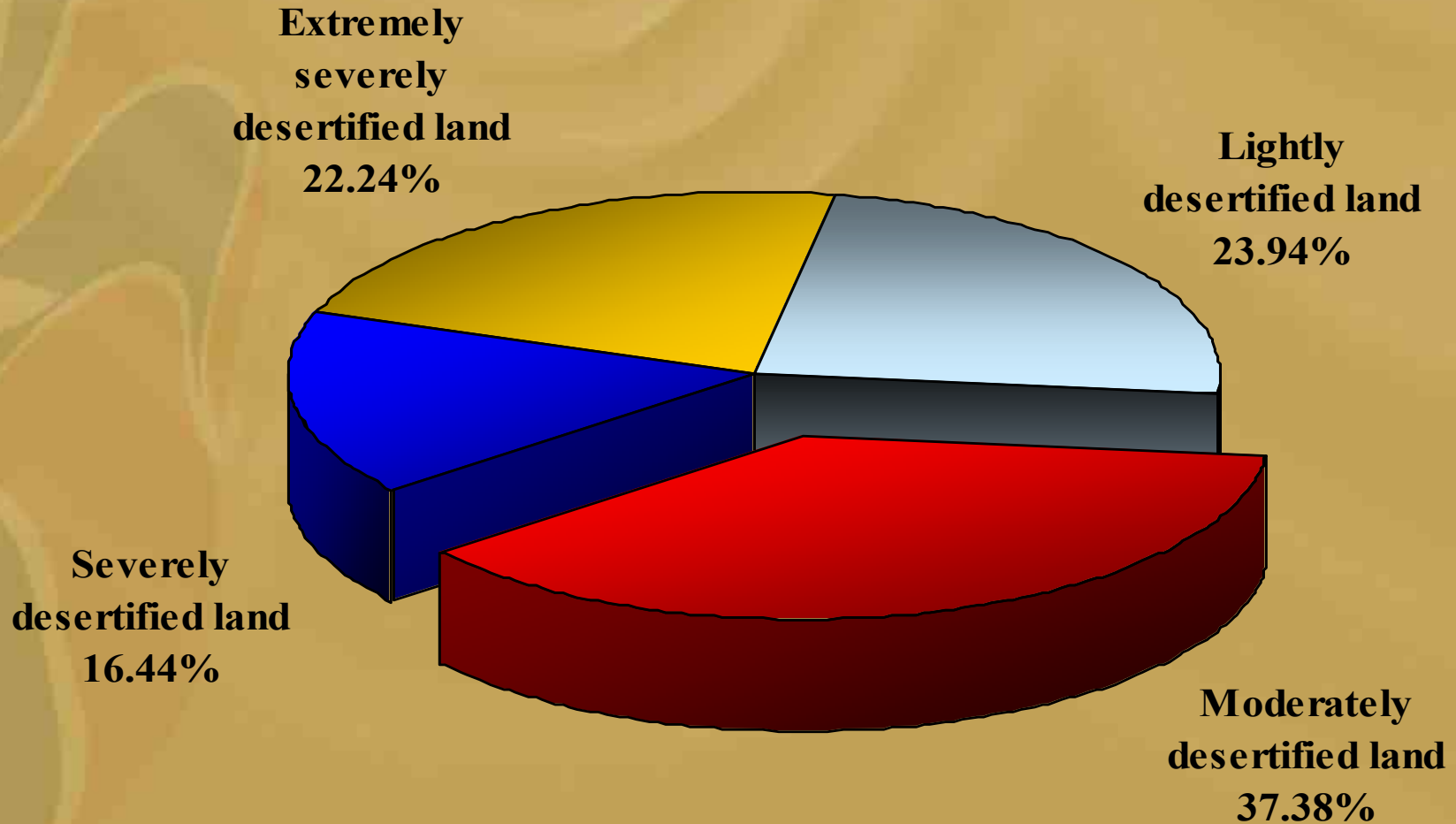
Distribution of Desertification in Different Climatic Zones



Status Quo in Terms of Distribution of Types of Desertification Land



Distribution of Desertified Land in Various Degrees



Status quo of land most vulnerable to sandification

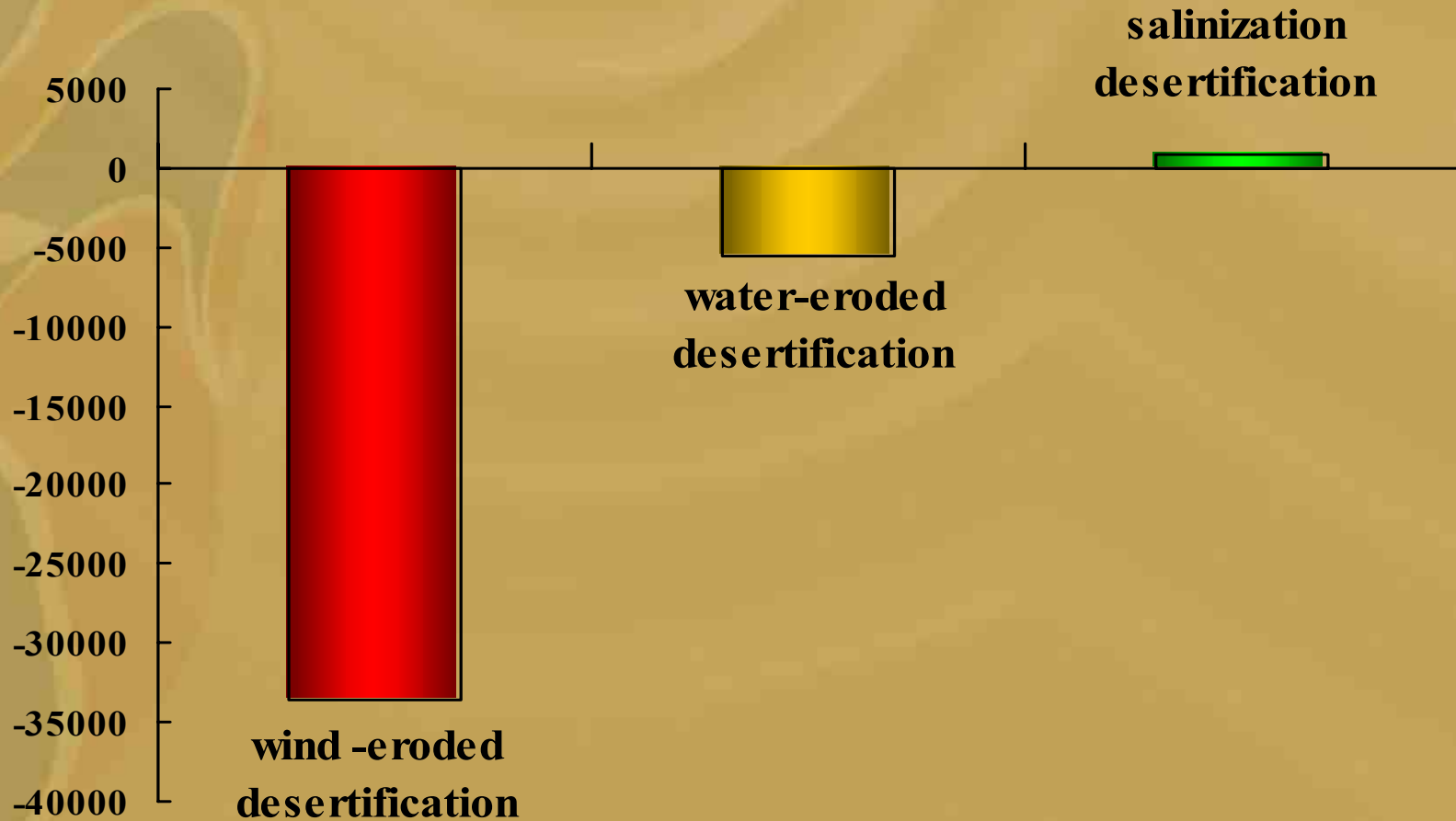
Land most vulnerable to sandification is a kind of degraded land due to over utilization of land or shortage of water resource.

