

State Forestry Administration, People's Republic of China
Parks and Forestry Department, Beijing City
Department of Forestry, Hebei Province

THE STUDY ON
VEGETATIVE REHABILITATION MODEL PROGRAM
FOR SAND STORM PREVENTION AROUND THE
CAPITAL BEIJING
IN THE PEOPLE'S REPUBLIC OF CHINA

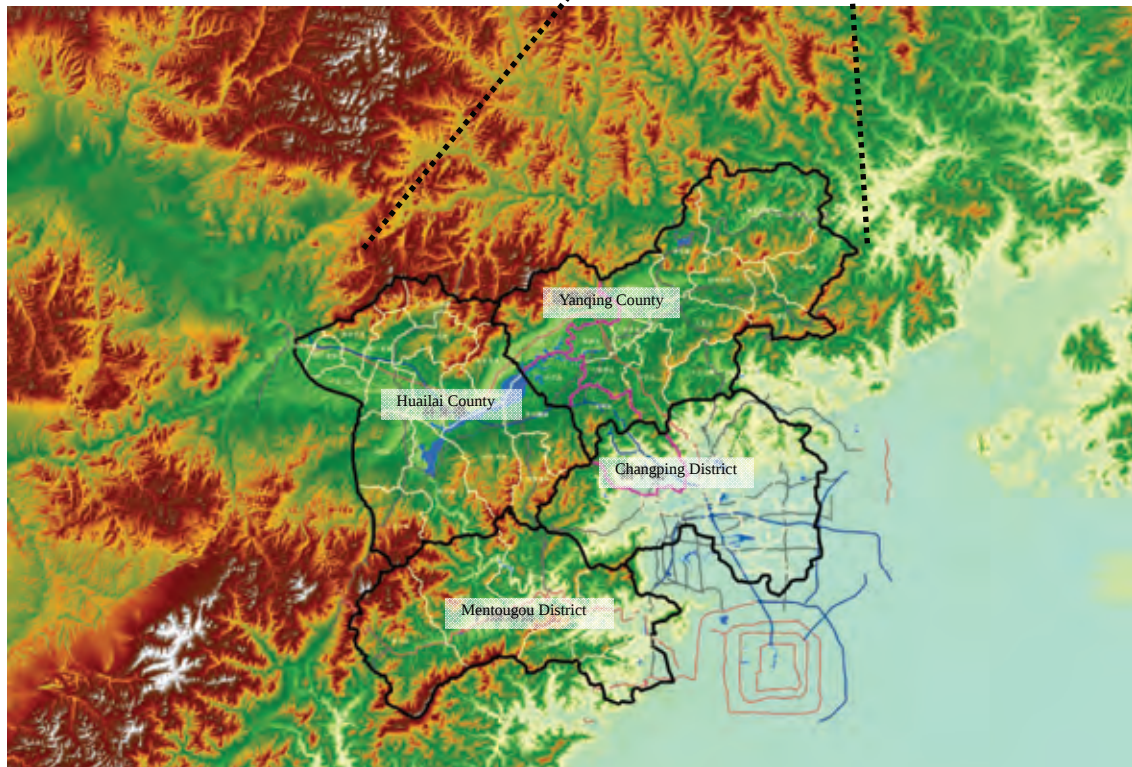
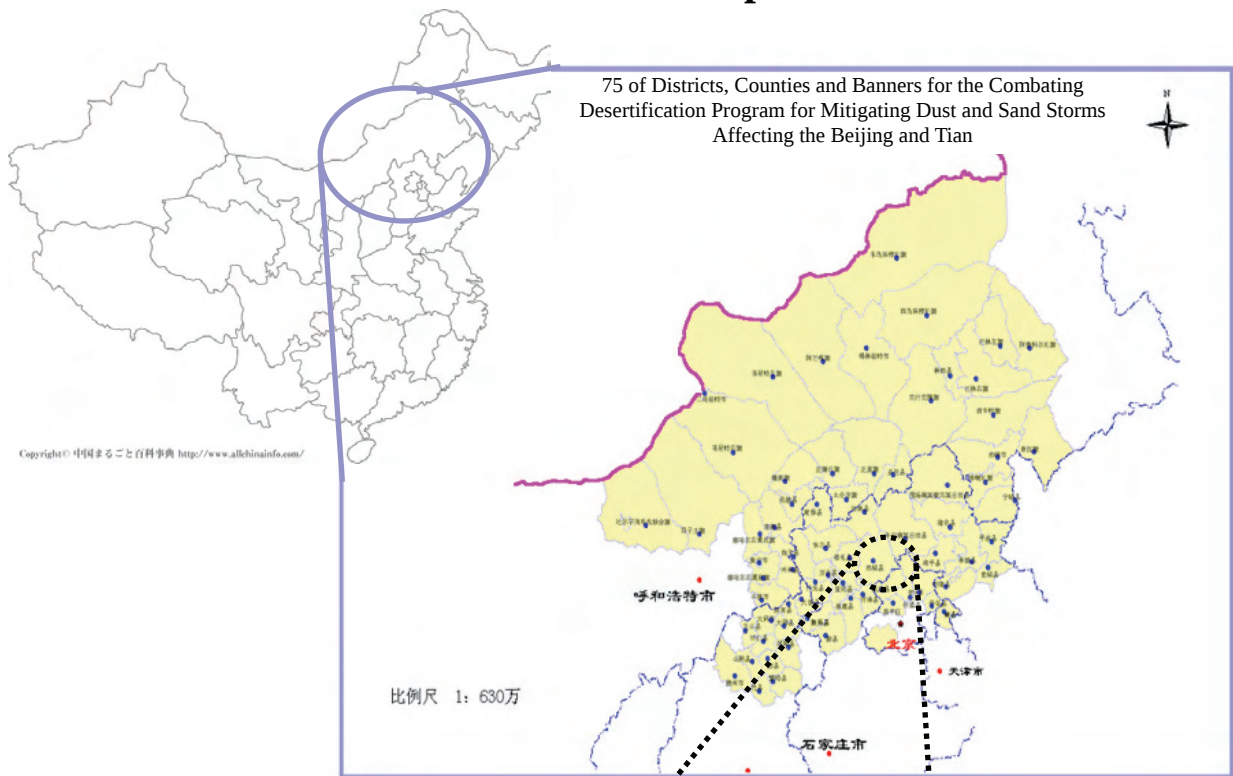
FINAL REPORT
Summary

February 2010

Japan International Cooperation Agency

Japan Overseas Forestry Consultants Association
Aero Asahi Corporation

Location Map



Map of the target study areas

Basic plan : indicated by black solid line

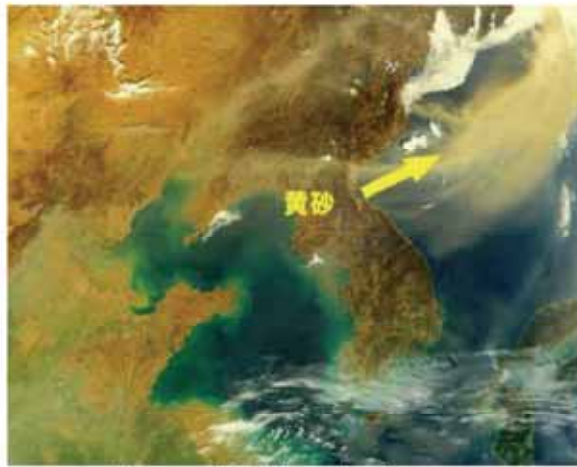
Yanqing County, Changping District, and Mentougou District in Beijing City; Huailai County in Hebei Province

Implementation Plan : indicated by pink solid line

From top to bottom: Zhangshanying-Zhen town, Kanghuang-Zhen town, and Badaling-Zhen town, Yanqing county of Beijing City; Nankou-Zhen town, Changping District of Beijing City

Photographs

1. Outline of the study



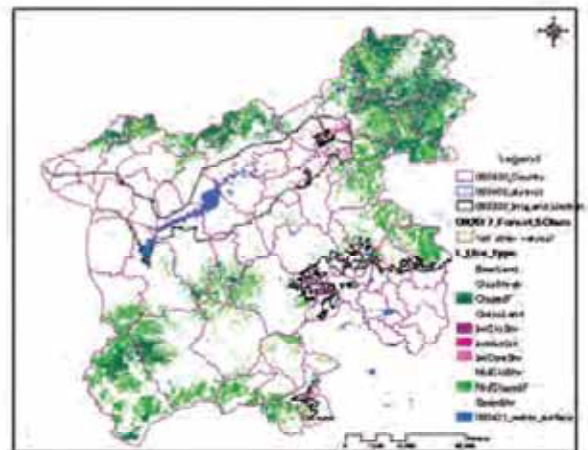
The way yellow sand is blown into Japan (a satellite image) Source: Website of the Ministry of the Environment, Japan



Photograph shows the deposits on the roof of a car left for a week in Beijing City



Dust and Sand Storms Hazard Map of 4 target Districts and Counties in the Basic Plan



Map of forest management operation types of 4 target Districts and Counties in the Basic Plan



Forest Resources Map of 4 Towns and Townships in the Implementation Plan



Field study of 4 Towns and Townships in the Implementation Plan

2. Existing model forests



A windbreak and sand fixation forest of *Platycladus orientalis*/*Populus* spp. in the aeolian soil deposit site around Quangting Shuiku Dam in Huailai County



A *Pinus tabulaeformis* and *Platycladus orientalis* mixed-forest in the non-irrigated montane in Yanqing County



A semi-remote and middle-hill *Platycladus orientalis* broad-leaved mixed, soil-water conservation forest in the Changping District



A mountainous needle-leaved and broad-leaved multi-species mixed forest (planted with watering operation) in the Mentougou District



A wind break and sand fixation forest of *Platycladus orientalis* in southern Quangting Shuiku Dam in Huailai County



A windbreak forest for cultivated farmland in the Changping District

3. New model forests



Temporary seedling stocking



Watering



Planting hole digging



Applying water retention chemical



A distant view of a model forest in Yanqing County



A closer view of the model forest in the left photograph (multiple tree species mixed planting)



A distant view of a model forest in the Changping District



A closer view of the model forest in the left photograph (*Pinus bungeana*. planting zone)



A full view of a model forest in Huailai County



A model forest in Huailai County (A lowland forest of *Zizyphus jujuba* var. *inermis* and *Juglans regia*)



A windbreak net (installing a net in a model forest in Huailai County)



A windbreak net installed in a vineyard in Huailai County (experimental)

4. Planting tree species for hill-side ecology protection forest in Yanqing County



Pinus tabulaeformis



Platycladus orientalis



Quercus mongolica



Continus coggia



Prunus armenica



Acer truncatum nica.armenica

5. People's participation



Workshop in a village



Participatory training



Demonstration forest of economic tree species



Technical training on economic tree species



Students participated in a commemorative tree planting ceremony for the Beijing Olympics



An evaluation workshop for the people's participation activities

Foreign currency exchange rates

Date	Japanese yen/Chinese yuan	Japanese yen/US \$	US \$/Chinese yuan
March 15, 2007	15.14	117.3	0.1291
June 15, 2007	16.11	122.9	0.1311
December 15, 2007	15.37	113.3	0.1356
June 15, 2008	15.68	108.02	0.145
December 15, 2008	13.33	91.25	0.146
June 15, 2009	14.39	98.42	0.1462
December 15, 2009	12.96	88.54	0.1463

Source: Searchina Currency Exchange Calculator <http://stock.searchchina.ne.jp/exchange/index>.

Rates quoted are median rates in major markets in Asia.

