World Bank loan

Ningxia Desertification Control and Ecological Protection Project

Environmental Impact Assessment Report

Public Disclosure Authorized

Client: **Ningxia Forestry International Cooperative Project Management Center**

EIA unit: **Environment Planning and Assessment Institute, Nankai University**

EIA certificate: EIA No. 1108, Environmental Protection Ministry, P. R. China

December 2011

Tianjin, P. R. China

Preface

In recent years, the use of the world bank loan for afforestation project items have many successful cases, such as “Forestry Resources Development and Protection Project”，“Forestry Development Project in Poor Areas”, “Sustainable Development of Forestry Project”,“Comprehensive Forestry Development in China”, “Guangxi Comprehensive Forestry Development and Protection Project” and “Shandong Ecological Afforestation Project”, etc, which actually promote the ecological environment conservation and forestry development in China.

Ningxia Hui Autonomous Region is located in west of China with bad ecological environment, especially serious land desertification. The existing desertification land is up to 1,257,000 hectares, accounting for 18.93% of the total land area 6,640,000 hectares. Through the past 50 years of hard work, the trend of land desertification has been inhibited to a certain degree, but the problem land desertification was still serious in local areas since improper grazing, exploitation and wood-cutting, which restricts the socioeconomic sustainable development and improvement of the ecological environment in Ningxia. For this purpose, in the five years during 2012~2016, the government of Ningxia Hui autonomous region intends to make use of the world bank loans to fulfill the area of desertification control 72,000 hectares in Mowusu sand and the middle and lower reaches of Yellow River in Ningxia part, including 7 counties (cities or districts): Xingqing district of Yinchuan city, Litong district of Wuzhong city, Lingwu city, Qingtongxia city, Pingluo county, Yanchi county, Zhongwei city. The implementation of the project will improve the ecological situation of Yellow River banks in Ningxia, accelerate the ecological improvement, adjust the forestry industrial structure and promote the socio-economic sustainable development. On the other hand, the sand land in Ningxia Hedong and western Inner Mongolia is one of the main sources of the dust in Beijing-Tianjin area. The implementation of the project will be helpful to reduce sand, floating dust and sandstorm weather across the regions. Of course, this project is conformity with the overall planning

of forestry development and“11th Five-Year”forestry development plan and prevention and control of desertification plan in Ningxia Hui autonomous region.

According to “Law of the People’s Republic of China on Environmental Impact Assessment”and other relevant laws and the EIA requirements of the world bank, Ningxia Forestry International Cooperative Project Management Center in June 2010 entrusts the EIA work of the project “World Bank Loan-Ningxia Desertification Control and Ecological Protection Project” to Environment Planning and Assessment Institute, Nankai University. Then, the EIA unit organized the team to write the EIA outline for this project. After the EIA outline was passed by the relevant experts of the World Bank in China, the EIA unit made investigations in the project area for the related counties (cities, districts) and, drew up the EIA report for “World Bank Financed-Ningxia Desertification Control and Ecological Protection Project” based on the full data collecting and thorough investigations.

In the process of writing the report, the Ningxia Forestry International Cooperative Project Management Center and related forestry leaders, experts and colleagues from the relevant districts, cities and counties gave the warm and steadfast supports, Mr Feng yi-ren, the experimental expert of the World Bank, gave many constructive amendments to the finalization of the report. We here sincerely thank to the all above!

Contents

1 Basis of environmental impact assesment (EIA)

1.1 Significance of drawing up the EIA report

Ningxia, located in the interior of the country, belongs to arid and semi-arid climate region, with bad natural conditions, and land desertification is comparatively serious, which arouses the party and state leaders more attention. In April 2007, the president, the CPC general secretary, Hu Jintao Ningxia pointed out when he visited: “strive to make a change from the sand push person back to person push sand back, I hope that the comrades in Ningxia insist on implementing the ecological environment protection and construction as a great event of ‘Pains for the moment, gains for the millennia’, make solid and long-term efforts to improve the ecological environment continuously and contribute to the building of ecological shelters for the western China”. In September 2007, the state council premier Wen Jiabao made important instructions in “Great Achievements of Yen Loan to Ningxia Sandstorm Control Project” issued by audit Administration, fully affirming the experience of Ningxia sandstorms control. In September 2008, “Some Views on Further Promoting the Economic and Social Development in Ningxia by the State Council” clearly stated “support for constructiong Ningxia as a comprehensive national demonstrative area of sand prevetion and control and building the important ecological security barrier of western China”.

To fully implement the instruction of the General Secretary Hu Jintao on “constructing ecological shelters for the west of China” and the spirit of “some views on further promoting the economic and social development of Ningxia from the state council”, the Party Committee and the government of Ningxia autonomous region, proposed the governing concept “carrying out the ecological construction is carrying out development”, and planed to use the world bank loan in implementing desertification control project in the eastern banks of Yellow River, which finally was named “Prevention and Control of Desertification and Ecological Environment Protection Project in Ningxia”. Therefore, carrying out the spirit of instructions by the state council, against the serious problems such as various drought, ecological systems degradation, the construction of project area for prevention and control of desertification in accordance with ecological priority and the economic requirements is the important task of prevention and control of desertification and ecological development of Ningxia, which relates to the socioeconomic sustainable development of Ningixa, but also as the important part of building ecological shelters for the

wastern China, plays a vital role for the protection of the middle and lower reaches of the Yellow River and the ecological security of Beijing and Tianjin areas.

The EIA for "Ningxia Desertification Control and Ecological Protection Project"is the requirement of world bank and the ecological security of the state.Through the EIA work, the the environmental impact and ecological risks of the project implementation (construction and operation) could be qualitatively and quantitatively analyzed and evaluated, focus on the impacts of the project implementation on mode of land use, land resources, groundwater resources and surface water resources, on soil and biodiversity, the protection of species and natural habitat, such as *Ammopiptanthus mongolicus*, and on animal husbandry production and social economy. The potential impact on the Ming dynasty ruins of ancient great wall and the influence of using pesticides and fertilizers on environment could also be identified and evaluated after the project implementation, etc..

This evaluation data are based on the relevant studies and site investigation by the research team and the information gathered in the local departments. Through the qualitative and quantitative analysis on all kinds of adverse environmental impact caused by the project implementation, the ecological risks of project implementation could be estimated and determined, which would be useful to put forward rationalization proposals in the project design.

Finally, through the evaluation on the project planning and design, the adverse environmental effects caused by the project implementation could be reduced or avoided, and through the recognition and monitoring, the mitigation measures on the project design and construction scheme could be proposed and reasonable cost effective measures could be recommended to prevent the environmental negative effect by the project implementation or reduce it to an acceptable level.