The area of land most vulnerable to sandification is 318,600 km², accounting for 3.32% of the total country's territory, mainly distributed in 4 provinces.

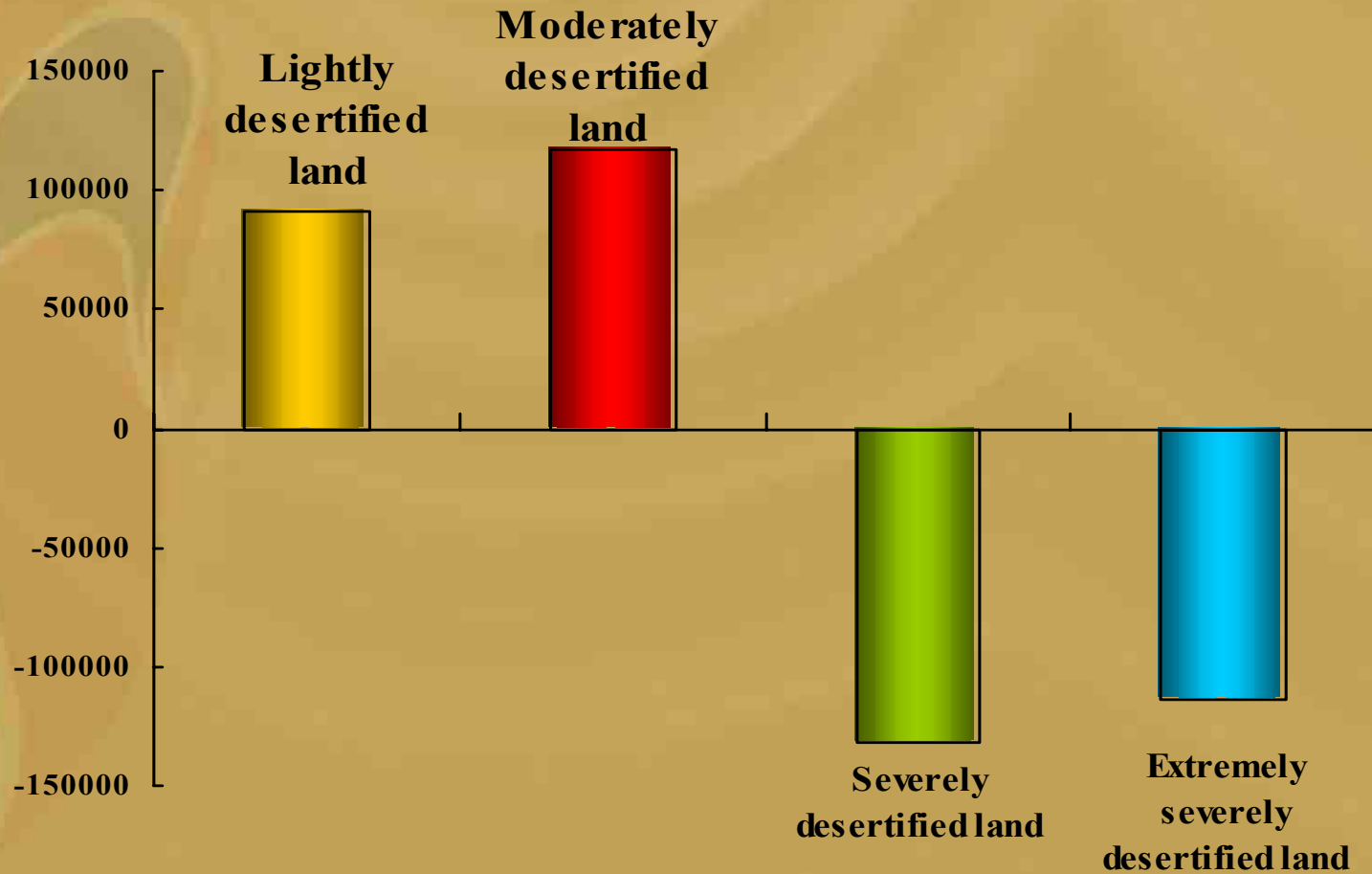
Dynamic Changes of Desertification

Compared with 1999, the national desertified land area **decreased by 37,924 km²**, representing an annual drop of 7585 km².