Unit conversion table

Measurement unit	China	(In Pinyin)	Japan [];conversion rate	International
Currency	人民币、元	yuan	日元（円）(yen)	US\$, EURO
Distance	厘米	limi	cm	cm
	米	mi	m	m
	公里	gongli	km	km
Area	cm ²	pingfanglimi	cm ²	cm ²
	亩	mu	[1 mu=1/15ha =0.0667ha]	
	ha、公顷、hm ²	gongqing	ha	ha
	km ²	pingfanggongli	km ²	km ²
Quantity	克	ke	g	g
	两	liang	[1 liang=50g]	
	斤	jin	[1 jin=500g]	
	公斤	gongjin	kg	kg
	吨	dun	t	t

Table of Contents of the Summary

1.	Introduction	1
1.1	Background of the study.....	1
1.2	Objective and scope of the study.....	1
1.3	Basic policies of the study	2
2.	Overview of the Study Areas.....	3
3.	Current situations of the Combating Desertification Plan in 4 Target Districts and Counties and Future Tasks	4
4.	Basic Plan	5
4.1	Objectives of the Basic Plan.....	5
4.2	Classifying, zoning, making a GIS database of natural condition of target study area	8
4.3	Classifying the target area for the forest management operations to reduce sand and dust flow ...	10
4.4	Classifying forest management operations.....	12
4.5	Social conditions and forest management operations.....	12
4.6	Selecting villages to focus on and priority towns and townships in implementing sand and dust flow reduction and vegetative rehabilitation measures.....	12
4.7	Target operation size.....	13
4.8	Estimation of required project cost.....	13
4.9	Targets of forest management.....	15
4.10	Guideline for formulating the Basic Plan	15
5.	Farmland/Agriculture/Farmers and Forest Management Operations: -Agriculture and Forestry after the Chinese Improvement and Open Door Policy-.....	15
5.1	Farmland/agriculture and suburban forests	15
5.2	Windbreak forest for farm land	15
5.3	Forest management through people's participation.....	18
6.	Implementation Plan.....	19
6.1	Basic conditions of the areas covered by the Implementation Plan.....	20
6.2	Situations of land use and forests	20
6.3	Project objectives and guiding philosophy	21
6.4	Principles and references of the implementation plan	21
6.5	Major project operation measures under the plan.....	21
6.6	Estimation of required project investment.....	22
7.	Support to model forest establishment	23
7.1	Purposed of model forest establishment and procedures of implementation	23
7.2	Selection model forests from existing forests.....	23
7.3	Establishment of new model forests (Japanese and Chinese sides).....	24
7.4	Manual of forest vegetative rehabilitation techniques	27

Summary

1. Introduction

1.1 Background of the study

As of 2004, as much as 2,636,200 km² of land in the People's Republic of China has turned to desertified land which is equivalent to 27.46% of the national land. Wind from the northwest blows into the populous Beijing City, the capital of China, as well as neighboring cities including Tianjin City, bringing in sand from desert and desertified lands from, such region as the Inner Mongolia.

Damages from such sand storms can range from traffic disruptions on roads and airline routes to rising concerns about human health problems, such as respiratory diseases. Such sand, called 'yellow sand' in Japan, is not only blown into China but also to the Republic of Korea and Japan.

Under these circumstances, the Chinese government has been implementing "The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting the Beijing and Tianjin Areas." However, the counties in Beijing and Tianjin cities that are responsible for formulating specific implementation plans for this Program have difficulties in conducting sufficient studies to formulate plans due to their lack of technical competence.

Their plans have not fully harmonized with natural environment. Although activities of the program conducted around rivers and farmlands need to be coordinated with the Department of Waterworks and Agriculture of the county concerns, their implementation plans do not seem to have proper coordination. Formulating plans that are realistic and well coordinated with other related departments is a task for counties to tackle.

Under these circumstances, the Chinese government requested in May 2005, that the Japanese government provided them with support to formulate implementation plans for "The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting Beijing and Tianjin Areas."

As the result, both governments have jointly conducted "Vegetative Rehabilitation Model Program for Sand Storm Prevention around Beijing, Capital of The People's Republic of China" for 36 months, from March 2007 to February 2010.

1.2 Objective and scope of the study

The objective of this study is to enable the Chinese counterparts (hereinafter referred to as C/P) so that they will be able to autonomously plan and implement programs for vegetative rehabilitation of their forests, through formulation of implementation plans for vegetative rehabilitation of forests to reduce dust and sand storm damage around the Beijing and Tianjin areas, and technology transfer to the C/P and through establishing model forests.

The target areas are Mentougou District, the Changping District, Yanqing County of Beijing City and Huailai County in Hebei Province (hereinafter referred to as 4 target Districts and Counties), covering a total area of 6,617 km².

Counterpart institutions of the study are the Parks and Forestry Department, Beijing City, the Department of Forestry of Hebei Province, and each Department of Forestry of 4 target Districts and Counties. The Parks and Forestry Department, Beijing City is the institution that is in charge of overall implementation of the study, while its Cooperation Office manages day to day practical matter of the study. The State Forestry Administration, People's Republic of China, is the central supervisory government organization of China.

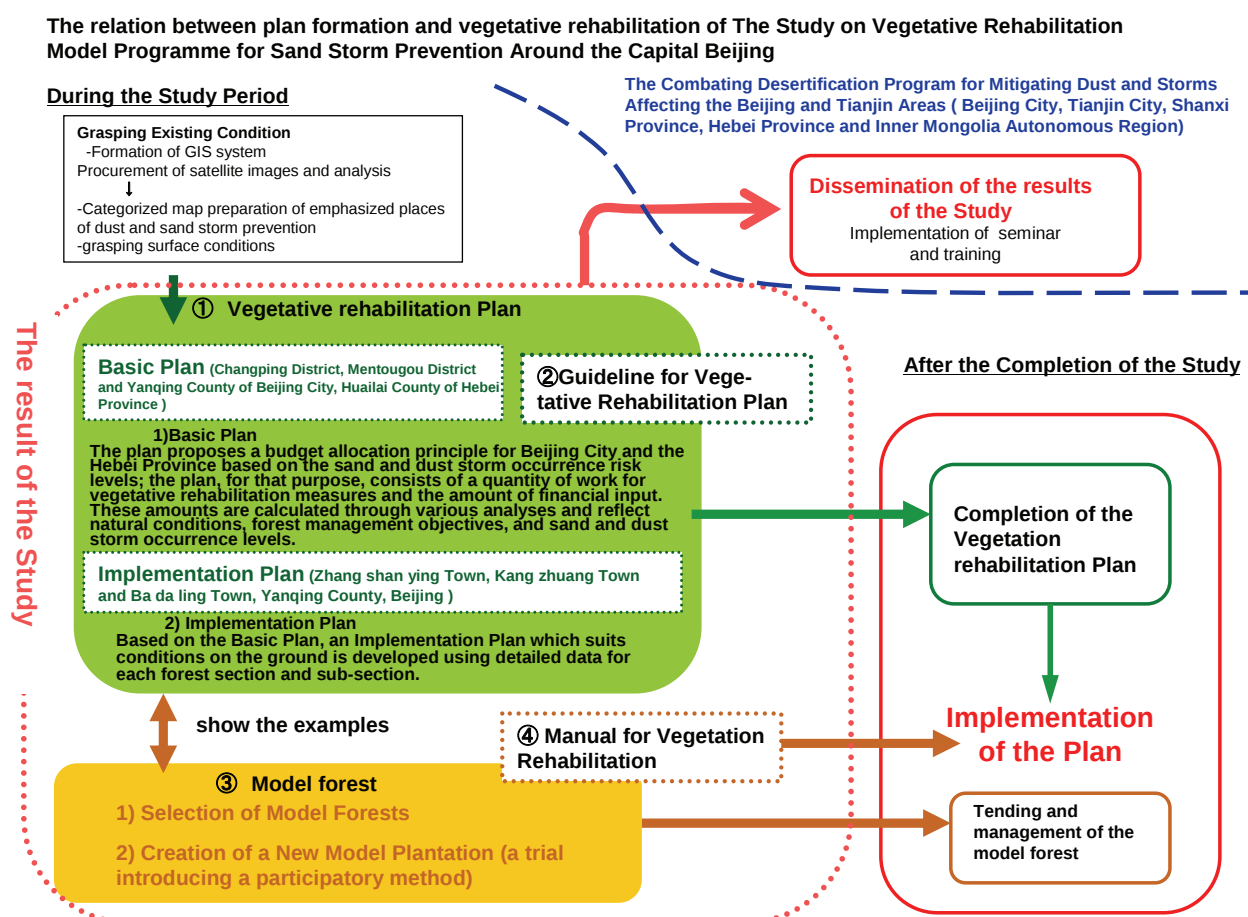
1.3 Basic policies of the study

Basic policies for implementing activities of this study are described below.

- (1) To formulate scientifically acceptable implementation plans of dust and sand storm origin management with full coordination among related departments
- (2) To transfer technology of formulating plans to staff members of Forestry Department of Counties, who are in charge of making forest management plans
- (3) To create practical model forests in appropriate places
- (4) To disseminate technology for formulating vegetative rehabilitation plans and for creating model forests, aiming at combating sand storms

During the study period, the interpretation of “the regulation on foreign organization and/or personnel engaged survey work management” of 1 March, 2007 was presented. Based on this interpretation, the Basic Plan for 4 target Districts and Counties and the Implementation Plan for 4 Towns and Townships for the Implementation Plan were formulated.

The relationship between the study and vegetative rehabilitation techniques and their dissemination are described in the following chart.



2. Overview of the Study Areas

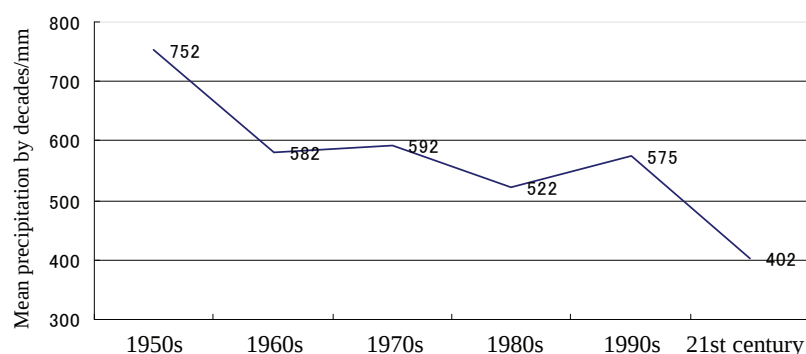
(Natural environment)

Beijing City is surrounded by mountains in its three parts, western, northern, and northeastern. The southern part of Beijing City is a plain that stretches and gently slopes down to Bo Hai Sea. The western part of Beijing City is adjacent to the northern Tai Hang Shan Mai mountain range and the northern part of Beijing City touches the western Yanshan Mai mountain range. There is a basin in the mountain ranges in the northwestern-northern part of Beijing City. Beyond the mountains spreads the middle part of Inner Mongolia Plateau.

(Climate/weather)

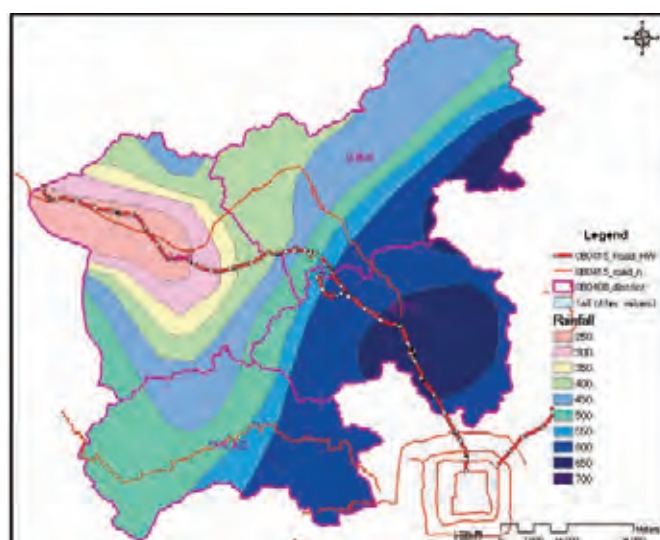
Beijing City has a warm-temperate continental monsoonal climate. The mean annual temperature in all of Beijing City is 11.5°C and the mean annual temperature in the plains of the Changping, Huairou, and Fangshan Districts is 12°C while the mountainous areas including Yanqing County and the Mentougou District is 9-11°C. Huailai County is located in the mid-temperate/semi-arid area, having a temperate continental monsoonal climate. The mean annual temperature on riverine plains is 9.1°C, in the southern mountainous area 3.3°C, and in the northern mountainous area 3.2°C.

The precipitation yearly range is wide, the annual precipitation in Beijing City has significantly dropped since 2000 from the past mean annual precipitation. The distribution of the mean annual precipitation greatly varies as shown below from 300 mm/year to 700 mm/year, depending on regions.



Mean precipitation by decades in Beijing City

Source: Beijing City Environmental Quality Report
<http://www.stkeda.com/bjAgrWtrRsr/2003/2003-yul.htm>.