1.2 Aim of EIA

Environmental impact assessment is a process of environmental management, the objective of EIA is not only to implement environmental protection policies of state, but also to implement the basic requirements of environmental management guidance "combining prevention with utilization, giving priority to prevention and control". The EIA is designed to illustrate the present situation of environmental quality in the construction project area, to predict the extent and scope of the adverse effects, pollution and the local

ecological environmental damage during the project construction and operation. Therefore, the EIA could provide scientific basis for site selection, rational layout, optimized design and cleaner production of the construction project, ensuring the virtuous circle of ecological environment.

The specific objectives of the project related are as follows:

(1) Analyze the natural conditions and social and economic conditions qualitatively and quantitatively in the project area, build EIA index system, identify and filter out the key environmental factors of this project, and evaluate the ecological environment conditions in the project area before and after the project implementation.

(2) Research on the characteristics of resources and environment in the project area, through analysis of ecological water consumption and water balance; evaluate the environmental impact including positive and negative effects and e environmental risk of the project implementation, with focus on rationality of the project implementation.

(3) According to the characteristics of resources and environment in the project area and environmental impact analyses, analyze and demonstrate substitute plan of the project, put forward rationalization proposals for the project design and construction plan, reduce or prevent the bad effect of project implementation on the environment.

(4) Enhance positive effect through preventing, reducing, mitigating or compensating the negative environmental effect caused by the project construction; improve the location selection, plan, design and operation of the project.

Finally, submit the assessment conclusion, and put forward the environmental management and monitoring plan and capacity building programmes of the project.

1.3 Guiding ideology of EIA

Implementing sustainable development strategy and scientific outlook on development, according to "'the 11th five year' and medium-term and long-term science and technology development plan of Ningxia ecology and environment", "prevention and control of desertification planning in Ningxia Hui autonomous region" "the 11th five year' forestry development plan in Ningxia hui autonomous", combined with the relevant requirements of the world bank, based on the regional socio-economy development and environmental

situation, with focus on studying ecological suitability division and environmental bearing capacity, predict possible future changes of the project areas after the project implementation, put forward the suitable planting scale to fit the bearing capacity, point out the potential environmental effect, strive to achieve good ecological, social and economic returns by the project implementation.

1.4 Principles of EIA

(1) Principle of Sustainable Development

According to sustainable development principles, analyze and evaluate the project planning and implementation plan, raise proposals and environmental protection measures to ensure that the regional development is consistent with sustainable development strategy and try to make the coordinated development of economy, social development and eco-environmental construction.

(2) Principle of Ecological priority

In the light of realities, fully implement ecological priority principle at different levels, such as macroscopic strategies, mesoscopic management and microscopic regulation, etc, reflect the connotations of ecological priority principle in many aspects: long-term and short-term, absolute and relative, the overall and local areas, etc.

(3) Principle of Innovative

Vigorously bring in technology frontiers and research achievements on ecological hydrology, environmental economics and environmental geography, and based on the specific conditions, put forward new ideas helpful for coordinated development of economy and environment in the project area.

(4) Principle of Combining Forward-looking and Operation

Fully consider the requirements of future development, the EIA possessed with certain forsight not only plays the guiding role better in the construction of Ningxia project area, but also ensures the various countermeasures and methods having such features as technological feasibility, economical reasonability, reliable effectiveness, practicality and strong operability according to the current realities.

(5) Principle of Involvement

Since the EIA involved in many areas and related to interests of different sides, encourage the public active participation in the EIA process, consult opinions and demands from all sectors of society, make a thorough knowledge of the EIA object, reveal the potential environmental problems, reduce randomness and blindness of decision-making to

the utmost extent and increase the scientific level of policy making.

1.5 Scope and emphasis of EIA

1.5.1 Scope of EIA

The scope of EIA includes the preparation for EIA report, the assessment on potentially environmental risk and environmental effects and making environmental management and monitoring plan.

The focuses of EIA are as follows：(1) screen most appropriate contents of the project construction with a reasonable level; (2) build reliable environmental background value based on the forecast; (3) build environmental aims, standards and performance indicators; (4) through the early EIA, prevent and reduce the adverse environmental effects caused by the project implementation in the project planning and design; (5) identify and quantify the interests, accumulation effect and residual influence or the risks by the project construction, such as those environmental impacts that can not be avoided or mitigated; (6) consider the project progress, cost estimates, designing environmental management and monitoring plan; (7) provide information for the investigation of decision makers through information opening and public participation; (8) provide guidance for more concrete planning and executing.

The environmental problems related to the project site selection are solved by the EIA team through making project selection procedure, while those related to the afforestation management are finished by making environment protection guidelines (EPG) that include the project design, completion and management, water and soil conservation, integrated disease and pest control, fire prevention and control, and monitoring and evaluation of the project. These guidelines will provide guidance for ecological afforestation project design, construction and operation. The EIA team will submit a vegetation diseases and pests management plan (PMP) in accordance with the comprehensive management of diseases and pests. In pratice, the EPG and PMP from other ecological afforestation project of the World Bank will also be a reference to facilitate this task.

The project consists of three subprojects, such as the followings：

Component one: Control of desertification and degradation of land

This subproject's objective is to solve shifting sand and sustainable utilization of land, including three parts:

Fixation of shifting sand The objective is to control shifting sand through constructing the bush woods with artificial straw checkerboard barriers, which will cover 20096.96 ha (301454 mu) and occupy 26.44% of the whole constructing area of the project.

Control of degraded land and vegetation restoration The goal is to restore natural vegetation and protect ecological environment. This part include to build the enclosure area and to construct the shrub forest. The former covers 44303.53 ha (664553 mu), the later covers 4423.96 ha (66359 mu), and they will occupy 58.29% and 5.82%of the whole constructing area of the project, respectively.

Integrated management of land The goal is to reduce the negative effects resulted from the utilization of land. A artificial grassland will be planted, covering 866.67 ha (13000 mu), which is 1.14% of the whole constructing area of the project.

Component two: cultivation of shelter belts

The subproject's objective is to protect the main agricultural land or agricultural production facilities by planting trees and shrubs. Ecological protection forest will cover 6086.58 ha (91299 mu), which is 8.01% of the whole constructing area of the project.

Component three: Project management and capacity building

(a) Capacity building, it contains international communication for 16 person-times, domestic trainings for 650 person-times and grass-roots training for 11100 person-times.

(b) Research and demonstration.

(c) Monitoring and evaluation.