Dynamic Changes in Desertification Types (km²)



Dynamic Changes in Terms of Desertification Degree (km²)



2. Development and Cause of Desertification in North China

Historical situation

- In the Pleistocene about **10 thousand years ago**, the occurrence and reversion of desert were mainly controlled by global climate change driven by earth orbital parameters.
- Since the Holocene, especially **recent 2000 years**, human activities gradually became another important factor. However, sandy desertification was still primarily caused by climate change.

Historical situation

- In the **last 100 years**, the process of sandy desertification was affected by not only climate change, but also the intensified human activities

Type of human activities

Wind erosion is the main factor affecting desertification in North China, various human activities include:

- overgrazing (30.1%)
- excess reclamation (26.9%)
- excess firewood gathering (32.7%)
- irrational use of water resource (9.6%)
- regardless of environmental protection in building factories, mines and transportations (0.7%).

3. Desertification Monitoring in China

Indicator system for desertification monitoring and evaluation

A series of indicators for sandy desertification evaluation was determined in China in the past. In recent ten years, more progresses were made in the studies of indicator system for desertification monitoring and evaluation.

Desertification monitoring in China

Three times national desertification surveys were carried out in 1994, 1999 and 2004.

The 3rd National Monitoring Survey for Desertification and Sandification was implemented by the State Forestry Administration and with the involvement of several sectors as agriculture, water conservancy, environmental protection and meteorology.

A National Geography Information Management System for Desertification and Sandification was established.

- **Scope of monitoring:**

Arid, semi-arid and sub-humid area, distributed generally in **10 provinces** belonging to North and West China, with **270 counties** involved. Key monitoring area was **farm-pastoral transitional zone** in North China.

- **Contents of monitoring:**

The **status** of desertification land distribution and **dynamic macroscopic data** in arid areas for the state, provinces and **typical regions** are requested to provide in an appointed time.

Maps of desertification land distribution should be prepared timely when need.

Countermeasures and suggestions for desertification combating are put forward based on surveys and analysis.

- **Monitoring classification system:**

It consists of determination of land use type, desertification type and degree.



China's Desertification monitoring system

Three levels of desertification monitoring.

(1) The National Desertification Monitoring Centre:

To provide timely data for central government in making strategic policy and specific measurement for desertification combating and land protection,

(2) Provincial Sub-center

In charge of province monitoring.

(3) Desertification monitoring station

Sequential investigation and record- area, type and degree in the representative zone of each station, and to sub-center and national center.

4. China's Key Forestry Programs on Desertification Combating

The essential strategy in combating desertification in China is to control structure and function of agro-forest complex ecosystem, rationally use water and land resources, so as to promote a virtuous cycle within ecosystem.

A number of **key programs on sandification prevention and control** have been launched and implemented such as

- the six major forestry programs
- grassland protection improvement program
- small watershed integrated management program

Program for converting cropland to forest/shrubbery

The objectives:

- **to halt cultivation in the area with severe soil and water loss, desertification, salination and Karst rocky desertification, or low and unsteady yields**
- **to plant tree and grass according to specific local conditions and restore vegetation.**

Started in 1999

退耕还林工程总体布局示意图

比例尺：1：26000000



Involved:

25 provinces with totally 1897 counties. The emphasis was put on West and Middle China.

Key counties:

856 counties, occupying 29.9% of total national counties, 45.1% of total counties involved in program region.

Priority:

- important arable land with high ecological function in riverhead region
- steep slope land surrounding lakes
- severe soil and water loss land
- severe windstorm area





Program of Combating desertification in the wind sand sources areas affecting Beijing and Tianjin

The objectives:

to mitigate the damage of wind and sand storm
and build an ecological defense for North China
started in 2001



Scope:

involve Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia with 75 counties in total.

comprehensive control measures on forest and grass vegetation restore:

- conversion of cropland to forest
- afforestation;
- manual grass planting
- aerial seeding enclosure
- grassland construction
- seed base,
- grazing prohibition

- warm shed building
- riverhead project
- water-saving irrigation project
- small watershed comprehensive treatment
- eco-immigration with 180 thousand people

Three-North Shelterbelt Program



The objectives:

to change the status of wind-sand damage and soil and water loss in Northwest, North and Northeast China

Scope:

The program covers 551 counties with a total area of 4.069 million square kilometers (42.4% of China's total land area)

Plan:

started in 1978 and completed in 2050 including 4 phases and 8 periods.

Other Shelterbelt Programs

**Shelterbelt Program for upper
and middle reaches of the Yangtze River**

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5. Practical Strategies and Countermeasures to Combat Desertification

- **Stabilizing sands techniques** (biological, engineering and chemical stabilizing sands techniques)
- **Shelterbelt techniques system**
(in oasis, in pasture of sandy land and for railway in sandy land areas)
- **Typical models** in combating desertification in China

Biological stabilizing sands techniques

Sands enclosure to restore natural vegetation: to fence in vegetation-destroyed land in arid and semi-arid areas so as to prevent human activities and animal use, and gradually restore natural vegetation.

fully enclosure, half- enclosure and alternate enclosure.

Fully enclosure: to forbid all the human activities destroying plants growth.

Alternate enclosure: implemented around the divided zones in turn. **Sands enclosure is proved to be low cost and high efficiency.**



Enclosure--fenced grassland



Biological barrier to stabilize sands

Engineering stabilizing sands techniques



Sand barriers are made by **straw**, brushwood or branch, used to control direction and speed of wind sand so as to prevent strong wind sand. They are also the precondition and necessary condition for biological stabilizing sands.

There are vertical and horizontal sand barriers. The **vertical sand barriers are 50-100 cm high** above sand surface, horizontal barriers are 20-50 cm. The sand barrier are vertical to dominant wind direction with shape of **check-board with 1mX1m**.

Sand barriers made by straw



After sand barriers were set up, cultivated grass was grown up, as a function of the vanward precondition plants.

Sand barriers made by straw



After sand barriers were set up, cultivated grass was grown up, as a function of the vanward precondition plants.

Shelterbelt techniques system in oasis

consists of:

- stabilizing sands belt with sands enclosure (a wide shrub shelterbelt with width of 200 m at least outside of oasis)
- shelterbelt on the edge of oasis (the second defence line)
- cropland shelterbelt inside of the oasis (adjusting microclimate on cropland)

Shelterbelt for railway in sandy land areas



Building shelterbelt for railway in desertification and semi-desertification is the most difficult projection.