Rainfall distribution in 4 target Districts and Counties

(Vegetation)

The natural vegetation of the Yanshan Mai mountain range in the north of Beijing City and the northern Tai Hang Shan Mai mountain range has temperate and warm-temperate deciduous forests of *Quercus spp.*, *Betula spp.*, *Populus davidiana*, and *Ulmus spp.*, etc., with lobules. Much of the existing vegetation, however, consists of secondary forests of deciduous shrubs, such as *Betula spp.*, *Vitex spp.*, *Lespedeza spp.*, and *Prunus armenica*. The major man-made forests planting species in this area have been *Pinus tabulaeformis*, and in the higher altitude *Lalix spp.*.

(Socio-economic situation in 4 target Districts and Counties)

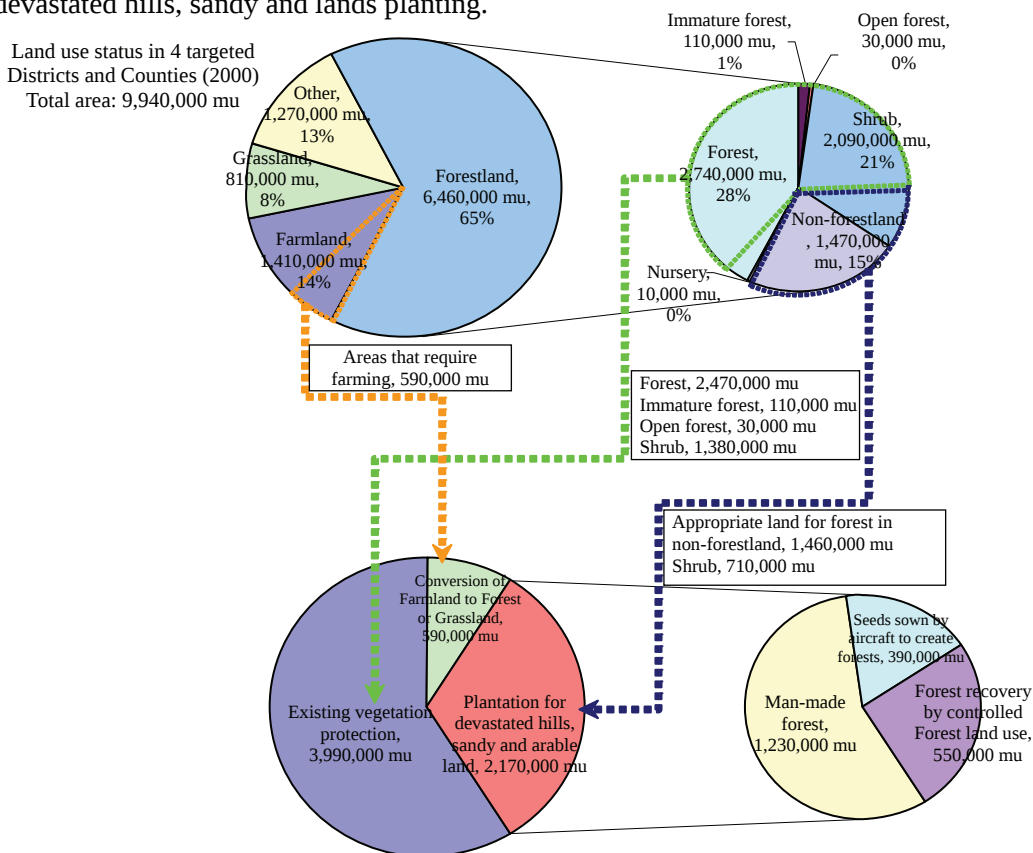
The total population of the 4 target Districts and Counties is 2,199,000 (source: 2002 Beijing Statistical Yearbook), with 1,307,000 being agricultural population and 1,080,000 of labor force population. The population density in these areas is 205 persons/km².

According to the study team's survey of 9 villages in the target areas in 2007, an average village has a population of 300~1,600, with an area of 4,000~26,000 mu (267 ha~1,600 ha). The average size of a household is 2~3 persons, and the annual income per household is 8,000~24,000 Chinese yuan. The per capita area other than forest in an average village is 0.17~1.1 ha. The mean annual rainfall ranges from 300 mm to 600 mm, and securing water for agricultural purposes is crucial.

3. Current situations of the Combating Desertification Plan in 4 Target Districts and Counties and Future Tasks

(Outlines of the Combating Desertification Plan in 4 target Districts and Counties)

Forests, open forests, immature forests, and some shrubs are selected to be the targets of protecting vegetation in the forestland. According to this plan, all the non-forestland as of the year 2000 (but appropriate for tree planting) and some parts of devastated shrubs will be planted as devastated hills, sandy and lands planting.



The Combating Desertification Program Duties in 4 targeted Districts and Counties and Forestry Development (2001-2010)

(Progress of the Combating Desertification Program)

“The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting the Beijing and Tianjin Areas” is a 10-year program. As of 2009, it was reported that the progress of the program is 94% and the duration of the program would be extended for another two years.

(Future tasks for the Combating Desertification Program)

The following is a summary of future tasks to be considered for “The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting the Beijing and Tianjin Areas.”

- (1) Vegetative rehabilitation in the target areas is in its initial stage (immature and tending operation stage) and requires continuous tending and protection works.
- (2) Matured forest land, shrub land, and immature forest land needs supplementary plantings. Over matured old stands require regeneration.
- (3) Existing forests need to be transformed from single layered forests into nature-like forests, such as multiple layered forests and needle-leaved/broad-leaved mixed forests.
- (4) Villagers have started growing agricultural products for urban people, their non-agricultural incomes have been increasing. Their economic dependence on forests has been decreasing. Under the circumstances, it is necessary to put importance on harmonious balance between the public functions and the productive functions of forests.

The study has prepared two plans, the Basic Plan and the Implementation Plan, duly reflecting the above tasks.

4. Basic Plan

4.1 Objectives of the Basic Plan

The Basic Plan covers a total area of 6,618 km² in 4 target Districts and Counties. The Basic Plan includes the grasping the current situation from a macroscopic viewpoint of the target areas using satellite images, comparatively assessing dust and sand storms potential, identifying areas for vegetative rehabilitation to be introduced, and selecting suitable forest management operations, considering the natural and social conditions.

Based on above activities, the Basic Plan has established the “Goals of Forest Management,” projecting forests to be realized in the near future and it has the role to give target Districts and Counties with guidelines for their formulation of the Implementation Plan.

(Methods of formulating the Basic Plan)

- (1) Using SPOT satellite data, DEM (a Digital Elevation Model that has a grid spacing of 3 seconds in latitude and longitude), and other available existing data open to the public, the study has examined the present state of vegetation cover of the land surface and analyzed sand storm hazard levels.

Without using the existing data of forest compartment and sub-compartment, a forest GIS database using polygons based on boundaries of Towns and Townships, hazardous area classifications, vegetation cover grading, rainfall distribution, altitude, gradients, slope directions, forests classifications, and attributes of land in and/or neighbors of forest planning areas have been prepared.

In such polygons, land surface has been mapped with an approximate 0.0001 ha minimum mapping unit, based on which the forest GIS database has been established. The basic statistical

data table has been prepared, based on the GIS database.

- (2) Allocation of forest management method, which were grouped according to vegetation cover grading, rainfall distribution, altitude, gradients, slope directions and forest classification, to all polygons, except for those that had attributes outside of targeted areas.
- (3) All information has been organized and accumulated as GIS data. Administratively implementation priority towns and townships, considering their location and natural and socio-economic conditions and reflecting the results of the sand storm hazard level analysis, has been established.

Yearly plans for 5years of towns and townships with estimated cost for necessary operations have been estimated. The goals of forest management, aiming at vegetative rehabilitation of forests , have been proposed.

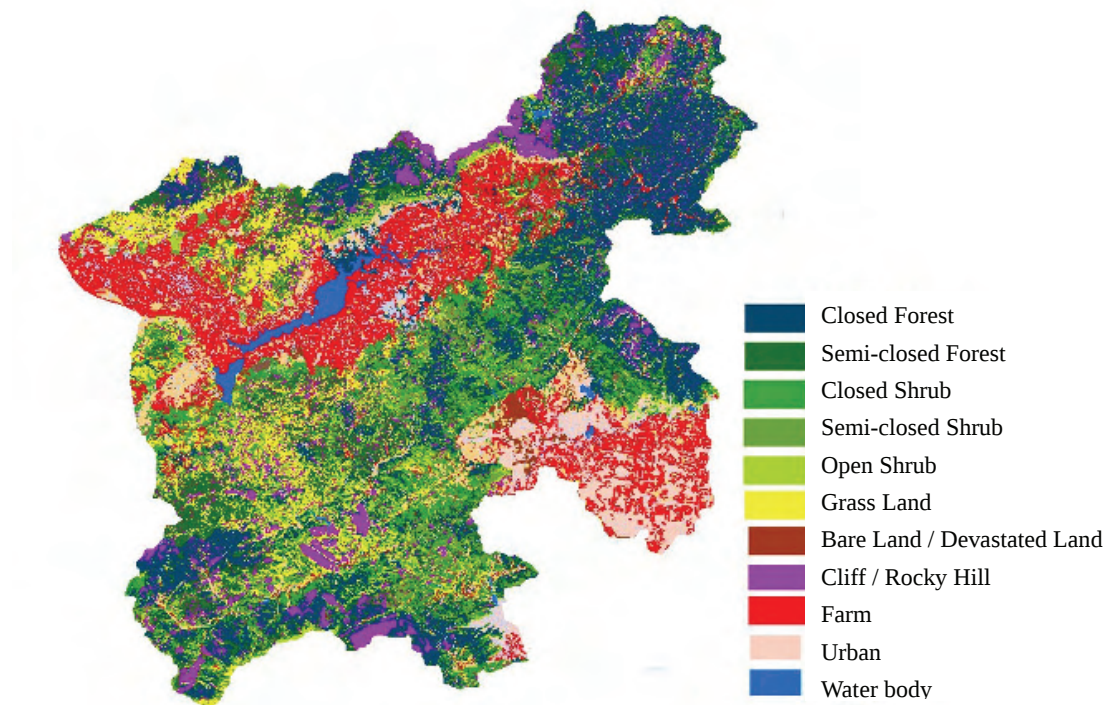
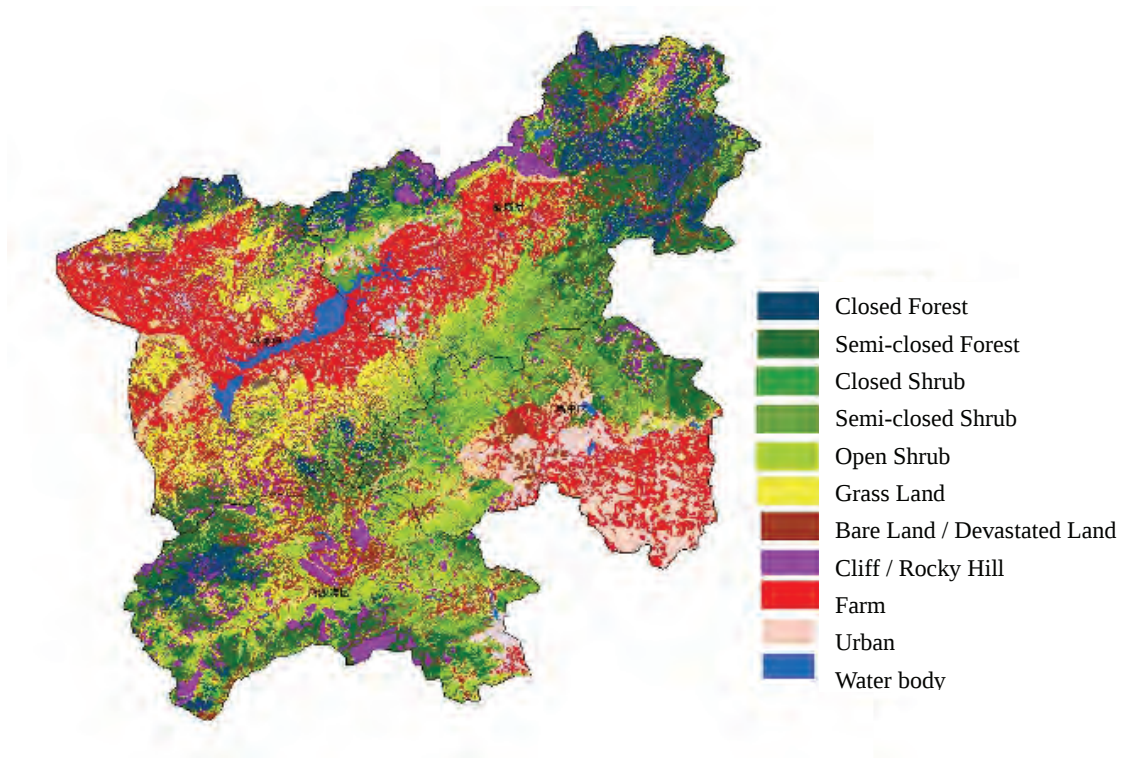
(Goals of the Basic Plan)

The target of the Basic Plan is prepared as the target values for forest management. These are done in the following steps: firstly, examination of land use and forest conditions to specify the areas that require forest management operations; secondly, determination of possible forest management operations to introduce to each area that requires operations, fitting to natural and socio-economic conditions; and finally compiling the results for each type of forest management operation by area, assuming that ongoing maintenance and control operations to continue appropriately.