1.5.2 Emphasis of EIA

Through analysis of environmental capacity, especially ecological water consumption and water balance, the work of EIA is to explore the ecological risks caused by the project implement, with focus on the problem of ecological water consumption resulted from 36,500 hectare tree and shrub shelter forest and 9,000 hectare ecological economic forest, comprehensively evaluate the environmental impacts of constructing 90,000 hectare ecological shelter forest on farmland resource, groundwater resource, surface water resource, soil, biodiversity, ecosystem health, sensitive nature reserve, husbandry production and socio-economy, and at the same time, evaluate the environmental impact of fertilizers and pesticides utilization after the project implementation.

In addition to the above general description, according to the background investigation,

the EIA should pay more attention to the following aspects: (a) analysis of water balance; (b) the problems related to *Ammopiptanthus mongolicus* community enclosure, including existed environment problems, challenges and other background values; (c) EIA and EMP need to affirm the accurate scope of the restoration region in degradation area and describe the specific models of restoring the community/ecosystem; (d) analysis of substitute programs, qualitative and quantitative analysis of afforestation mode and the rationality of tree species, shrub species and grass species selected in the three subprojects.

1.6 The technical route of EIA

Since this project is about natural resources (forestry), biodiversity and management of nature reserves, it does not include major land clearing work in any virgin forest and valuable bush-land/grassland, neither has long period construction work. Thus, this project belongs to class B according to the business guideline of the World Bank (OP 4.01).

"Simplified method" is used to carry out the EIA on this project. On the basis of consulting with the World Bank consultants, the Chinese environmental experts and the project office of the World Bank in Ningxia, the key environmental factors are screened to assess their environmental impacts.

The purpose of this research is to guarantee that the project can not make any heavy influence on the biological, ecological and/or social environment of Ningxia hui autonomous region, ensuring the sustainable development in this region. The project EIA will pay more attention to absorb the experience of other ecological afforestation projects of the World Bank, draw lessons from effective EMP and guidance in other projects, which are applied to this project. The concrete technical route is shown in Figure 1-1.

1.7 Evaluation factors and index system of EIA

This report uses environmental matrix method to identify the environmental impact. After Leopold (1971) advanced the environmental matrix evaluation method, it was widely used in all kinds of EIA projects, in which planning objects, indexes, plans and environmental factors as lines and rows of the matrix, symbols, numbers or words which can express the causal relationship between behavior and environmental factors are filled in the corresponding position. Through analysis and empirical parameters, the interactions of

the two columns in the matrix are determined and a specific value in the table reflects the causality among indexes in the corresponding ranks, thus the impacts of one particular project on environment can be analyzed qualitatively and quantitatively generally. Therefore, the environmental discrimination factors and matrix must be defined at first.

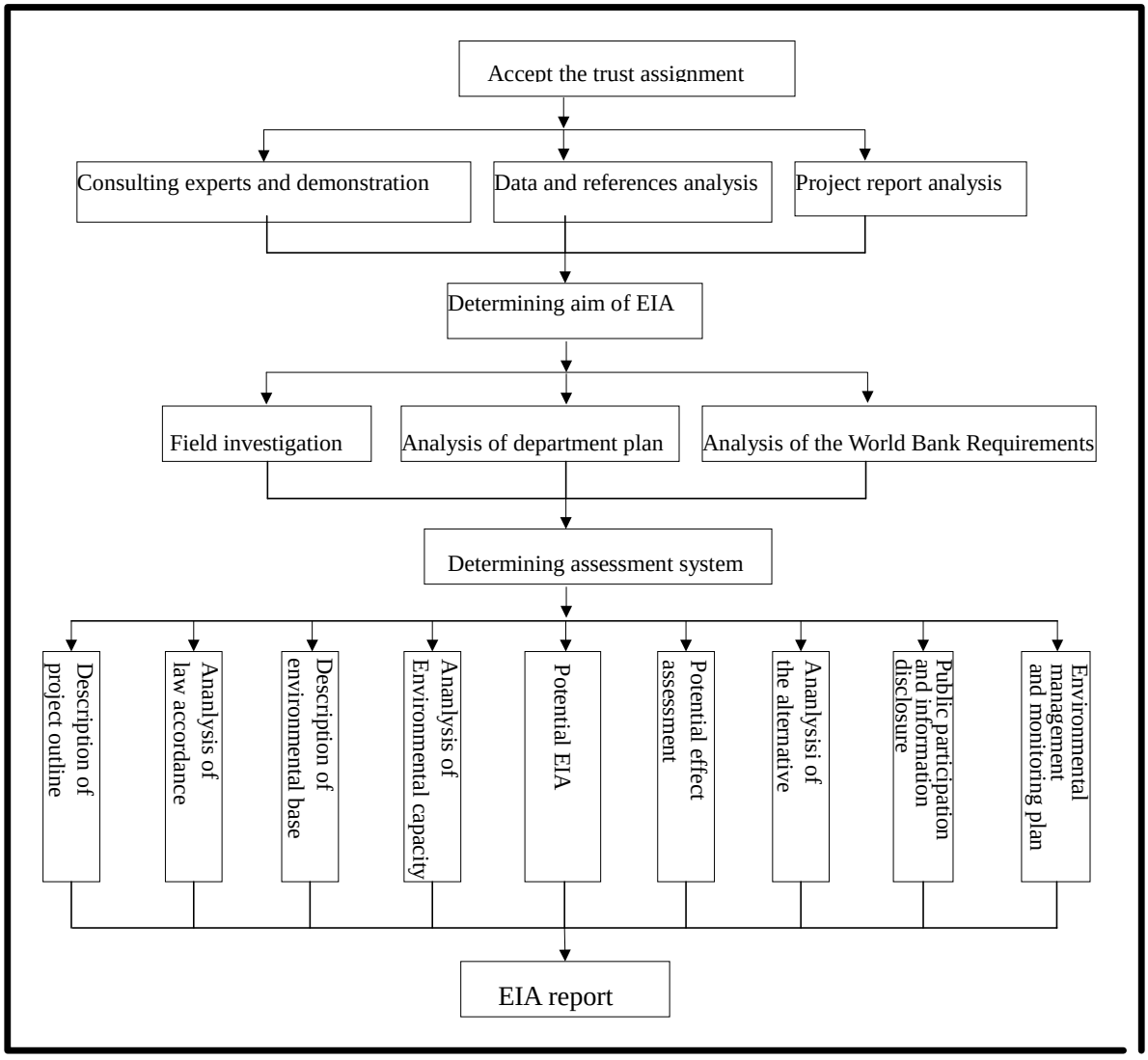


Figure 1-1 The EIA technical route of Ningxia Desertification Control and Ecological Protection Project