Shapotou railway Shelterbelt in Ningxia of China is a successful example of combating desertification.

Some typical patterns in combating desertification in China

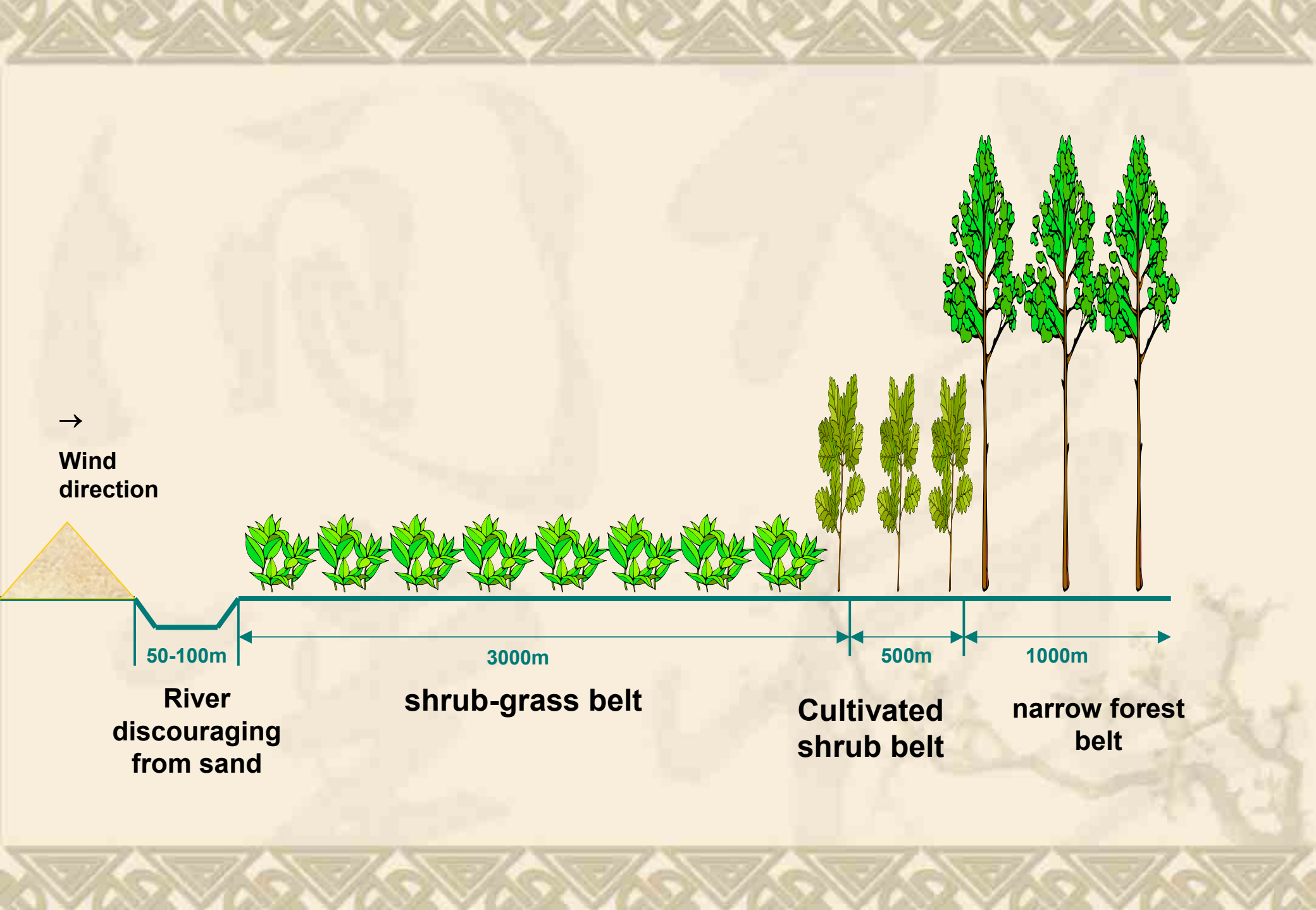
- Typical patterns for **combating desertification in oasis of arid areas**--- Shelterbelt system in oasis in Hetian, XinJiang Autonomous Regions
- Typical patterns for **combating desertification for railway in arid areas**—Shapotou, Ningxia railway sands stabilization
- Typical patterns for **combating desertification in farm**---pastoral transition zone in semi-arid region

Shelterbelt system in oasis in Hetian, XinJiang Autonomous Regions

located in north of Kunlun Mountai, south-west of Taklimakan Desert ,annual precipitation 34.8 mm and evaporation of 2564 mm.

Practical countermeasures

- **Sands enclosure:** To protect and restore natural desert vegetation so as to maintain and expand oasis.
- **Shelterbelt system :** To build shelterbelt system with tree-shrub-grass and multi-trees varieties in the edge of oasis and desert.
- **Cropland shelterbelt network:** To build a cropland shelterbelt network with narrow forest belt and small network in oasis, such as economic trees or grape aisle.





Tree-shrub-grass model



Cropland shelterbelt



**Sandy land
Su (Crisp) Pear**

combating desertification for railway in arid areas—Shapotou, Ningxia railway sands stabilization

located in south-east of Tengger Desert and bordered upon irrigated Plain in Zhongwei. There are **lots of high shifting dunes** threatening the Bao-lan railway. There is annual precipitation of 186.2 mm. The vegetation fraction is less than 1%.



Practical countermeasures



The shelterbelt system consists of **five belts outward of the railway** with the length 300 meters of windward and 200 m of leeward, straw barrier belt is the core part.

- **Sands stabilization and fireproof belt:** Stones, loess or slag are lay along with railway roadbed, 200 m windward and 10 m leeward.
- **Afforestation belt with irrigation:** to reclaim terraces for farming and build irrigation channel for afforestation (shrub) in the scope of 60 meters of windward outside of the first belt and 40 meters of leeward outside.