The following are the table and a chart that present the present land use and goals of forest management.

Current situation of forests and target areas for forest management (Unit: ha)

Category	Present total area (ha) A	Total target area (ha) B	B/A	Remarks
Closed forest	48,686	160,881	3.3	Assumptions made for calculating target area 1. Present forests (closed forest and closed shrubs, etc.) will be maintained in the future. 2. Areas where planting or other forest management operations were conducted will turn into forests in the future. 3. Present cliffs, road areas, sites for housing, and bodies of water will remain unchanged.
Semi-closed forest	98,511	48,278	0.5	
Closed shrub	11,156	68,607	6.1	
Semi-closed shrub	41,764	41,239	1.0	
Open shrub	92,682	21,783	0.2	
Forest area total	292,799	340,789	1.2	
Grass land	58,132	58,487	1.0	
Bare land	41,589	0	0.0	
Cultivated farm land and fruit orchard	141,050	134,294	1.0	
Cliffs	51,700	51,700	1.0	
Resident area and others	35,049	35,049	1.0	
Road area	32,386	32,386	1.0	
Water body	9,125	9,125	1.0	
Other than forest	369,031	321,040	0.9	
Total	661,829	661,829	1.0	



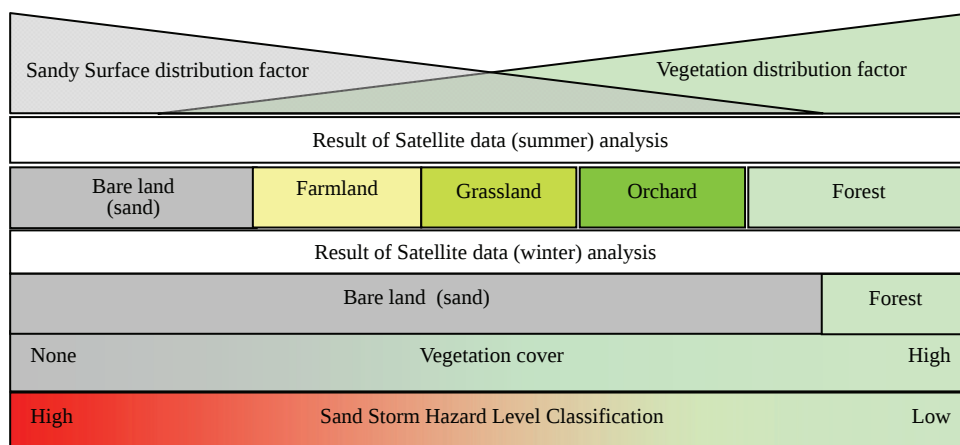
Land-use and forest type at present in the Basic Plan targeted areas (top)
Goals of forest management (bottom)

Analysis methods and calculation procedures used for the present condition of the forest and target area for forest management that is shown above is explained 4.3, which follow.

4.2 Classifying, zoning, making a GIS database of natural condition of target study area (Analysis of sand storm hazard levels and wind simulation analysis)

Analysis the influences of existing sand and wind on the land surface in a comprehensive manner has been conducted and comparatively assessment hazard levels of sand storm occurrences to classify into 5 levels has been conducted

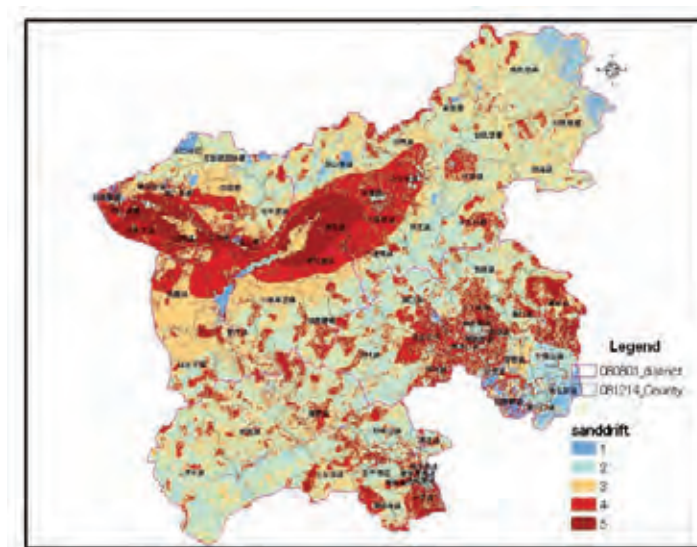
The sand storm hazard level analysis has been done in the way of the chart bellow.



The results of the wind analysis shows that windy areas stretch from the Quangting Shuiku Dam, which is located in parts of Huailai and Yanqing Counties, and the neighboring area, blowing over the mountain, to the Changping District; especially, comparatively strong wind blows, along the air currents, in the Xishan area. The following table shows the estimated areas of hazard levels caused by sand storms.

Areas of Hazard Levels [areas by (sand factors + wind factors)] (1,000 ha)

County	1	2	3	4	5	Total
Yanqing County	8.59	59	89.3	33.5	10.5	201
Huailai County	6.8	29.2	82.8	40.2	21.1	180
Changping District	8.91	44	46	29.1	7.17	135
Mentougou District	2.6	56.1	64.8	18.1	3.89	146
Total	26.9	188	283	121	42.7	662



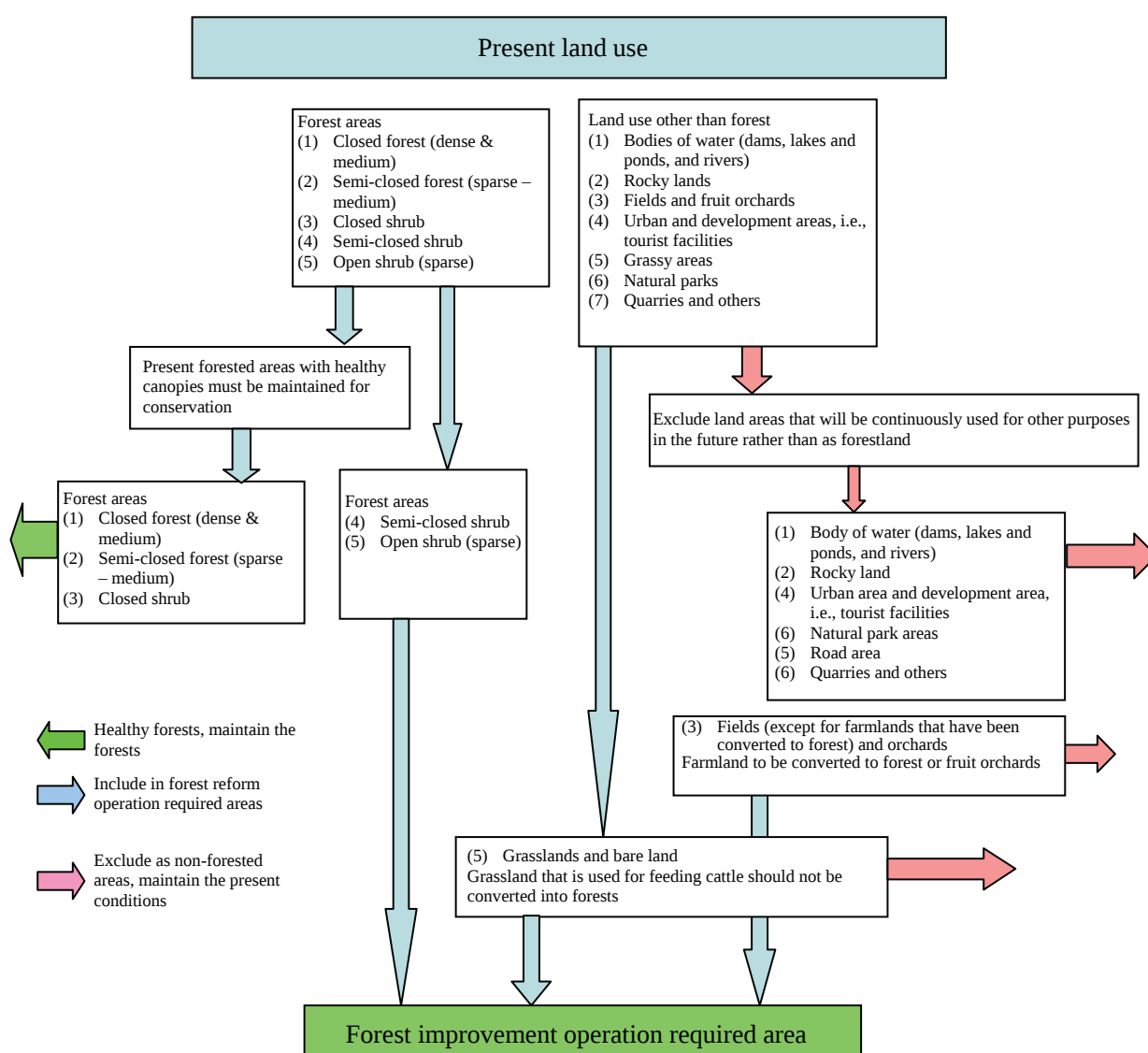
Comprehensive distribution map of sand storms hazard areas

(Analysis of the current situation of forests in the Basic Plan target area)

Overlaying and processing data of the satellite images of forests in summer have been done in order to categorize the forests. Applying also the distribution map of natural forests in the Map of Forest Resources Survey published by Beijing City, as well as other obtained data, forests have been categorized into (1) Closed forests, (2) Semi-closed forests, (3) Closed shrubs, (4) Semi-closed shrubs, and (5) Open shrubs.

(The targeted area for the forest management operations to combat sand storms (Forest improvement operation required area))

Among the 5 types of forests, semi-closed shrubs and open shrubs require forest improvement operations. Semi-closed shrubs need improvement of their vegetation cover by supplementary planting. Open shrub areas need new planting, if it is possible. The specified forest improvement operation required areas consists of the semi-closed shrub, the open shrub area, as well as grassland (excluding grasslands for fodder purpose) and bare land, excluding road areas.



A flow chart of the techniques to specify the forest improvement operation required area based on the current situation of land use

As the result of the calculations, the forest improvement operation required area to such as planting, etc., has been determined to be a total of 209,142 ha, which is less than 30% of the target area for the Basic Plan, which is 661,830 ha.

Summary of the area of forest improvement operation required areas, by forest type and land use (Unit: ha)

Land Use	a Yanqing County	b Changping District	c Mentougou District	d Huailai County	Total (ha)
Semi-closed shrub	9,966	14,055	10,195	1,003	35,219
Open shrub	19,483	19,871	33,725	11,302	84,380
Grass land	2,872	1,069	5,554	34,208	43,703
Bare land	3,500	3,953	16,539	15,090	39,082
Conversion of Farmland (steep slope) to Forest	315	22	212	83	633
Conversion of Farmland (remote area) to Forest	494	699	357	4,573	6,124
Total	36,630	39,669	66,583	66,260	209,142

(Farm land that requires windbreak forests (forests for reducing sand and dust flow)

The analysis of the present situations of farmlands which can possibly be irrigated in Huailai County and Yanqing County, and the farmland where city areas and farmland areas intermingled in the Changping and Mentougou districts were conducted. The purpose of this was to analyze the target area which needs windbreak forests and sand and dust flow reduction forests. The location of such farmlands was been grasped, using satellite images. As the results of the analysis, a table of farmland area by major crops for the farmland areas that require windbreak forests has been prepared.