1.7.1 Identification of environmental impact factors

Through analysis of the eleventh five-year plan and regional characters of environmental resources in the Ningxia Hui Autonomous Region, combined the FSR of 'Ningxia Desertification Control and Ecological Protection Project'and layout of the project, this EIA is to analyze the impacts of this project on resources and environment and

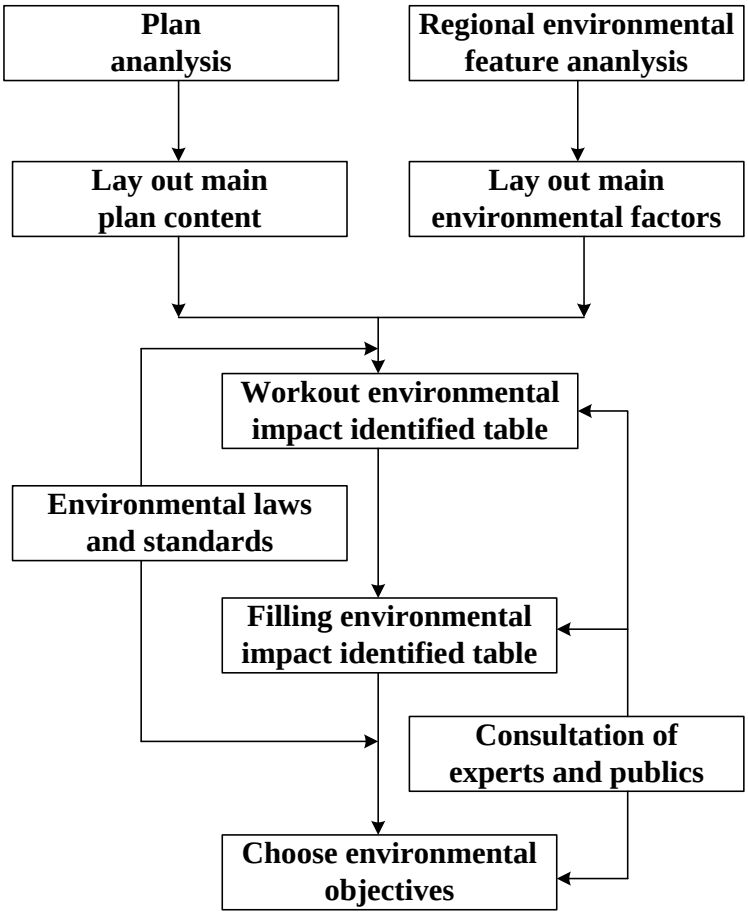


Figure 1-2 Discrimination of environmental influencing factors of the project

determine the environmental factors in the identification matrix by consulting with experts and public. The discrimination process of single environmental impact factor is shown in Figure 1-2.

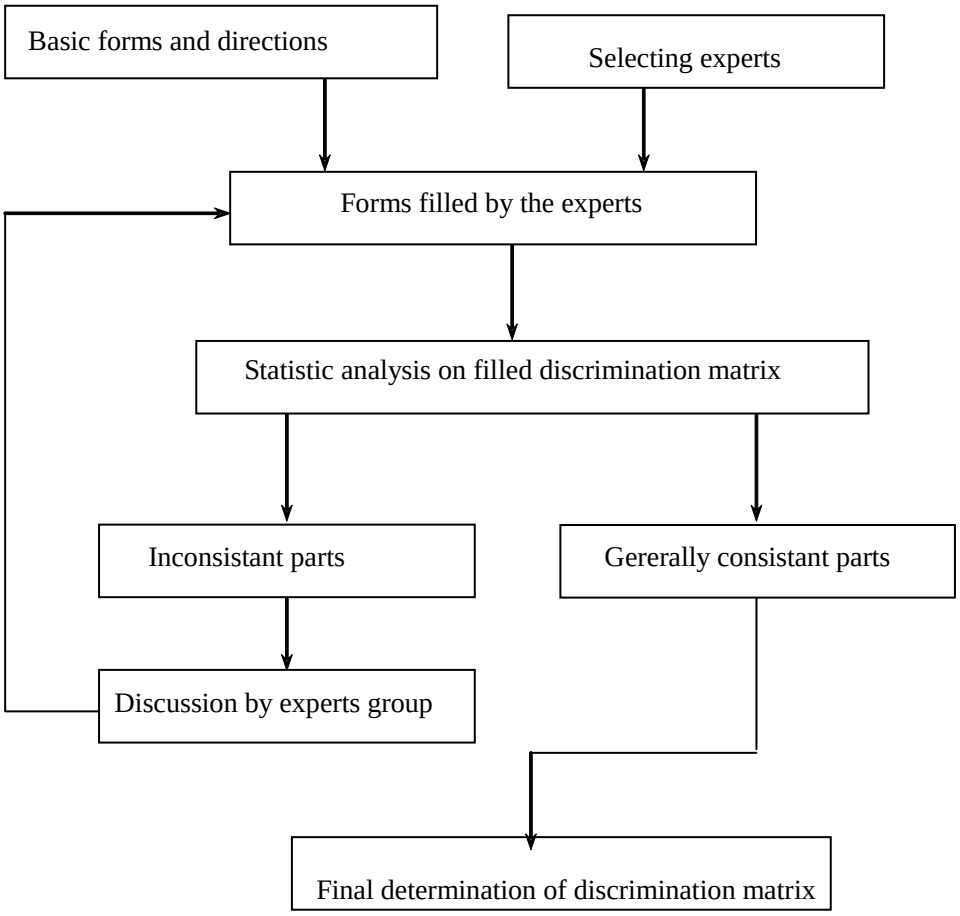


Figure 1-3 Basic procedure of discrimination matrix filling in experts consulting method

According to the conditions of resource and environment in the project area of "Ningxia Ecological Protection Project on Sand Control", environmental factors can be divided into three aspects, natural environment, ecological environment and social environment. The panned development activities will be taken as row of environmental impact discrimination matrix, while, the environmental factors that will be affected as the column. The degree of any environmental impact caused by the development activities was roughly assessed and divided into three classes, significant environmental impact, general environmental impact and minor environmental impact, expressed as number 3, 2 and 1 respectively. Those significant environmental impacts will be paid more attention in the EIA and environmental protection plan. Then, the environmental impact discrimination matrix was filled by the evaluators and experts on the basis of investigation in detail. The specific nethod is: after the evaluators state the overall directions, the experts fill the

discrimination matrix, then the evaluators analyze statistically the discrimination matrix, the basically consistant parts are confirmed, inconsistant parts are put forward and discussed by leading experts, finally, the inconsistent parts should be refilled. Repeat this process until generally consistent opinion reachs. The process is shown in Figure 1-3.