- **Straw barrier belt:** In the scope of 240 meters of windward outside and 160 meters of leeward outside, straw check-board barriers to stabilize sands with 1mx1m are set up. With the benefits of vegetation shelterbelt in a long time the soil macrobiotic crust gradually formed on the sands surface and become thick, which adjusted soil water and nutrition, some vegetation was survival.
- **Forefront stopping sands belt:** The vertical sand barriers made from wattle are set up at top of dunes, the barriers with 1 m are buried 30 cm underground.
- **Sands enclosure belt:** In the windward slope of dunes in forefront stopping sands belt, it is enclosed with sand barriers and planting shrubs.

The combating techniques in Shapotou award special prize in science and technology in China, and also by UNEP and UNDP.

Comparison of controlled desertified land with non-controlled area



Integrated measures in sand area in Yulin county Shaanxi Province in farm-pastoral transition zone in semi-arid region

located in south of Ordos Plateau, south-east of Mu Us Sand Land. Annual precipitation 316-450 mm, evaporation 2092-2506 mm.

Practical countermeasures:

- To build shelterbelt system with different structures according to topography, water resources and features of sandy plants.
- To develop integrated exploitation models with agro-forest system, including fruits trees, medicinal materials, economic crops, trees nursery, animal husbandry.

Converting cropland to forest shrub land in the north of Yinshan Mountain in Inner Mongolia, farm-pastoral transition zone in semi-arid region

Practical countermeasures:

Bio-measures are given priority: The wide shelterbelt is modified to narrow shelterbelt. Shrubs are dominant with tree-shrub-grass combination.

Hills as unit for rehabilitation:

- The top of upland hills with severe wind erosion and sloping cropping field with gradient ($\geq 15^\circ$) are converted to grass and shrubs.
- Sloping cropping fields along with slope at the middle and bottom of the hills are changed as contour ploughing so as to control water erosion.
- The bottomland is improved as cropland with high productivity.

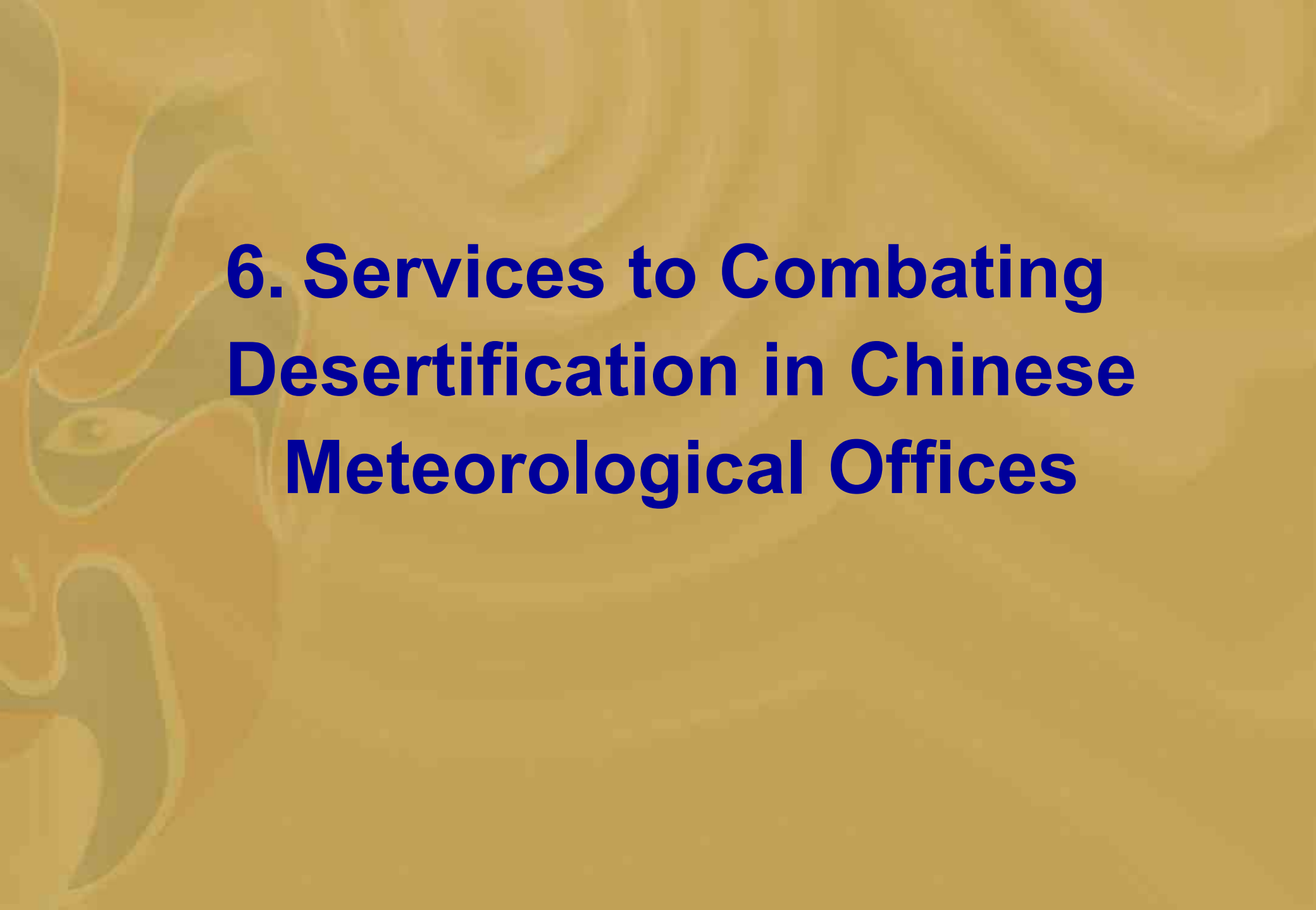


Integrated ecological-economic exploitation in family courtyard in Wongniute county in Inner Mongolia, farm-pastoral transition zone in semi-arid region

Located in west of Horqin Sandy land with annual precipitation of 340 mm, evaporation of 2233.7 mm

Practical countermeasures

- to transform solar energy to heat in green houses and shed for vegetable, grape tree and animal husbandry in winter
- to use biogas produced from dejecta of pigs to heat and fuel for family.