4.3 Classifying the target area for the forest management operations to reduce sand and dust flow

(Analysis of natural conditions in the forest, which need forest improvement operation)

In order to categorize forest management operation, duly considering fitness to natural conditions, like forest recovery through planting, comprehensive analysis of the natural condition was conducted. The results of categorization were stored as GIS data-base as polygon information.

The stored data were overlaid on the GIS map to identify each forest management operation and to identify a total area for each operation and location on the map. Through the process above, suitable forest management operations were investigated in order to match them with the natural conditions in each area as well as each management objective.

(Classification of land conditions

-vegetative rehabilitation techniques and the analysis of suitable areas-)

Classification of natural conditions by rainfall distribution, altitude, gradient, and slope direction was done to prepare a Table of Target Areas by Natural Conditions, which follows.

**Total areas of the forest improvement operation required areas by natural conditions
(4 target Districts and Counties)**

Unit of area: ha

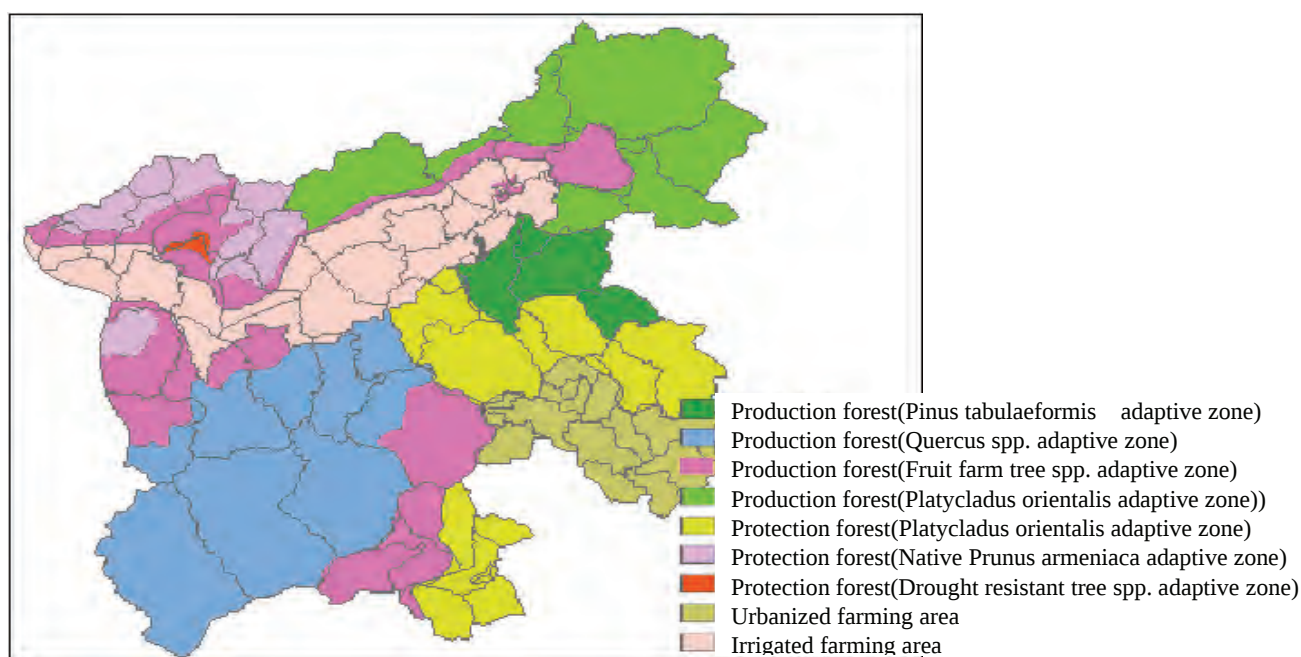
Altitude category		Rainfall level category		Gradient category		Slope direction category	
Category	Area	Category	Area	Category	Area	Category	Area
400 m (0-400 m)	47,906	250 mm (Less than 250 mm)	4,726	1 (flat $\leq 5^\circ$)	12,027	A Flat (no direction angle)	179
600 m (400-600 m)	59,516	400 mm (250-400 mm)	41,826	2 ($5^\circ \leq$ gentle $\leq 15^\circ$)	73,922	B Sunshade (Northwest-North-Northeast)	80,272
800 m (600-800 m)	53,118	500 mm (400-600 mm)	73,056	3 ($15^\circ <$ midium $\leq 25^\circ$)	85,241	C Intermediate (other than A,B,D)	55,569
1,000 m (800-1,200 m)	30,945	600 mm (600 mm or greater)	89,535	4 (steep $> 25^\circ$)	37,953	D Sunny side (Southeast -South-Southwest)	73,122
1,400 m (1,200 m or higher)	17,658						
Total	209,142		209,142		209,142		209,142

(Classification of land conditions

- Objectives of forest management (forest classification for management)-)

Classifying land conditions was conducted by applying in principle, demarcations used in the forestry demarcation map in the Beijing Agricultural Resources and Its Zoning Maps (Map Publishing Co., 1986) and have determined forest zone considering the objectives of forest management. Such classified forest zones, which include the most suitable natural conditions for forest, can be used as a base to examine which forest management operation method, such as planting, etc. can be implemented to achieve the major objectives of the particular forest.

Forest which need improvement operations were shown on the GIS map, according to: altitude, rainfall distribution, gradient, and slope direction.



Forest management zone for the Basic Plan target areas (for the purpose of forest management, in addition to water source nourishment and the conservation of water and soil)

4.4 Classifying forest management operations

Analysis of the present situation of forest improvement operation required areas, major objectives of management in forest management zones, and four types of natural conditions stated above was conducted. Thereafter allocation of operations (forest management operation coding abbreviation) for forest recovery to each polygon in the GIS-Map was done, carefully observing the how each condition is overlaid in the map.

In general, four types of actions are taken for vegetative rehabilitation:

- (1) Supplementary planting is conducted as much as possible for those forests that are not fully closed, in an effort to have them closed canopies in the near future.
- (2) Planting is planned for the areas that have no forests, as far as technically and financially feasible.
- (3) For those areas that are difficult to conduct planting but that have existing natural trees that are possible to grow, forestland use should be controlled to remove factors that hinder natural vegetation recovery.
- (4) For the areas that planting cannot expect to establish forests with the present techniques and ordinary budgeting, natural regeneration is expected to occur for gradual recovery of forests over a long period of time.

4.5 Social conditions and forest management operations

The forest management operations for vegetative rehabilitation that are proposed in 4.4 have been adjusted, taking the benefits to the residents in the mountainous villages, into consideration.

4.6 Selecting villages to focus on and priority towns and townships in implementing sand and dust flow reduction and vegetative rehabilitation measures

It is logical to start implementing planting operations of the Implementation Plan, etc. for the areas that have high vegetative rehabilitation requirements. However, in the stage of formulating the Basic Plan, which will be the basis of actual operational plans for the program, it is important to determine how the program should progress considering an efficient allocation of available resources from the Country and the Counties.

In order to determine the priority, combining the layers of data images that were stored in the GIS database and higher priority areas that have higher hazard levels of sand storms by deep mountain villages and by low land-mountain-side villages were extended, taking following factors into consideration.

- (1) The ratio of the areas with higher hazard levels in the total land area in the village to select the priority villages.
- (2) Towns/townships that have many of such priority villages are made priority towns /townships. Adjustments of in implementing operations progress are determined as shown in the following table.

Table of budget distribution by period (5years)

	1st period	2nd period	3rd period	4th period
Progress in implementation	Priority Towns and Townships 75%	Priority Towns and Townships 25%	Priority Towns and Townships 0%	Priority Towns and Townships 0%
	Semi-priority Towns and Townships 25%	Semi-priority Towns and Townships 50%	Semi-priority Towns and Townships 25%	Semi-priority Towns and Townships 0%
	Other 0%	Other 25%	Other 25%	Other 50%

4.7 Target operation size

Based on the methods explained, a table of the total area that requires forest improvement operations by priority towns and townships in each county and by operation IDs (forest management operation coding abbreviated). Part of the table is shown below.

Total area that requires forest improvement operations by Priority Towns and Townships in each county and by operation IDs

a Production forest (<i>Pinus tabulaeformis</i> adaptive zone)										(ha)
County	Category	a Planting <i>Pinus tabulaeformis</i> and other adaptive spp. Appropriate	b Planting <i>Pinus tabulaeformis</i> and other adaptive spp. Available	c Planting <i>Platycladus orientalis</i> and other adaptive spp. Appropriate	d Planting <i>Platycladus orientalis</i> and other adaptive spp. Available	e Planting <i>Quercus spp.</i> and other adaptive spp. Appropriate	f Planting <i>Quercus spp.</i> and other adaptive spp. Available	g Planting <i>Populus spp.</i>	h Planting Native <i>Prunus armeniaca</i> and other adaptive spp.	Planting area total
a Yanqing-County	Priority Towns	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Semi-priority Towns	1,353.59	1,241.68	348.19	0.00	0.00	0.00	0.00	14.91	2,958.37
	Other	8.46	8.45	1.17	0.00	0.00	0.00	0.00	0.00	18.08
	Sub total	1,362.05	1,250.13	349.36	0.00	0.00	0.00	0.00	14.91	2,976.45
b Changping District	Priority Towns	0.23	1.68	0.00	0.00	0.00	0.00	0.00	0.00	1.91
	Semi-priority Towns	219.07	86.35	3.16	0.00	0.00	0.00	0.51	0.15	309.24
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sub total	219.30	88.03	3.16	0.00	0.00	0.00	0.51	0.15	311.15
a Total production forest (<i>Pinus tabulaeformis</i> adaptive zone)		1,581.35	1,338.16	352.52	0.00	0.00	0.00	0.51	15.06	3,287.60

4.8 Estimation of required project cost

(Summary of the estimation of the project cost)

Based on the target project operation size by operation IDs and the unit price list, prepared separately “A Table of Operation Areas and Project Cost estimation by Project Periods and Operation Methods – including the estimated inflation rate as a calculation factor –.” has been prepared.

Table of Operation Areas and Project Cost by Project Periods and Operation Methods

(4 target Districts and Counties in total) (adjustments were made for the increase in wages/material costs by project periods)

Target areas for operations (ha)		Project period →		1st period (1st - 5th year)	2nd period (6th - 10th year)	3rd period (11th - 15th year)	4th period (16th - 20th year)	1st - 4th period Total
		Budget adjustment factor by project period (labor wage increase rate)		1.30	2.34	3.98	6.34	
Planting	64,200	Area (1000 ha)	Planting (1st year)	28	24	9	4	64
			Tending (2nd - 5th year)	55	102	66	26	250
			Total	83	126	75	30	314
		Cost (1 million Chinese yuan)	Planting (1st year)	1,642	1,401	556	217	3,816
			Tending (2nd - 5th year)	234	434	279	110	1,057
			Total	1,876	1,835	835	328	4,873
		Cost after the adjustment of labor wage increase rate		2,438	4,295	3,326	2,076	12,135
Supplement-ary planting	10,932	Area	Supplement planting (1st year)	5	4	1	1	11
			Tending (2nd - 5th year)	10	17	10	5	42
			Total	15	21	11	6	53
		Cost	Supplement planting (1st year)	94	135	65	13	306
			Tending (2nd - 5th year)	34	83	72	28	217
			Total	128	218	137	41	524
		Cost after the adjustment of labor wage increase rate		166	510	547	261	1,483
Sowing Seeds	59,401	Area	Sowing Seeds (1st year)	24	22	9	4	59
			Tending (2nd - 5th year)	49	93	63	26	230
			Total	73	115	72	30	289
		Cost	Sowing Seeds (1st year)	110	99	41	17	267
			Tending (2nd - 5th year)	97	186	125	52	460
			Total	207	285	166	69	727
		Cost after the adjustment of labor wage increase rate		269	668	662	437	2,036
Natural regeneration	74,603	Area		32	26	10	7	75
		Cost		0	0	0	0	0
		Cost after the adjustment of labor wage increase rate		0	0	0	0	0
Total	209,136	Area	1st year	87	76	31	15	209
			2nd - 5th year	111	212	143	57	522
			Total	198	288	174	72	731
		Cost	1st year	1,846	1,635	662	248	4,390
			2nd - 5th year	365	702	476	190	1,734
			Total	2,211	2,338	1,138	438	6,124
		Cost after the adjustment of labor wage increase rate		2,872	5,473	4,535	2,773	15,654

4.9 Targets of forest management

Projection of forests in 40 to 60 years henceforth was shown by using following suppositions;

- the existing closed forests will be maintained,
- parts of semi-closed forests will be transformed into closed forests,
- forest management operations, such as planting, will be conducted for the forests that require them
- adequate control will be implemented to improve forest conditions
- the size of non-forestry land areas will remain unchanged.