1.7.2 Discrimination matrix of environmental impact factors

Particular factor evaluation classification and environment classification principles defined by the china environmental protection administration are described in《Technical guideline for environmental impact assessment》(HJ/T2.1~2.3-9.3, HJ/T2.4~1995, HJ/T19~1997). The emphasis of EIA is on the impact of the project on ecological environment, water environment and social environment during the period of project implementation and operation. Furthermore, on the basis of potential environmental

Table 1-1 Environmental discrimination matrix of the EIA

in Ningxia Desertification Control and Ecological Protection Project

Composition of the project		Physical environment					Eco-environment						Social environment							
		hydrology	Water quality	Soil erosion	Environmenta air	topography	Animal and plant communities	Biodiversity increases	Soil fertility	Rare and dangered species	Incets ecological banlance	Land uses	immigrants	Village communication	Social economy	Cultural ruins	Miniority nationality	Public health	Employment
Enclosure sand vegataion		-1	1	3	1	1	2	1	2	3	1	2		-1	1	1			1
Shrub forest with artificial straw checkboard		-1	1	2	1	1	1	1	1						1				1
Arbor and shrub forest	Trees pecies arrangement	-2			2		1	1	2		1	1							2
	Land clearing		-1	-2	-1	-1	-2					1			1				1
	Planting fostering/ weeding			-1			-1				1				1				1
	Chemical fertilizer utilization		-1															-1	
	Pesticides utilization		-1				-1				-1							-2	
Newly building roads				-2	-1	-1	-1					-1		3	2				2
Newly building/expanding nursery			-1									1			1				1
Capacity building/management plan							2	2		1							1		1
Study plan of sandified land control			1				2	1							1				
Monitoring and evaluating							1	1											1

impacts, the EIA report takes water quality, land use, soil erosion and degradation of forests and biological diversity as the main evaluation factors. Water quality assessment focuses on the impact of land use on surface water and groundwater in the course of afforestation, timber harvesting and pesticides application at the stage of project implementation, while the assessment on land use focuses on that land-use patterns may change with more potentially increased changes of single species timber, afforestation and forest use.

The proposed project is a comprehensive one on prevention and control of desertification, including construction of artificial tree forest, shrub forest, artificial grass pane sandfence shrubs and enclosure sand vegetation, capacity building and environmental monitoring, So the interaction of these activites and their environmental impact is complex. Based on field surveying, secondary data collecting, consulting experts and exchanging with other research groups, Tthe discrimination matrix for this EIA is indicated in Table 1-1.

1.7.3 Scenario analysis of EIA

The nature of environmental impact assessment is a kind of scenario analysis.

As the base of environmental prediction and assessment in EIA, scenario analysis divides the study subject into main body and environment, recognizes the external factors that influence the major development through environmental research, sets kinds of possibilities of the major development by through analysis of all external factors causality, and predicts different possibilities of the major development according to quantitative model. The emphais of scenario analysis is how to get and deal with the experience of experts effectively, stresses the will of decision-makers in the future development, and requires wide information communications between planners and decision-makers to guide the quantitative analysis, being a forecast method combining qualitative and quantitative analysis. Scenario analysis can properly deal with the difficulties caused by uncertainties of plans in the environmental impact assessment for planningwhen combined with other forecast and evaluation methods.

Scenario analysis makes full use of knowledge and experience of experts from different majors and levels, takes the latest research achievments and project experience as references, predicts the situation of future development, draws the outline of future

development, discusses and predicts the driving factors of ecosystem changes, completely considers the uncertainties of the project implementation, and makes specific prediction quantitatively by combining the estimation of resource carrying capacity and environmental capacity.

A-Japanese financed sand control area in Pingluo

B-Artificial grass check board area in Xingqing

C-Arbor afforest area in Lingwu

D- Artificial grass check board area in Lingwu

E- German financed sand control area in Lingwu

F-*Artemisia ordosica* enclosure area in Lingwu

Figure 1-4 Probable scenes after performed Ningxia Desertification Control and Ecological Protection Project

Two kinds of scenario are set in the EIA of this project. One is zero solution scenario, in other words, it is the current situation, and the other is overall implementation of the project, the ecological, social and economic benefits increase markedly, the environmental quality improves, which is helpful to achieve a resource saving and environment-friendly society, and the time limit designed is from 2011 to 2020.

In fact, it is relatively difficult to set specific scenario, but the scenario set in other existed projects in surroundings of the project area and the same type of habitat in Ningxia can be used as the basis of scenario analysis of the project, for example, the situtations of artificial sand-fixation vegetations in shifting dunes in Shapetou of Zhongwei during the recent 50 years, and the conditions of desertification control projects made by China and Japan, China and Germany and so on. Figure 1-4 shows the possible partial scenario after the implementation of artificial grass pane sandfence shrubs, shrub forest, tree forest and closing of hillsides for facilitating afforestation in the past ecological protection projects, on which the estimation of biomass, carbon storage and biological diversity completely depends in this EIA.

1.8 Team of EIA in the project

Party A of the project, Ningxia Forestry International Cooperative Project Management Center, is in charge of the project implementation, Mr. He quanfa is the project leader, senior engineer Feng Xuejun et al. take part in the project.

Figure 1-5 Group photo of the EIA team in the investigation of Ningxia Desertification Control and Ecological Protection Project

Table 1-2 EIA team Information of Ningxia Desertification Control and Ecological Protection Project

Name	Agencies	Major	Professional titles	working years
Ju Meiting	Nankai University	EIA	Project leader	27
He Xingdong	Nankai University	Forestry and EIA	Project implementing leader	26
Gu Song	Nankai University	Meterology and Ecology	Professor	29
Liu Huifen	Tianjin Agricultural University	Agronomy	Professor	24
Li Yonghong	Nankai University	Soil science	Associate Professor	21
Shao Chaofeng	Nankai University	EIA	Associate Professor	5
Wu Jing	Nankai University	EIA	Associate Professor	6
Zhang Yufen	Nankai University	EIA	Associate Professor	8
Zhao Wenzhi	Cold and Arid Regions Environmental and Engineering Research Institute, the CAS	Water resources	Professor	25
Li Rong	Nankai University	Forestry and EIA	Graduate student	-
Ci Huacong	Nankai University	Forestry and EIA	Graduate student	-
Zhao Xuelai	Nankai University	Forestry and EIA	Graduate student	-
Xu Jingjing	Nankai University	Forestry and EIA	Graduate student	-

Party B, Environment Planning and Assessment Institute, Nankai University, is in charge of environmental impact assessment on this project. The institute has “State Class A qualification certificate of EIA”. A number of professors and associate professor engage in the work of EIA, and have completed more than 300 EIA tasks from the Environmental Protection Ministry, provinces and cities.