6. Services to Combating Desertification in Chinese Meteorological Offices

- **Research on desertification development and combating in terms of meteorological conditions**
- **Monitoring and assessing services to combating desertification of grassland**

Effects of man-made interfere on wind erosion and soil degradation in Xilinguole Steppe, Inner Mongolia

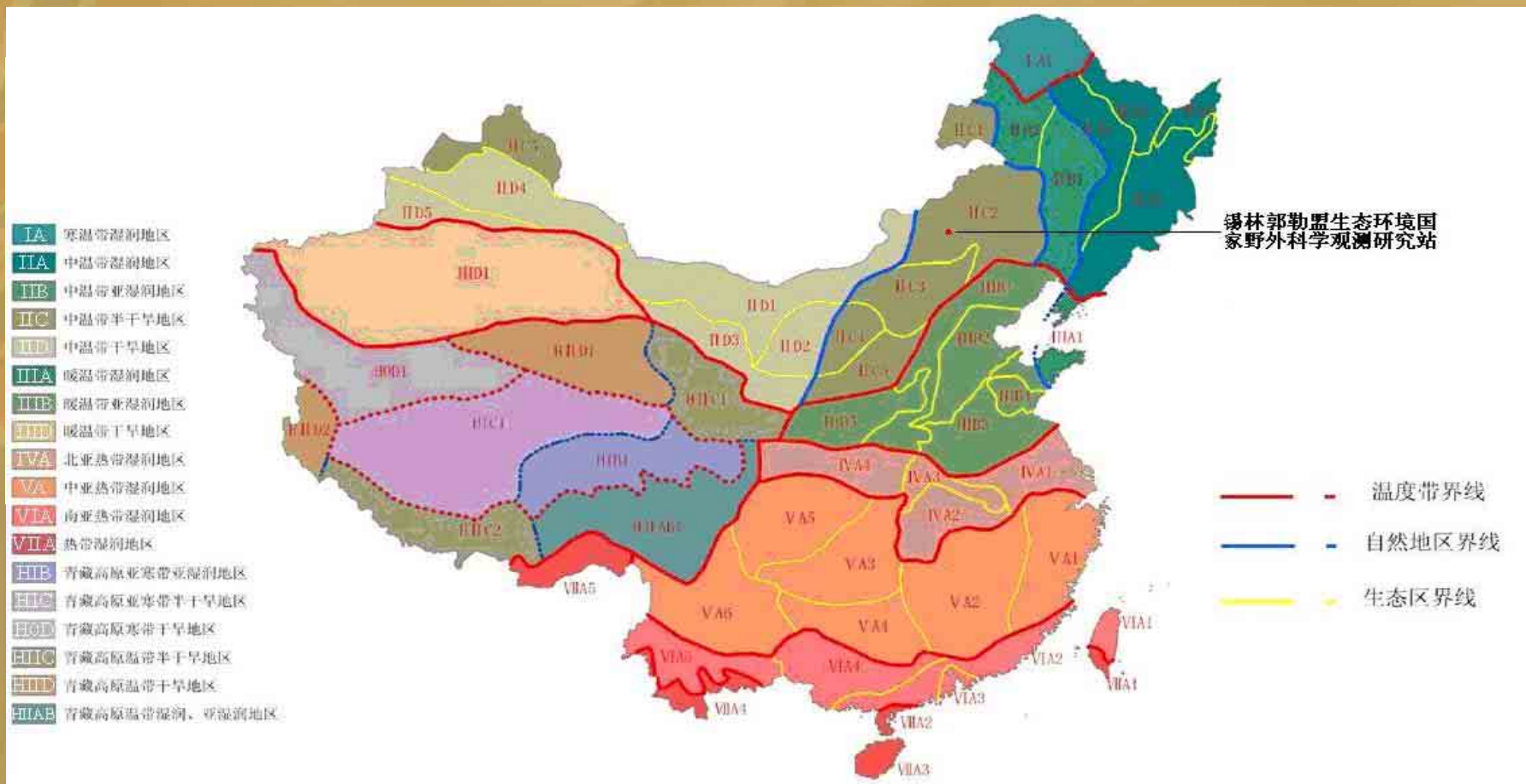


图1 国家生态系统野外观测研究站网络布局分区图

The biomass above the ground was measured in free grazing land, fenced grassland and cropland respectively in April, July, August and October.

The results show the biomass value :

fenced grassland in 1987> in 1997> in 2003>free grazing>cropland.

It indicates that reclamation and grazing might reduce the biomass of ecosystem, while fencing is in favor of increasing biomass.



Monitoring of wind erosion on land surface



Monitoring of wind erosion on land surface



Estimation of carrying capacity in animals in grassland

carrying capacity for animals in cold season

$$M = \sum_{i=1}^n \frac{Y_{ci}}{et} + \sum_{i=1}^n \frac{(g_i \cdot Y_{ci} + Y_{di}) a_i b_i}{et} \left(1 - \frac{f(L_i)}{P_i f(h_i)}\right)$$

Table 1 Comparison between rational and actual carrying capacity for animals in cool season in Xilinguole (sheep unit/km²)

steppe	Harvest year		Rational values		Actual values		excess (-) shortage (+) %	
	1996	1997	1996	1997	1996	1997	1996	1997
desert	bumper	poor	42	28	50	61	-19	-118
typical	bumper	bumper	72	50	107	83	-49	-66
meadow	bumper	bumper	154	113	76	101	+51	+11

There are imbalance in carrying capacity with excess or shortage. This information is useful for government to rationally use resources in grassland and alleviate desertification.