4.10 Guideline for formulating the Basic Plan

The Guideline for formulating the Basic Plan, including objectives, structure and the matters to be conducted for formulating of the Basic Plan has been compiled. (Full text of The Guidelines for formulating of the Basic Plan was prepared as an independent textbook, with a detailed manual for operations.)

5. Farmland/Agriculture/Farmers and Forest Management Operations:

-Agriculture and Forestry after the Chinese Improvement and Open Door Policy-

5.1 Farmland/agriculture and suburban forests

The Chinese Reform and Open Door Policy that started during the 1980s produced significant socio-economic progresses; the average per capita GDP of the country and of Beijing grew from US\$255 and US\$848 in 1980 to US\$2,774 and US\$7,654 in 2007, respectively.

5.2 Windbreak forest for farm land

(History of windbreak forest for farm land)

Shortly after the birth of new China (1953-1957) windbreak forest networks and windbreak forest belts were established in Kanghuang town. In general, windbreak forests for farmland were mostly established during the 1960s in a planned manner. Windbreak forests for farmland are common lands managed by the village communities.

(Windbreak forests for farmland after the Chinese Reform and Open Door Policy)

During the 1960s, farmlands were divided into large lots by windbreak forests, where cooperative cultivation was done. Accordingly, the positive and negative effects of windbreak forests were neutralized, leaving little room for dissatisfaction of inequality among the farmers.

With the transition to family farm-contract system following the introduction of the Reform and Open Door Policy, belt-like strips of land were allotted to the farmers. The negative effects of windbreak forest on the farmers who work on lots near the windbreak forest and the positive effects on those who work on lots somewhat away from the windbreak forest came to be felt distinctively by the individual farmers.

(Windbreak forest for farmland today)

The windbreak forest networks that were built during the 1960s are still aligned in an orderly manner in rectangular forms. The windbreak forest is approximately 400 meters long on a side and consists mostly of *Populus spp.* The growth of crops planted immediately close to the windbreak forest is not good.

(Challenges of windbreak forest for farmland)

Forestry Department that develops and implements windbreak forest plans for farmland operates under the principle of maintaining and promoting public interest. For individual farmers, plans that are made from such a standpoint are not easy to accept. It is very important to continue maintaining and enhancing windbreak forests for farmland through good coordination of the conflict of interest among the windbreak forests neighboring farmers concerned.

The basic design of the windbreak forests for farmland that exist today was prepared during the age of carts and horse carts. Windbreak forests for farmland must be integrated and coordinated with the modern-day road system involving farm roads for mechanized agriculture.

Presence of plural line tree lines and/or single lane tree line along the roads and waterways, and their lengths were estimated by the standard land sampling method. The estimated results are shown below.

Overview of tree lines existence along the roads and waterways by farmland type

Land types (Hill, irrigated, non-irrigated)	Major crops	Districts/counties included	Existing tree stands ; length in lines km (A)	No-tree lines ; length in km (B)	Total length in km (C)	Share of existing tree lines (A/C)	Interval of planned windbreak forest belt (lane)
Orchard/vineyard in hill, irrigated or urbanized	Fruit trees, grapes	Yanqing C., Changping D., Mentougou D., Huailai C.	814	349	1,164	0.70	500 m
Irrigated farmland	Corn, vegetables	Yanqing C., Huailai C.	876	1,096	1,971	0.44	500 m
Urbanized farming area	Vegetables	Changping D., Mentougou D.	1,670	0	1,670	1.00	500 m
Non-irrigated farming area	Corn, vegetables	Yanqing C., Mentougou D., Huailai C.	327	1,602	1,929	0.17	250 m
Total			3,687	3,048	6,734	0.55	

(Design of windbreak forest belt)

Five standard designs, as below, were prepared in consideration of the present situations of the irrigated farming areas and the urbanized farming areas (urbanized farmland for windbreak forest establishment and maintenance) and in accordance with the respective characteristics of the areas.

Overview of categories (designs) of windbreak forest

Design code	Design name	Objective farming area	Crops	Materials for windbreak forest	Tree layout	Remarks
5-01	Windbreak forest for farmland (tall trees)	Irrigated farmland	Corn, vegetables	Tall trees	Belt	Integrated with farm road
		Urbanized farmland				
5-02	Orchard windbreak hedge	Irrigated farmland	Fruit trees	Hedge	Belt	
		Urbanized farmland				
5-03	Vineyard windbreak net	Irrigated farmland	Grapes	Net	Belt	
		Urbanized farmland				
5-04	Windbreak forest for farmland (medium- to tall trees)	Non-irrigated farmland	Upland crops	Medium- to tall trees	Belt	Integrated with farm road
5-05	Agro-forestry and windbreak forest	Hill	Upland crops	Fruit trees, drought resistant shrub	Spot/belt	Use of farm road and terraced farmland

Operation quantity and investments that are estimated for the establishment of windbreak forests are shown below. The estimates were made for a period of five years; the estimated investment requirements include direct establishment costs (planting to tending) and the followings: (1) straw mulching expenses to prevent sand drift from orchards and (2) compensation for windbreak's sun-shade effects.

Planned windbreak areas and farmland concerned by District/County, by land type and by crop (total of 4 Districts/Counties)

Total of 4 Districts and Counties	Area of farmland concerned (ha)		Planned windbreak forests: Volume (km); Investment (× 1,000 yuan)			Farmlands concerned: Area (ha); Investment (× 1,000 yuan)			Investment total (× 1,000 yuan)
Type			Newly required forests total	Elongation of existing forests total	Planned length total	Newly required farmlands total	Existing farmlands total	Concerned farmlands total area	
Hill farming area total	37,013	Quantity	2,085	689	2,774	25,662	11,351	37,013	
		Investment	272,340	0	272,340	5,465	1,838	94,673	367,013
Irrigated farmland total	66,756	Quantity	1,179	1,310	2,595	32,990	33,765	66,756	
		Investment	216,145	0	216,145	0	13,745	13,745	229,890
Urbanized farmland total	22,688	Quantity	6	901	908	151	22,537	22,688	
		Investment	1,254	0	1,254	0	0	12,868	14,122
Grand total	126,457	Quantity	3,270	2,900	6,277	58,803	67,654	126,457	
		Investment	489,738	0	489,738	5,465	15,583	121,286	611,025

(Coordination between public and private interests)

“The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting the Beijing and Tianjin Areas.” have been promoted by the initiative of the administrative authorities in conjunction with the 2008 Olympic Games in Beijing. There is a big difference between forests in hills and windbreak forests for farmland and farmland in flat lands; the windbreak forests for farmland are common lands managed by the village communities, while most of the farmlands that the windbreak forest are intended to protect are worked under the family-farm contract system, necessitates coordination between public and private interest is required.

Combat against desertification to mitigate dust and sand storms is a public policy matter that should be implemented on a sustained basis to enhance the public interest functions of land. Administrative authorities must take the initiative in the control and guidance over land managers in their land use in this respect.

(Administrative planning on windbreak forests)

In summary, administrative planning on windbreak forests should be implemented based on the following principles and concepts:

- (1) Windbreak forests are an infrastructure for agricultural production. Effective measures to combat desertification in order to mitigate dust and sand storms must be implemented on a continued basis, also for the purposes of improving living environment and preserving landscape in urbanized farming areas.
- (2) The present policy direction of improving windbreak forests in conjunction with the improvement of public roads and farm roads should be maintained.
- (3) Plans to improve windbreak forests should be promoted in conjunction with agricultural infrastructure improvement plans.

- (4) Where water conditions are a limiting factors, water facilities for windbreak forests should be incorporated into the plans of the agriculture and waterworks sector, and the windbreak forests should be established to play productive functions, planting fast-growing tree varieties.
- (5) Where water conditions are favorable, windbreak forest management plans should be prepared with the view to ensuring profitable sale of harvested logs while securing the windbreak function.
- (6) While the main actor of managing windbreak forests for farmland is the communities(village committees), the Forestry Department should continue to work together with the village communities in developing management plans for the improvement of windbreak forests for farmland and coordinate the harvest schedule, harvest administrative procedure, regeneration etc.. For non-irrigated farming areas of poor site conditions (mainly water conditions), the windbreak forest establishment plan needs to be adapted to such conditions.
- (7) Installation of windbreak nets should be studied and implemented for grape-growing areas in cooperation with the Agriculture Departments.
Windbreak forests are established for the purpose of increasing the public value of forests, and accordingly certain levels of subsidy, financing and/or tax incentives are needed.

5.3 Forest management through people's participation

This Section clarifies the way of people's participation in village communities managed forests in suburban areas that are increasingly viewed as a public asset. Also, the ways to incorporate people's participation into forest management plans is described.

(General conditions for forestry of a viable entity)

Whether the forests are managed by people or by the administrative body, the following four points are critically important for making forestry viable:

- (1) Natural conditions that permit forests to grow.
- (2) Ensured ownership and management rights of the forest and the trees.
- (3) Availability of fund or manpower to enable planted trees to grow.
- (4) Forestry techniques

(Motivations for people's participation into forest establishment and management)

Even though the prerequisites for forestry's viability are met, some benefits and/or sense of satisfaction are needed as motivations for people's participation in forest management. The public value of forests is no reason for forestry managers to provide free-of-charge services to the people in cities.

(Sharing the costs of forest establishment and management)

The additional costs of maintaining and managing forests in good conditions should be borne in one way or another by the beneficiaries, namely, those who live in far-away big cities and in urban areas of the district and county.

(Organizing people participating in forest establishment and management)

Organizing people is indispensable for smooth promotion of people's participation. No generalized textbook-style organization is effective in actual situations, because the interest and ability of the people as well as the surrounding socio-economic institutional circumstances are different. The form of organization by which the people participate can vary from one that is loosely organized with free entry and exit to one that is fixed with articles of association.

(A case study of people's participation in forest establishment and management – Baicaowa village, Yanqing County –)

With the assumption that it is indeed possible to establish model forests through people's participation, the village of Baicaowa, Yanqing County was chosen as the model village in this study for people's participation-based vegetative rehabilitation. Baicaowa is a small village with a population of 200 and an area of 1,500 ha situated on an alluvial fan topography. The study team and its counterpart extended support to the resident group activities of Baicaowa village to explore desirable forms of people's participation in vegetative rehabilitation in Beijing, China.

In February 2008, a workshop was carried out on Baicaowa village with respect to its current situation and the directions of the people's participation by the use of Participatory Rural Appraisal (PRA) and other tools generally employed in the international cooperation. Support was extended until 2009 in respect of establishment of fruit tree management technique demonstration orchard, purchase of pertinent equipment and supplies and organization of workshops.

A monitoring survey was conducted in September 2009 to evaluate the people's participation. The result of the survey was that the villagers did participate in the pertinent activities and gave positive responses to the acquisition of equipment and supplies that were procured reflecting their wishes as well as the techniques and knowledge they obtained through the technical assistance given at the workshops and by the technical staff.

On the other hand, the survey results revealed that the depth of participation (will and action of voluntary participation), which is indicator for the effectiveness of people's participation, was still low, showing persistent dependency on initiatives from outside.

From the perspective of material and manpower investments made for economic development of the village, a certain level of positive judgment can be made because the program made irrigation water available to wider productive farms in the village.

(Directions of people's participation and administrative support)

The analysis of current situation as described above failed to confirm any dramatic changes in the sense of participation among the villagers which is regarded as the indicator of the depth of participation. However, it is fair to say the effectiveness of participatory manner collaborated with village committee and with subsidies was confirmed.

The effectiveness of the participatory tool as a method to understand the will and intent of the people was confirmed to certain extent.

6. Implementation Plan

(Objectives of the Implementation Plan)

The Implementation Plan was prepared for the purposes of developing an ecological and economic anti-desertification model for dust and sand storm affected northern Beijing area based on the Basic Plan and to provide an exemplar model for other regions in their development of models for combating desertification. The actual work of preparation was sub-contracted to Beijing Forestry Surveying and Planning Institute. The plan period was set for the 10 years starting from 2011 to coincide with the expected beginning of the 12th 5 year Plan. The methodologies of survey and analysis that were employed for the Basic Plan were followed.