Participants of the EIA for this project include 13 persons, four professors, five associate professors and four graduates (Figure 1-5). Table 1-2 shows the work unit, major, professional title and work experience of every person.

2 Survey of the project

2.1 Necessity of the project construction

(1) Project construction is the basic needs to modify wind hazard in the project area

There exists 1.257 million hectares of desertification land in Ningxia, 18.93% of the total land area of 6.64 million hectares. Since sand sources rich, the sandstorm occures frequently in Ningxia. Statistic results showed that 27 times of regional sandstorm had occurred in the spring from 1982 to 1999, including 5 times of serious sandstorm. In the super-large sandstorm on May 5, 1993, more than 20,000 heads of livestock died or disappeared, and enear 1.33 million hectares of cultivated land and grassland suffered injury with total economic loss of 270 million Yuan. Sandstorm occurred 12 times in 2000, and more than 10 times of sandstorm occurred in 2001 spring, which indicated that the frequency of sandstorm is increasing in recent years. Therefore, the state and Ningxia Hui Autonomous Region pay more attention to the treatment of sandstorm in Ningxia.

According to the third desertification monitoring results in 1995, total 467,000 hectares of desertification land were controlled in Ningxia, which made desertification land reduce to 1.183 million hectares in 2004 from 1.265 million hectares in 1949. Compared with 1999, shifting sandy land and semi-shifting sandy land reduced by 56,000 hectares and 61,000 hectares, respectively, implying that historic change of desertification control happened, the control rate of desertification bigger than the expanding rate of desertification. However, considering the restrictions of financial and material resources, the desertification land in Ningxia tends to become better on the whole but tend to deteriorate locally, and there is a long way to go to prevent and control desertification.

The problem of land desertification is serious in this project area, or Ningxia east Yellow River sandy land, where more than 2 million urban and rural residents live. According to third monitoring results of national land desertification and classification in terms of desertification land type of the seven counties (cities, districts) in this area, the area of shifting sand land is 77,070 hectares, accounting for 8.6% of total desertification area of 891,203 hectares; semi-shifting sand land is 71,489 hectares, accounting for 8%; fixed sand area is 549,762 hectares, accounting for 61.7%; Gobi area is 57,460 hectares,

accounting for 6.4%; wind erosion land is 1,512 hectares, accounted for 0.01%; desertification cultivated land is 133,963 hectares, accounting for 15%. The land area with an obvious trend of desertification is 93,126 hectares in the project area, being 5.2% of the total desertification monitoring area of 1,798,327 hectares in the project area. Vast desertification and poor environment in the project area has restricted the improvement of the local people's living standards.

In fact, our national leaders have also visited the project area and concerned the desertification land prevention and control work. General Secretary Hu Jintao planted *Calligonum* and *Salix psammophila* in Daquan forest farm, Baijingtan, Lingwu city of the project area on April 13, 2007 (Figure 2-1). He pointed out that: "Ecological environment is the important support to economic and social sustainable development", and "to realize the change from 'sand forced back people' to 'people forced sand back'", and "hope comrades of Ningxia to emphasize ecological environmental protection and construction, and to make ecological environment improve constantly, and to make contribution to western ecological barrier construction of our motherland". Therefore, the implementation of desertification prevention and control ecological protection project in Ningxia is of important meaning to control the hazards of sandstorms in the project area.

(2) Construction of the project is the needs of industry upgrading in the project area

The counties (or cities) along the Yellow River in Ningxia contribute more than 90% GDP and fiscal revenue to Ningxia, among which the Yellow River runs through 6 of 7 counties (cities, or districts), so it can be seen that the project area is the economic engine

A-**Hu Jingtao general secretary inspection**

B-Shrubs planted by Hu Jingtao

Figure 2-1 Hu Jingtao general secretary inspected Lingwu, Ningxia and planted shrubs

of Ningxia. Many important industrial bases and infrastructure, such as Ningdong Energy and Chemical Base, Hedong Airport of Yinchuan, and "The Yellow River Gold Coast" area are in the project area. Among them, the "Yellow gold coast" is along the Yellow River and is of several important effects including economic, tourism, flood protection and ecological safety. Ningdong Energy and Chemical Base is the energy, chemical and related industry clusters relaying on Ningdong coalfield, and is one of 13 key national one-hundred-million-ton coal bases. Construction of Ningdong Base is a key step of implementing the scientific development view, and of the implementation of national regional development strategy and energy development strategy, and is an important choice to achieve optimal allocation of resources and to effectively adjust the industrial structure, and is a major strategic decision and plan to from fundamentally reverse the development and to achieve leapfrog development, which matters economic and social development of Ningxia and is determined as "number-one project". Therefore, the project area is a strategic land of economic and social development in Ningxia, and matters the lifeblood of future economic and social development of Ningxia. Improvement of the region's ecological construction is the only effective way to achieve sustainable economic and social development in Ningxia, and protect Ningxia's economic and social leaping development.

(3) Construction of the project is the need of constructing western ecological barrier

Ningxia is located in the middle of farming and animal husbandry ecotone, which is in southeast margin of the Central Asian and is between the Taklimakan Desert and Mongolia Gobi desert area. West, north and east of Ningxia are surrounded by the Tengger Desert, Ulan Buh Desert and the Mu Us desert area, and Ningxia is one of the main path of 'west sand moved east'. Sand dust of northeastern Kazakhstan and western Mongolia enters into the north and west (or East) South region of our country through Xinjiang, Gansu and Ningxia. So Ningxia is one of three high frequent dust storms areas in Northwest China, and is an important transit point and choke of 'west sand moved east'. As these reasons, according to the State Council "several opinions to further promote economic and social development in Ningxia", Ningxia is the national anti-desertification comprehensive demonstration area. One of the aims is to build important west ecological security barrier,

so the project area is an important component of the barrier. Therefore, in order to implement the "opinions" of the State Council and to solve the problems of serious ecosystem degradation, drought and water shortage in varying degrees in Ningxia, the construction of anti-desertification project area of ecological priority and economic improvement is not only the important task of anti-desertification and ecological construction in Ningxia, and is the fundamental task of national sustainable development. The construction of project area is of great significance of building an important ecological barrier in western China, especially to the ecological safety in Beijing and Tianjin.