Meteorological information services to animal husbandry of steppe

Various bulletins are reported to government, department of ecosystem protecting and combating desertification:

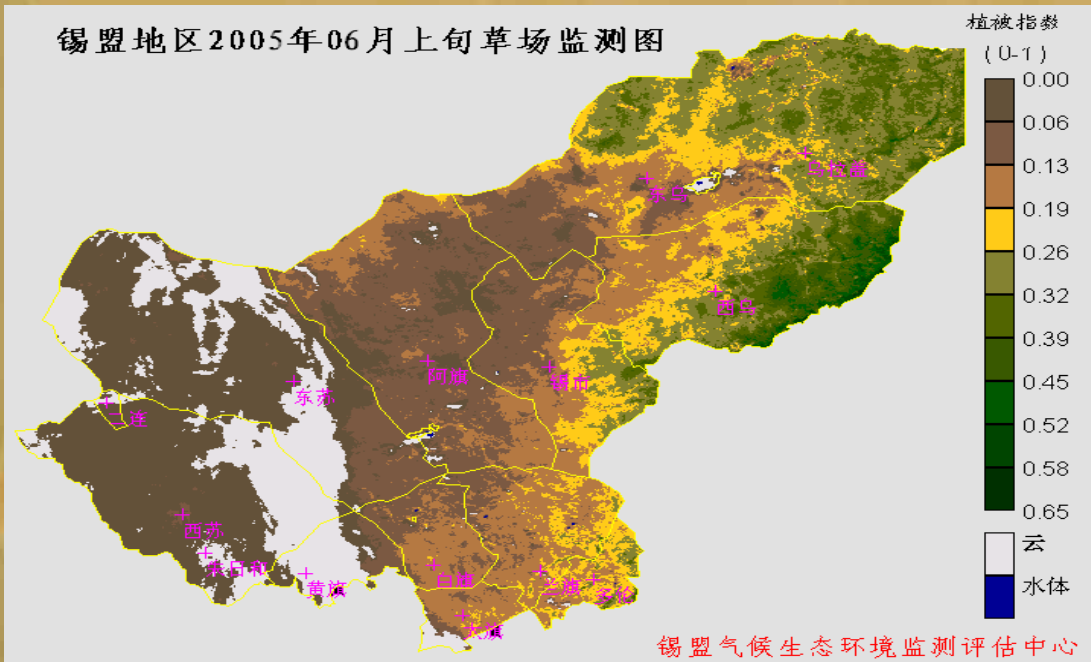
- climate review
- effects of climate on
- ecological environment
- outlook of climate-environment
- suggestions on ecosystem protecting and combating desertification.



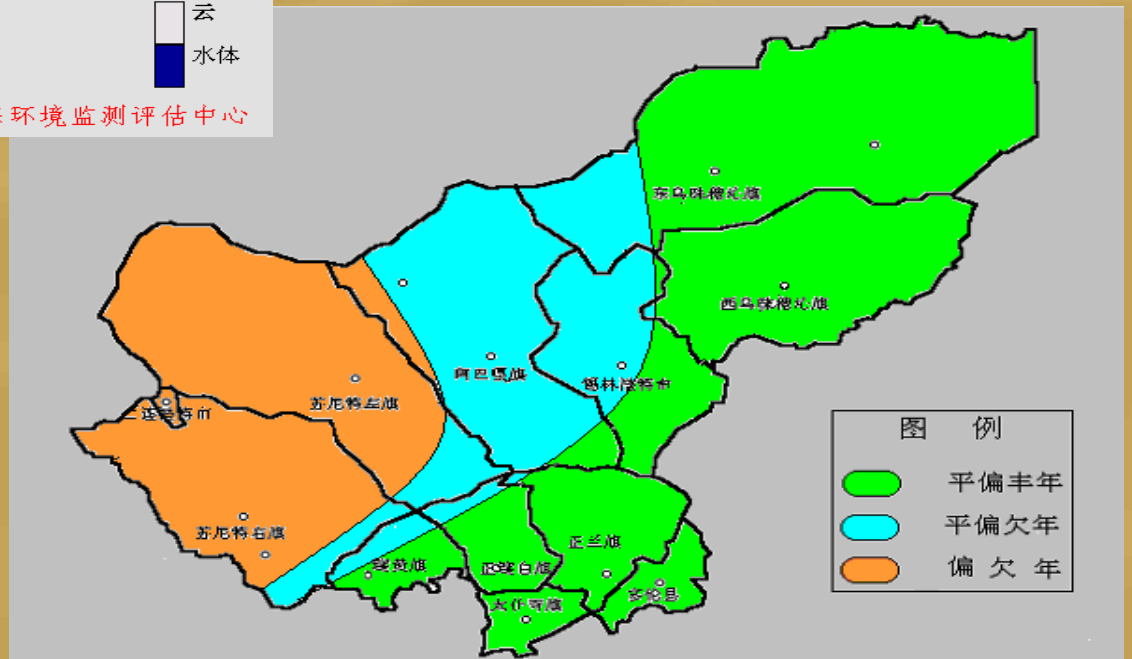
Meteorological information services to animal husbandry of steppe

- **Forecasting of grass return green date and date of enough grass for animals:** adopted by government as basis of determining beginning and ending date of seasonal sand enclosure.
- **The estimation of carrying capacity for animals in cold season:** used to determine proper number of full-grown animal.

锡盟地区2005年06月上旬草场监测图



Monitoring of grass growth status in Xilinhaote, Inner Mongolia in first decade on June, 2005



Forecast of grass yield in natural pasture for 2005

Monitoring and predicting of dust storm in China

- **Observation network of CMA:** It consists of 2456 meteorological observation stations. Apart from conventional observation data in CMA, some data of adjacent countries is available by WMO data exchange used in dust storm monitoring.
- **Sand storm monitoring network in CMA:** There are 24 observation stations located in the areas suffered by sand storm in northern region of China, important data such as PM₁₀ (particle matter with diameter less than 10 μm), visibility measured by instruments and dust fallout are obtained real time.

Monitoring and predicting of dust storm in China

- **Sand storm monitoring network in China**
Environment Protect Administration: There are 45 observation stations located in the 11 provinces in northern region of China. PM10 and TSP (total suspended particle) are measured.
- **Monitoring using meteorological satellite.** The data from meteorological satellite -China Fengyun 2C is retrieved to get distribution and intensification of East-Asia sand storm.