6.1 Basic conditions of the areas covered by the Implementation Plan

(Location, area and natural and socio-economic profiles)

(1) The location and area of the area covered by the Implementation Plan

Four Towns and Townships, namely, Zhangshanying town, Kanghuang town and Badaling-Zhen of Yanqing County and Nankou-Zhen of Changping District, all of Beijing City were chosen as the area for planning. This area of Implementation Plan includes Townships and Villages under one of major sand storm flow course.

(2) Natural conditions of the area of Implementation Plan

The elevation of flat land ranges between 500 and 600 m and that of hills/mountains between 600 and 2,200 m. The climate type is continental monsoon, and the area extends in the climatic transaction zone of warm to mid-warm temperate and semi-dry to semi-humid temperate climate. The annual average temperature is 8.8°C and the precipitation concentrates in the 3 months of June, July and August with the annual average rainfall of 467 mm.

North and northwest winds blow in the spring, causing serious dryness. The annual average wind speed is 5.1 m/sec., with the appearance of 17 m/sec. or stronger wind tens of days in a year and the yearly maximum wind speed of 24 m/sec..

The soil is of the cinnamon soil belt of the warm temperate and semi-humid zone. The vegetation consists mostly of natural forests; *Quercus liaotungensis* is the dominant species and spreads mainly on the sunshade slope side at elevations between 800 and 1,800 m. *Pinus tabulaeformis* and *Quercus spp.* are mixed. Many are regenerated forests by sprouting. On the sunny side slope, semi-dry tolerant shrub spp. and grasses are mixed.

At the middle height mountains, the vegetation is preserved in fair conditions and recovery vegetation is relatively fast. At the sunny side slope of hill-side and gentle hills and sharp slopes of 35° or more, the vegetation is sparse and soil erosion is severe. Planted forests of *Pinus tabulaeformis* and other tree species spread at elevations between 600 and 1,000 m.

(3) Socioeconomic profile of the area of Implementation Plan

The area of Implementation Plan encompasses 4 Towns and Townships (Zhangshanying, Kanghuang, Badaling-Zhen and Nankou-Zhen), which include 106 administrative villages. There are 40,700 households with a total population of 106,600, divided into farm households (60%) and non-farm households (40%). The economic conditions of the area are good; the total agricultural output of the Towns and Townships amounts to 535.366 million yuan and non-agricultural production 2,236.097 million yuan.

6.2 Situations of land use and forests

The vegetation coverage was analyzed by the use of SPOT 5 satellite image data of winter and summer. The compartment and sub-compartment data were renewed through on-site survey was carried out. The results are summarized below.

Land use areas and statistics

Number	1	2	3	4	5	6	7	8	9	10	
Land category	Forest	Shrub	Appropriate for forestry	Fruit tree	Nursery	Cropping farmland	Land for building construction	Road area	Water body	Dis-adaptive land for use	Total area
Area (ha)	18,892	5,818	2,083	4,458	86	15,174	2,089	2,369	444	1,498	52,911
(%)	35.7	11	3.9	8.4	0.2	28.7	3.9	4.5	0.8	2.8	

Note: category by SPOT satellite (summer image)

Results of on-site survey of compartment and sub-compartment data for the project area

Towns and Townships	Needle leaved Forest	Broad leaved Forest	Mixed forest	Open forest	Nursery area	Appropriate for planting	Immature forest	Shrub	Forest land With no tree cover	Land for forestry production support
Zhangshanying	971	6,433	736	10	75	467	582	2,206	-	-
Kanghuang	51	2,310	15	67	98	69	-	-	-	-
Badaling-Zhen	1,022	1,799	1,016	17	14	533	1,359	2,040	-	5
Nankou-Zhen	812	2,844	3,670	0	1	250	730	6,626	75	5
Project area	2,856	13,386	5,436	93	188	1,319	2,671	10,872	75	10

(Land use of each Town and Township)

The present condition of forests is characterized by the following phenomena and problems:

- (1) Not much variety in tree species and forest age
- (2) Windbreak forests are old-aged and the forest stand vitality is declining.
- (3) Forest management and maintenance have been poor and the growth of trees is not good.
- (4) Land use efficiency of appropriate land for forest is low.

6.3 Project objectives and guiding philosophy

"Three Representations" ideology initiated by Jian Zemin and modern forestry theory are guiding principles of the project, which include: (a) to accelerate the pace of development of forestry, and to reduce the time required for the rehabilitation and expand forest resources; (b) to increase the forest vegetation effectively, slow down soil erosion, and improve the ecological environment, and (c) to prevent desertification and expansion of soil erosion in 10 years so as to bring beautiful greenery back to the Capital city.

6.4 Principles and references of the implementation plan

(Principles of the plan)

- (1) As a matter of principle, the planning shall be systematic, comprehensive measures shall be designed and guidance shall be carried out by group according to individual situation of the land.
- (2) As a matter of principle, ecology shall be given the highest priority, and ecological improvement and economic development shall be harmonized.
- (3) As a matter of principle, grouping and reformation of forest shall be the main tool so as to achieve rational protection and utilization of the resources available.
- (4) As a matter of principle, excellent indigenous tree species shall be given preference so as to preserve biological diversity.
- (5) As a matter of principle, the starting baseline shall be kept at high levels so as to aspire for much higher standards.

(References)

Forest management classification, pertinent development plans, applicable laws and regulations, natural conditions, resource situations (including access to forests), socio-economic situation

6.5 Major project operation measures under the plan

(Design principles)

- (1) Selection of tree species will be made in full consideration of the local natural and social conditions and active participation of local residents will be encouraged.

- (2) Forestry techniques will be mobilized comprehensively so that mixed forests of many tree species will be established.
- (3) Planting will be done mainly in spring, using large-size seedlings.
- (4) Initial planting density will be approximately 56 seedlings per 1 mu (1/15ha=0.067ha). When preparing land, existing trees of desired species will be preserved so as to keep indigenous vegetation and prevent soil erosion.
- (5) The mixture rate of needle-leaved and broad-leaved forest will be 4:6 as standard.

(Design model by analysis of land conditions)

In consideration of the present situation of the forests, 12 forest management models to be introduced to each land category were developed. The natural and socio-economic conditions of each land category were summarized and the respective forest management methods (operations to be applied) were defined.

6.6 Estimation of required project investment

(Bases for investment estimate)

The data and information on which the required investment was estimated include: “Construction Cost Estimation and Basic Design Compilation Method of Forestry Department” and “Indirect cost estimation for construction work” of the State Forestry Administration, People’s Republic of China, “Beijing Afforestation and forest management operation guideline” and other construction cost information of Beijing City.

(Estimated project investment)

Based on the summary list of forest management operation models by forest type, land category and natural conditions of the Implementation Plan, a unit operation cost table for unit area of each operation to be applied was prepared, each unit operation cost was then multiplied by the area of the land to which each operation is applied. The results of estimation made by this method are summarized below.

Direct costs of forest management operation

Contents of forest management operation		Area (ha)	Unit costs over 10 years (yuan/ha)	Cost required over 10 years (x 10,000 yuan)
Man-made forest	Planting (ordinary slope area)	447	102,749	4,593
	Planting (gentle slope area)	786	91,514	7,193
Improvement of Needle leaved pure stand		1,370	30,297	4,150
Selective cutting in broad-leaved forest		7,276	1,980	1,441
Shrub land management		9,383	540	507
Supplementary planting in open forest		93	61,458	573
Improvement of less efficient forest	Improvement of less efficient pure stand	1,440	63,130	9,089
	Improvement of less efficient mixed stand	2,120	30,545	6,477
	Improvement of less efficient shrub	3,496	43,160	15,087
Tending of immature forest		2,408	35,250	8,489
Regeneration of protection forest		482	19,536	941
Tending of fruit orchard		456	24,000	1,094
Total required cost (10 years)				59,634

Apart from the above, other chart including a schedule chart of yearly forest management activities were prepared for the 10 years.

7. Support to model forest establishment

7.1 Purposed of model forest establishment and procedures of implementation

The support to establishing model forests is extended for the primary purpose of demonstrating good examples for implementation of the Plan. Hopefully also, it will serve to help support local residents. Specifically, two types of activities were conducted: selection of existing models out of excellent and suitable forests and establishment new model forests.

7.2 Selection model forests from existing forests

(Selection policy)

The existing forests in the Counties and Districts concerned vary in growth stage and stand growth. The model forests to be selected should preferably have the following characteristics:

- (1) High generality to be a useful model under similar conditions
- (2) Easiness in maintenance and management after establishment
- (3) Inexpensive establishment cost
- (4) High effectiveness as mitigation of dust and sand storm
- (5) Long duration of the expected functions
- (6) High economic profitability in so far as the expected functions are maintained
- (7) Well harmonized with the local ecosystem
- (8) Good access and other conveniences to be a model for others
- (9) Convenience of continued validation by the Chinese side after the present study

(Present situation of existing forests in the area concerned and likely candidate of model forests)

Afforestation activities began in China in 1950s. However, most of the planted forests were logged and exploited by the farmland expansion campaign during "The Great Leap Forward" movement and "The Great Proletarian Cultural Revolution" and little of them are maintained. Starting in 1978, massive artificial afforestation took place, triggered by the Three-North Shelterbelt Programme.

The efforts, however, resulted in poor initial survival rate, poor long term survival rate and poor growth. Since 1998 at last, adequate levels of funds were secured for afforestation, and improvements were seen in site preparation, seedling raising and planting quality. It was conceived, therefore, that forests to be recommended as model forests would be mostly those planted after 2000.

(Selection process and an overview of selected model forests)

The forestry departments of the Counties and Districts concerned were presented the contents of expected demonstration effect and the types of model forests and were requested to recommend candidate forests. The actual work of survey was sub-contracted to the China Anti-desertification Training Center.

Out of 23 candidate locations, 10 were selected out as existing model forests. The two model forests in Yanqing County were established by direct seeding and seedlings planting on mountainous area and presented models for forestation in poor water supply conditions. The three model forests in Changping District were for three topographic types of flat land, plateau and gravel mixed sandy area.

The two model forests in Mentougou District serve as models of irrigated afforestation in remote highlands. The three model forests in Huailai County are models of afforestation to realize sustainable ecological and socio-economic development in the loess plateau, aeolian sandy soil area and other dust and sand storm land.

7.3 Establishment of new model forests (Japanese and Chinese sides)

(Model forests established by the Japanese side)

(1) Model forest types and technical specifications

The types and technical specifications of the model forests established by Japanese side are as follows:

Name	Protection forest for hill-side ecology	Protection forest for mid-highland ecology	Protection forest for alluvial fan area by economic trees
District/Country	Yanqing County	Changping District	Huailai County
Time of implementation	Spring 2008: site preparation Summer 2008: planting	Autumn 2008: site preparation Spring 2009: planting	Autumn 2008: site preparation Spring/Summer 2009: planting
Area	30 ha	40 ha	10 ha
Location	Mountain slope at 600-700 m above sea level, sandy soil, soil thickness:10-50 cm	Gentle hill-like plateau in the mid-mountain at 400-500m above sea level, sandy loess, soil thickness: 50-150 cm	Alluvial fan area at 500-600 m above sea level, sandy soil with thickness of 10-20 cm at slope and sandy loess with thickness of 100 cm or more at fan area
Precipitation	460 mm/yr. (multiple years' average)	550 mm/yr. (multiple years' average)	380 mm/yr. (multiple years' average)
Existing tree species	Naturally grown <i>Prunus armenica</i> and <i>Robinia pseudoacacia</i> with scattered presence of previously planted <i>Platycladus orientalis</i> and <i>Pinus tabulaeformis</i> . These tree species should be reserved and maintained.	Many naturally grown trees including <i>Prunus armenica</i> , <i>Prunus persica</i> , <i>Zizyphus jujube</i> var. <i>spinosa</i> , <i>Corylus heterophylla</i> var. <i>thunbergii</i> , etc. These tree species should be reserved and maintained with a density of some 200 trees/ha.	Sparse natural growth of <i>Prunus armenica</i> , <i>Vitex negundo</i> var. <i>heterophylla</i> , <i>Zizyphus jujuba</i> var. <i>spinosa</i> , etc. These tree species should be reserved and maintained as much as possible.
Planted tree species	<i>Pinus tabulaeformis</i> ., <i>Platycladus orientalis</i> , <i>Continus coggygia</i> , <i>Prunus armenica</i> , <i>Quercus mongolica</i> ., <i>Acer turuncatum</i>	<i>Pinus bungeana</i> Zucc., <i>Platycladus orientalis</i> , <i>Pinus tabulaeformis</i> , <i>Koelreuteria paniculata</i> , <i>Continus coggygia</i> , <i>Quercus mongolica</i> , <i>Fraxinus japonica</i> , <i>Sophora japonica</i> , <i>Cedrela sinensis</i>	<i>Pinus tabulaeformis</i> , <i>Zizyphus jujuba</i> var. <i>inermis</i> , <i>Juglans regia</i>
Seedling	Only pot seedlings of 2 years and/or older were used. Some of them were tall pot seedlings (80 cm or taller)	Needle-leaved: all tall pot seedlings. Broad-leaved: bare seedlings for <i>Fraxinus japonica</i> , <i>Sophora japonica</i> and <i>Cedrela sinensis</i> and pot seedlings for others	High quality tall pot seedling for <i>Pinus tabulaeformis</i> .; bare root grafted seedling for <i>Zizyphus jujuba</i> var. <i>inermis</i> and <i>Juglans regia</i>
Site preparation	Weeding (in strips) + fish scale shaped planting hole (longer dia.0.7 m × shorter dia.0.6 m × depth 0.6 m) + add soil (partially as needed)	Weeding (in strips) + fish scale shaped planting hole (longer dia.0.7 m × shorter dia.0.6 m × depth 0.6 m)	slopes: fish scale shaped planting hole (longer dia.0.7 m × shorter dia.0.6 m × depth 0.4 m); Alluvial fan: round hole (dia.0.8 m × depth 0.6 m)
Planting density	General: 4 m × 2 m; Gentle slope: 3 m × 3 m (1,111 – 1,250 seedlings/ha)	General: 4 m × 2 m; Gentle slope: 3 m × 3 m (1,111 – 1,250 seedlings/ha)	<i>Juglans regia</i> : 4 m×3 m (830 seedlings/ha); <i>Pinus tabulaeformis</i> : 3 m × 2 m (1,600 seedlings/ha); <i>Zizyphus jujuba</i> var. <i>inermis</i> : 4 m × 2 m (1,250 seedlings/ha)
Drought prevention	Water retention chemical used, watering during planting, anti-evapotranspiration chemical used for tall pot seedlings, cut weed used to cover foot of planted seedlings	Water retention chemical used, watering during planting, plastic sheet mulching to cover foot of seedlings	Watering during planting, plastic sheet mulching to cover foot of seedlings
Tending	Inter-tillage weeding, bush cutting, watering in autumn (once at least)	Inter-tillage weeding, bush cutting, watering in summer (twice at least as special measure in drought year), watering in autumn (once)	Inter-tillage weeding, bush cutting, watering in autumn (at least once); watering in summer (five times at least) for <i>Juglans regia</i> and <i>Zizyphus jujuba</i> var. <i>inermis</i>

(2) Outline of sub-contracted work and survival of model forests

Establishment of model forests was sub-contracted to Beijing Xinbeilin Ecology Research Institute Co., Ltd., who implemented the work in two phases (Phase1 in Yanqing County and Phase2 in Changping District and Huailai County) beginning from 2008.

Precipitation that affects the survival and growth of the planted seedlings was high in 2008 and very low (severe draught) in 2009. In fact, 2009 was referred to as a severe drought year in decades; cumulative precipitation to end-September of the year was some 300 mm in Yanqing County, 290 mm in Changping District and 265 mm Huailai County.

① Survival rate

The survival rates shortly after planting (one month after planting) were 95% or higher and the roughly estimated survival rates as of end-July, 2009 were 90% or higher. The model forests of *Juglans regia* and *Zizyphus jujuba* var. *inermis* in Huailai County were replanted in early November, because many scions had withered (scion mortality rate was around 50%) even though the stocks of grafting had survived.

As of October 2009, all tree species showed survival rate of 85% or higher, except for the 70~80% recorded by *Quercus mongolica* and excluding the replanted *Juglans regia* and *Zizyphus jujuba* var. *inermis*. The overall average survival rates of the three locations were 90% or higher.

② Growth

A final survey of survival and growth was conducted in mid-October, 2009. In the model forests of Yanqing County that were planted in 2008, *Platycladus orientalis* and *Prunus armenica* had heights of up to 10 cm, *Pinus tabulaeformis* had early sprouts of 10~20 cm, and *Continus coggygria* had heights of 10~50 cm. Hardly any height growth was observed in *Quercus mongolica*.

In the model forests of Changping District that were planted in 2009, only the *Pinus bungeana* that had been planted in the spring showed clearly visible growth; most of the early sprouts at the time of the October survey had grown of 5~15 cm. No clear height growth was observed in other tree species. In the model forests of Huailai County, *Pinus tabulaeformis* showed growths of 5~18 cm, but no clear height growth was observed in *Juglans regia* and *Zizyphus jujuba* var. *inermis*.

(3) Overall evaluation of newly established model forests

An on-site evaluation meeting was held in September 2009, participated by outside specialists, as well. High valuation was given to the project policy, forestation design and implementation; especially high praise was given to the design of the project that is characterized by multiple-species planting using needle-leaved and broad leaved and high and low trees and taking into account the local conditions with the view to enhancing ecological multi-functionality and eventual economic gains.

As major tasks for the future, more effective counter-measures against drought and more intensive tending works were recommended.

(4) Trial installation of windbreak net at orchards

The vineyards in the area of the study become bare land seasonally from end-October year to end-March of the following year because the grapevines are buried underground. This is believed to be a major source of dust and sand storm.

The study team suggested at the December 2008 meeting that windbreak net should be included in the project design. In response to the opinion of the local personnel concerned that such a net is totally new and it should preferably be installed on a trial basis and tested as to its effectiveness in this study, windbreak nets were installed from June through October 2009 in the model forest of Huailai County and some existing vineyards in the County.

The windbreak effectiveness was evaluated using a simplified method by comparing the wind velocities upstream and downstream of the net in late autumn to early winter (mid-November) after the leaves fell and the grapevines were buried underground. Even though equipment failures and time constraints prevented quantitative judgment and conclusions, the effect of the nets in reducing the wind velocity was evident. The Forestry Department of Huailai County is expected to continue the study in spring of 2010 and onward.

(Model forests established by the Chinese side)

The agreement between the two governments provided that a total of 600 ha model forests should be selected and established. With regard to establishment of new model forests, 80 ha of them should be newly established by the funds from Japan while certain ha of new model forest should be established by the Chinese side.

With due consideration of the technical suggestions made by the study team, the Chinese side established 160 ha of model forests at two locations in Yanqing County and 15 ha at two locations in Changping District, in accordance with the forestation plans of the host counties.

These man-made forests were established in and after 2007 and have the following characteristics:

- ① The site conditions are relatively harsh.
- ② Multiple-species planting was intensively carried out without compromising economic viability.
- ③ Tall seedlings were used to pursue quick forestation effect (visible effect of the project and functional effect of the stands).
- ④ Watering was made in all cases to seek high survival rate because tall seedlings were used.

Obviously, this kind of afforestation with these characteristics requires high unit costs. These cases are believed to serve as worthy models for afforestation and greening of areas (both hills and flat lands) surrounding big cities that are making remarkable economic development in China today.

The types and technical specifications of the model forests established by the Chinese side are summarized below.

	Protection forest for mid-highland ecology in Yanqing County	Protection forest for devastated river bank windbreak and sand fixation in Yanqing County	Protection forest for low-land soil and water conservation in Changping District	Protection forest for road in flat plane of Changping District
Location	Penyiao village, Jiuxian Town	Guchen village, Jiuxian Town	Xin village, Liucun Town	Beihaozuang village, Chengnan Town
Site conditions	Many rocks; thin sandy soil; poor in fertility and water retention	Sandy soil with many large cobbles; poor in fertility and water retention	Relatively thick sandy loam; medium in fertility and water retention	Mixture of loam and wet grass land soil; good in fertility and water retention
Area	53 ha	110 ha	13.8 ha	1.2 ha (belt)
Tree species composition	<i>Platycladus orientalis</i> : 60%	<i>Robinia pseudoacacia</i> : 30%	<i>Platycladus orientalis</i> : 60%	Broad-leaved: 70%
	<i>Pinus tabulaeformis</i> : 10%	<i>Acer spp</i> : 20%	Broad-leaved: 40%	<i>Pinus tabulaeformis</i> : 30%
	<i>Koeleruteria paniculata</i> : 10%	<i>Populus alba</i> var. <i>pyramidalis</i> 20%		
	<i>Continus coggygia</i> : 10%	<i>Fraxinus japonica</i> : 20%		
	<i>Quercus mongolica</i> : 10%	<i>Platycladus orientalis</i> : 10%		
Planting density	840 ~1,110/ha	810/ha	1,110/ha	1,110/ha

Seedling standards	Needle-leaved: tall pot seedling of height 120 cm or greater	Needle-leaved: tall pot seedling of height 120 cm or greater	<i>Platycladus orientalis</i> : tall pot seedling of height 100 - 120 cm	<i>Pinus tabulaeformis</i> .: root and soil bound seedling with straw-rope of height 2.5 - ~3 m
	Broad-leaved: large pot seedling with 3 cm DBH	Broad-leaved: large pot seedling with 3 ~ 5 cm DBH	Broad-leaved: large pot seedling with 2 cm DBH	Broad-leaved: root and soil bound seedling with straw-rope of 8 cm DBH or greater
Site preparation timing and hole size standards	Planting hole preparation from Nov. 2006 through Mar.2007; standards: 80 cm × 80 cm × 60 cm	Planting hole preparation from Oct.2007 through Mar.2008; standards: 100 cm × 100 cm × 80 cm	Planting hole preparation from Nov.2007 through Mar.2009; standards: 80 cm × 80 cm × 60 cm	Planting hole preparation from Nov.2008 through Mar.2009; standards: 80 cm × 80 cm × 60 cm
Planting method	Spring planting, with watering	Spring planting, with watering	Spring planting, with watering	Spring planting, with watering
Planting timing	Mar. ~ May 2007	Mar. ~ May 2008	Mar. ~ May 2008	Mar. ~ May 2009
Survival rate in planting year	90%	95%	90%	98%
Tending works (including planned ones)	Watering 2~3 times a year for 2 years; weeding once; pest control once	Watering 2~3 times a year for 3 years; weeding once; pest control once	Watering 2-3 times a year for 2 years; weeding once	Watering 2~3 times a year for 2 years
Present situation of stand	Average tree height: 1.5-1.8 m; Average DBH.: 3~5 cm	Average tree height: 1.8m; Average chest height dia.: 3~5 cm	Average tree height: 1.5 ~2 m; Average chest height dia.: 2.5 cm	Average tree height: 3 m; Average chest height dia.: 8 cm

7.4 Manual of forest vegetative rehabilitation techniques

(Purpose and method of manual preparation)

A technical manual was prepared for the anti-desertification forest vegetative rehabilitation works (windbreak, desert fixation, water/soil drift prevention, etc.) in the counties and districts of the study and in “The Combating Desertification Program for Mitigating Dust and Sand Storms Affecting the Beijing and Tianjin Areas”, for the purpose of providing easy-to-apply technique sets with specific examples (mainly technology for afforestation) that are suited to the individual objectives, site conditions, socio-economic conditions, etc.

In the manual preparation, cases of existing and new model forests and other excellent stands were collected, and available technical manuals and relevant materials on afforestation and forest management were referred. In addition, interviews with afforestation organizations and researchers were conducted so as to make the manual reflect knowledge and make the more pertinent and suited to the local conditions as well as practical forest vegetative rehabilitation techniques (technical models).

(Outline of the manual)

The manual consists of parts on basic theories and knowledge, on basic techniques for anti-desertification forests and on practical examples and cases. The basic theories and knowledge part describes basic knowledge, afforestation techniques and tending/management of man-made forests with emphasis on anti-desertification forests.

The volume on basic techniques for anti-desertification forests contains technical information on basic afforestation techniques(knowledge), implementation techniques of afforestation and tending techniques for the establishment of farm/ranch protection forests, water/soil retention forests and windbreak/desert fixation forests that are important in mitigating dust and sand storm problem. The volume on practical examples and cases introduces the existing 10 model forests chosen by this study, new model forests established in the three locations as well as other important cases.