(4) Construction of the project is the objective need of building a well-off society

Several factors restrict agricultural and rural economic sustainable development of project area, including large proportion rural population, large quantity of poverty population, single income channel, economic and social backwardness. The construction of sand control project of the east coast of the Yellow River, not only can play important roles to improve the regional ecological situation, control dust source in Ningxia Hui Autonomous Region, strand transit dust, protect regional agricultural efficient production, but also play important roles to promote the development of forestry industry in the sandy area in Ningxia, to improve the living environment, and to promote the development of production and the improvement of basic living conditions of farmers. Practice shows that only a stable eco-forestry system can promote the coordinated development of agriculture, animal husbandry, water and other industries and sectors. Therefore, the project is the need to promote regional coordinated economic development. In addition, through participation in project construction and project training, farmers in the project area can learn new knowledge, new technology and new ideas, which are of great significance to improve their quality, and lay the foundation for achieving sustainable development in the project area.

(5) Construction of the project is the urgent need to protect the Yellow River

Yellow River carries a rich history of the Chinese nation for thousands of years, and is a symbol of Chinese culture. She nurtured the Chinese people along the Yellow River, but also nurtured the descendants of Ningxia. It has always been said that "the rich world of the Yellow River in Ningxia". The Yellow River flows through 397 km in Ningxia. Since the Han Dynasty the Ningxia Plain has been formed through cutting water drainage and

developing irrigated agriculture. Along the Yellow River, four prefecture-level cities including Yinchuan, Shizuishan, Wuzhong and Zhongwei are distributed, and 43% of the area of 10 cities including Ping Luo, Qingtongxia, Lingwu, Zhongwei, Yongiing and Zhongning are also there. There places concentrate 57% of the population in Ningxia , 80% of the town, 90% of the urban population, and create more than 90% of the GDP and fiscal revenue in Ningxia. However, Mu Us Desert is close to the Yellow River in Ningxia, and winds bring a large number of dusts each year directly into the Yellow River, which causes river sediment and blocking river. Implementation of this project will effectively prevent the sand sediment from the Mu Us Desert to Yellow River through ecological construction; artificial afforestation and sand control combination of plant conservation, and is of positive significance to the protection of the ecological safety of the Yellow River.

(6) Construction of the project is the need of implementing international conventions

On December 18, 2009, Premier Wen Jiabao attended the United Nations Climate Change Conference in Copenhagen and pointed out: "The Chinese government establishing the goal to reduce greenhouse gas emissions is a voluntary action under the circumstances, and is responsible to the Chinese people and all mankind without any conditions, and is not linked to the emission reduction targets of any other countries. We will be sincere in what we say, and will carry out what we do. No matter what outcome will be reached in this meeting, we will be fully committed to achieve and even exceed the goal." Today, the Chinese GDP has surpassed Japan as the world's second, and in the future from now on China will continue to show the image of a responsible country, and similarly the Chinese government will resolutely carry out the "United Nations Convention to Combat Desertification" and the "United Nations Framework Convention on Climate Change "(Kyoto Protocol) and other international conventions. Implementation of this project will increase the area of vegetation and reduce sandstorm damage, and will help to ensure the ecological safety in China, also is the need for performing "Desertification Convention", the "Kyoto Protocol" and other international conventions

Above all, in order to change the ecological environment along the Yellow River in Ningxia, and to improve production and living conditions of urban and rural residents, and to protect the ecological base of national energy security, it is necessary to implement

"Ningxia Desertification Control and Ecological Protection Project".

2.2 Outline of the project

2.2.1 The organizational structure of the project

In order to ensure the smooth implementation of Ningxia desertification ecological protection project, Ningxia Hui Autonomous Region Department of Finance, Development and Reform Commission and Forestry Bureau set up a joint leading group of Ningxia external debt project, and a program executive office is set up under the leading group.

The program executive office is in the management centre of Ningxia forestry international cooperation project, whose main functions are: (1) Organize and prepare the project plans, annual implementation plans, investment plans, monitoring plans, etc., coordinating, summarizing the work; (2) Be responsible for the quality and progress of projects, the management of funds, the project quality inspection and acceptance, supervision of work, and timely reporting to the leadership group; (3) Make science and technology training, technology promotion, training backbone of the project, to make technical guidance and to promote advanced technology and management experience; (4) Monitor and evaluate, information management of the project, and be responsible for a summary of information and feedback work.

Accordingly, Development and Reform Bureau, Finance Bureau and the Forestry Bureau in all project counties (cities, districts) have set up joint leadership groups, and program executive offices are set up under the leading groups. The organization structure is shown in Figure 2-2.

2.2.2 Overall layout and content of engineering

According to the topography and the development and utilization state, the project area along the Yellow Rive is divided into two categories: Lingyan tableland control area of desertification that is located in desert steppe zone and Yinchuan plain salty desertification control area which belongs to the old agricultural area of the alluvial plain. Specific distribution of the project area is within the north of Honhdunzi Pingluo County, the south of Guangwu town Qingtongxia, the east of Qingshan village, Yanchi County, Castle Peak, the west of Xijiao forest farm of Zhongwei City, and the project area is involved in 7 counties (or districts), including Xingqing District of Yinchuan City, Litong District,

Lingwu City, Qingtongxia City, Pingluo County, Yanchi County, Zhongwei City. The project area contains 14 state-owned forest farms and 12 townships. The cities and counties in the project area are shown in Figure 2-3 and Figure 2-4.

The project will be implemented over a period of five years. Desertification control and ecological restoration activities will cover an appropriate total area of 72,000 hectares. The project will include three components, as follows:

Component 1 – Controlling Desertification and Degradation. This component will address the main drivers of desertification and degradation which relate to moving sand through wind erosion dynamics and unsustainable land use practices. The component includes three sub-components:

(a) Moving Sand Stabilization. The objective of this sub-component is to halt the movement of shifting sand dunes and prevent encroachment of shifting sand onto agricultural land, settlements and infrastructure. It will support the planning, detailed design, and establishment of straw checker boards combined with the seeding and planting of indigenous shrub and grass on about 21,500 hectares of moving and semi-moving sand dune areas. These activities will be complemented in the selected sites by supporting investments in fire control measures, including the construction of fire breaking tracks and passage routes, watch towers, and small buildings for technical staff and workers, and project information boards and warning signs.

(b) Degradation Control and Re-vegetation. The objective of this sub-component is to control and reserve degradation of arid and semi-arid shrubland and steppe areas caused by unsustainable land use, mainlu from grazing, and to restore a natural protective vegetation cover. Some 44,000 hectarea of degraded arid and semi-arid areas will be closed, protected, and managed for natural re-vegetation and supplemented by shrub planting and assisted vegetation restoration. An additional 5,000 hectares will be planted with trees and shrubs. The sub-component will also support construction of access tracks serving also as fire breaks, watch towers and other infrastructure required to manage and monitor the rehabilitated areas.