Sand storm monitoring station



Sand storm forecast city

Present operational services of Monitoring and numerical predicting of dust storm in China

China dust storm website and information services

The contents of website:

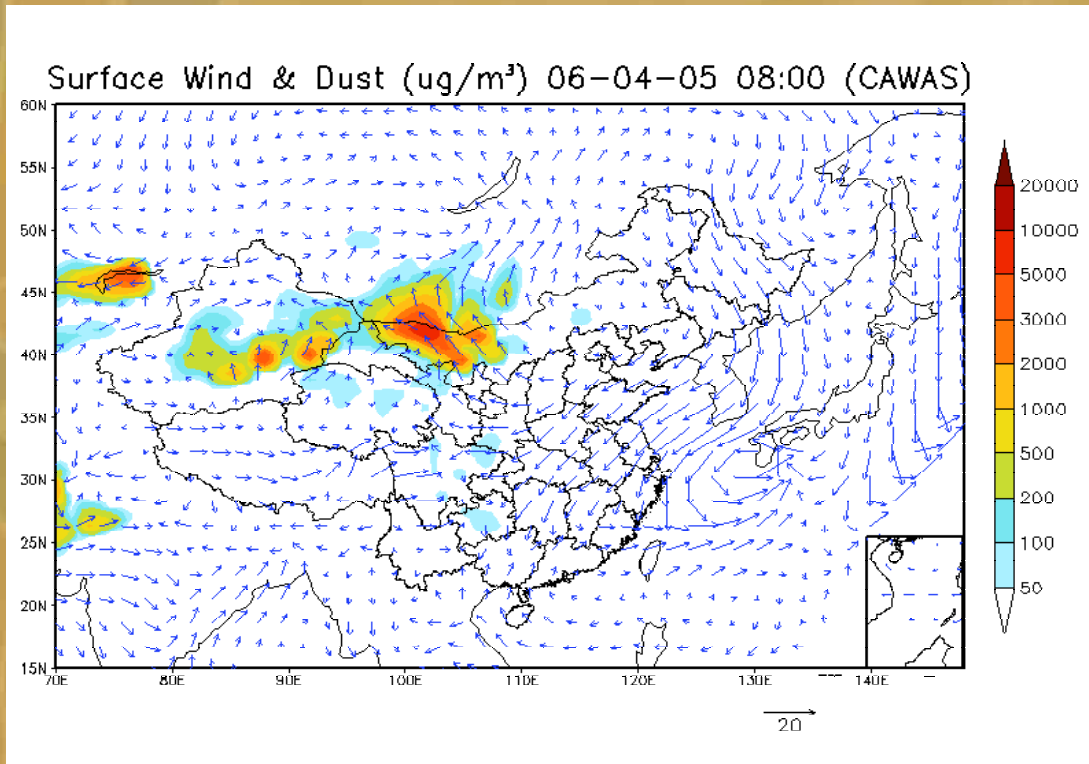
- dust storm monitoring
- dust storm forecast
- dust storm assessment
- dust storm yearbook
- knowledge
- dust storm research

The screenshot displays the homepage of the China Dust Storm Website. At the top, there is a banner with the text "Welcome to Chinese dust storm Website!" and "Welcome to Chinese". Below the banner are navigation links: "Introduction of Website", "Contact us", and "Leave words". A circular logo of the National Weather Bureau is also present. The main navigation menu includes: "First Page", "Development of news", "Monitoring information", "Historic data", "Dust event summary", and "Scientific study". A search bar is located below the navigation menu with the text "choose the searching" and a "searching" button. The website is titled "中国沙尘暴网" (China Dust Storm Website) and "www.duststorm.com.cn".

The main content area is divided into several sections:

- Forecasting:** "stream and 'Mongolia cyclone', northern".
- Development of news:** A list of news items including "We 'dance with dust' in spring?", "Snow water from Kunlun Mountains to...", "Something good of sandstorms", "Beijing Youth Daily 2005-4-9 9:35:38", "How to tame Mingqing desert in a scien", "Qinghai-Tibet plateau to be main sour", "Influence of warming climate to China", and "Mongolia, China, Japan, South Korea a".
- Historic data:** "Sandstorm" assaults Ji'nan, "Strong sandstorm hit part of Central South Korea assaulte", "Worst regional sandstorm in", "Sandstorm and blowing dust s".
- Summary of dust event:** "The harm of dust events", "The major disserving modes o", "The harmfulness of black win", "Climate and natural disaster", "Seven kinds of climatic type".
- Monitoring information:** "monitoring information26-1", "monitoring information25-1", "monitoring information24-1", "monitoring information14-1".
- Scientific study:** "Experts forecast the climate", "The cause of formation and p", "Four countermeasures provide", "Introduction to EOS satellit".
- Fellowship Link:** "CMA", "WMO Secretariat", "EUMETNET", "SMI_Meteoswiss", "ECMWF".
- Secondary planet Photograph:** A satellite image of Earth showing dust storms over Asia.
- Welcome to Whina Duststorm Website:** "www.duststorm.gov.cn", "www.duststorm.com.cn", "www.duststorm.net.cn", "www.chinaduststorm.net", "www.chinaduststorm.com".

Numerical forecast of dust storm



**Sand storm forecast from 5, Apr.
2006 to 11, Apr. 2006**

CMA developed an advanced numerical forecast system of dust storm describing the concentration distribution of sand dust in Asia, and has been put into operation in CMA.

It well predicted the dust storm weather process in 2004, 2005 and 2006.

The numerical forecast information is issued on official website of CMA and website of WWRP, International Sand storm Research Programme.

6. Conclusions and Discussion

challenges in coping with desertification

- The global climate warming, frequent and severe drought are existing facts, and future climate change will continue to influence desertification.
- There are still various human-driving factors leading to deteriorating vegetation in sandy areas and extension of sandification.
- Combating desertification is a big problem with long time and large scale, which requires more density and frequent time monitoring network.
- The research on relationship between climate and occurrence, development of desertification as well as combating countermeasures should be carried out furthermore.
- It will take a long time to rehabilitate the plant community to a stable status and to restore ecological system of sandy land.

Opportunities to cope with desertification

- In view of characteristics of desertification structural measures are the major and preliminary.
- To promote the measures of prohibiting reclamation, overgrazing and firewood collection.
- To popularize and apply practical technologies and models for desertification prevention and control
- To follow natural laws, adopt biological- agronomical-engineering measures and to combine artificial rehabilitation with human-promoted natural restoration according to local conditions.
- To carry out technique training and demonstration to make farmers master and apply countermeasure to cope with desertification.

Non-structural measures by NMHS's

- **The desertification monitoring in terms of meteorological condition in desertified region should be strengthened.**
- **Further researches should be carried out to make clear the relationship between climate and desertification, and combating countermeasures.**
- **The agrometeorological information services are useful for governments and farmers to make division and adopt countermeasures in combating desertification.**

奈曼旗
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Thanks



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