(c) Integrated Land Management. The objective of this sub-component is to complement sub-component 1(a) and 1(b) and mitigate any potential negative impacts on land users from desertification control and vegetation rehabilitation measures. It will support the implementation of the project's Resettlement Policy

Framework and seek to improve acceptance and ensure long-term sustainability of the expected project outcomes. It wil finance compensatory investments, such as economic tree plantations and fodder production for livestock in cases where access restrictions to grazing areas might occur. It will also support the development of long-term land management arrangements for all relevant project sites where such arrangements are feasible.

Component 2 – Protective Shelterbelt Plantations. The objective of this component is to protect key farmland and infrastructure from desertification and sand encroachment through tree and shrub shelterbelt plantations, It will support the establishment of multi-layer and multi-storey shelterbelt of some 5,500 hectares along roads, irrigation canals and around agricultural fields and fruit orchards in key strategically selected locations. The shelterbelts will serve as wind breaks, improve the ecological enviromment and help sustain and increase agricultural yields. It will also support supplemental irrigation installations to ensure the successful establishment of shelterbelt plantings.

Component 3 – Project Management, Capacity Building and M&E. This component will support: (a) the provision of office and monitoring equipment for the County Project Management Offices; (b) consulting services for the design, supervision (including safeguards implementation), monitoring and acceptance checks of protection planting; technical training; and advisory services; (c) information and awareness campaigns for project beneficiaries and stakeholders, including on fire protection and on post-plantation management; (d) a project impact monitoring and evaluation (M&E) system to monitor implementation achievements and assess the environmental and soci-economic impacts; and (e) applied research and demonstrations to generate and disseminate an improved understanding of desertificationb control approaches.

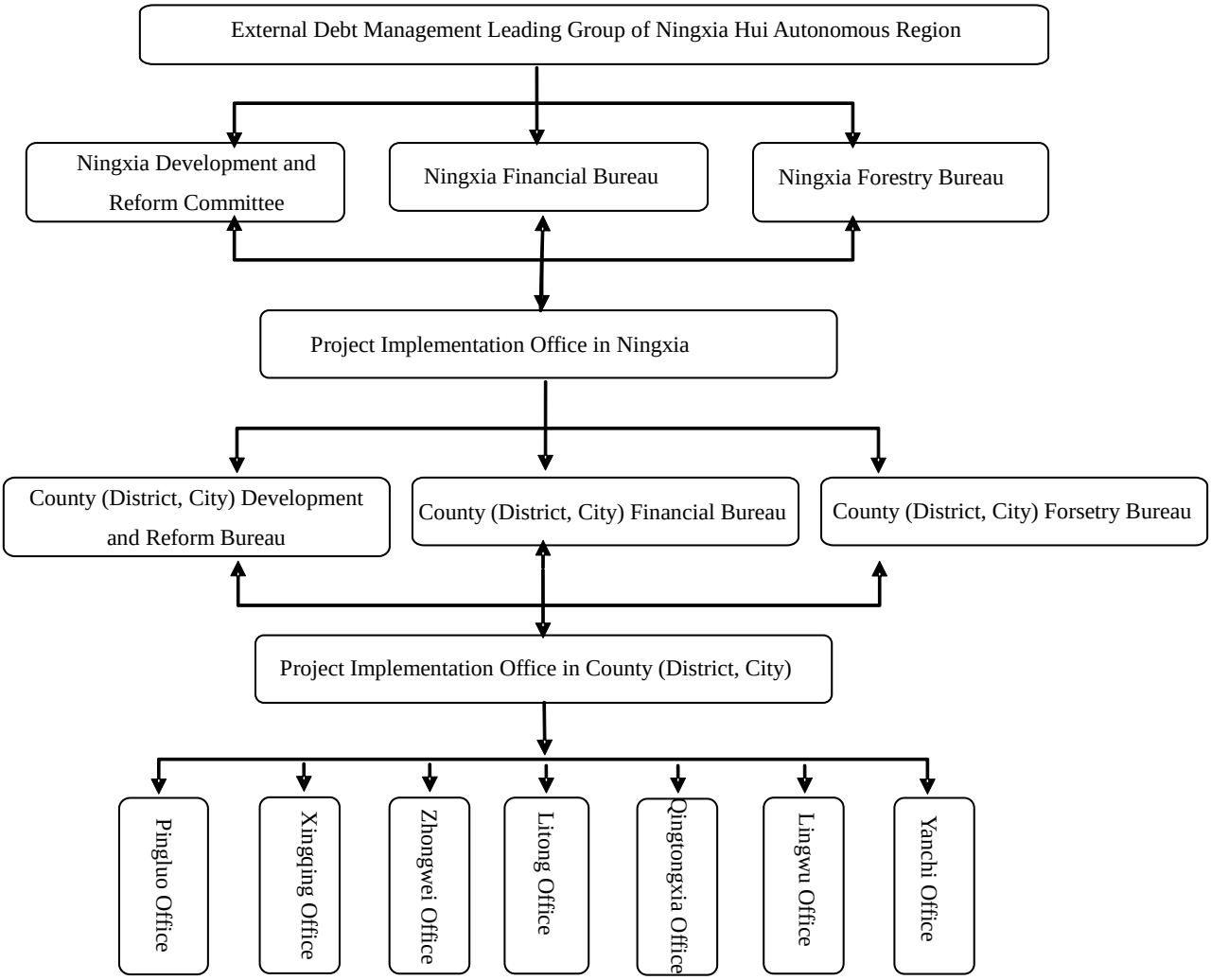


Figure2-2 The organization frame of Ningxia Desertification Control and Ecological Protection Program

The project total planning investment is 719.71 million yuan, including World Bank loan $ 80,000,000 (about 504 million yuan discount), 70% of total investment, and China's support funds of about 215.71 million yuan, 30% of total investment. China matching funds have two aspects: the investment of the project cities, counties and enterprises and the masses of labor and capital investment.

Afforestation projects belong to seven counties (cities, or districts), including Xingqing District of Yinchuan City, Pingluo County, Lingwu City, Yanchi County, Litong District Wuzhong City, Qingtongxia City and Zhongwei City. 76,000 ha of ecological shelter forest will be constructed, including tree forest 5214.05 ha, shrub forest 5296.5 ha,

shrub forest with artificial straw checkboard 20096.96 ha, enclosure sand vegetation 44303.54 ha, see Table 2-1.

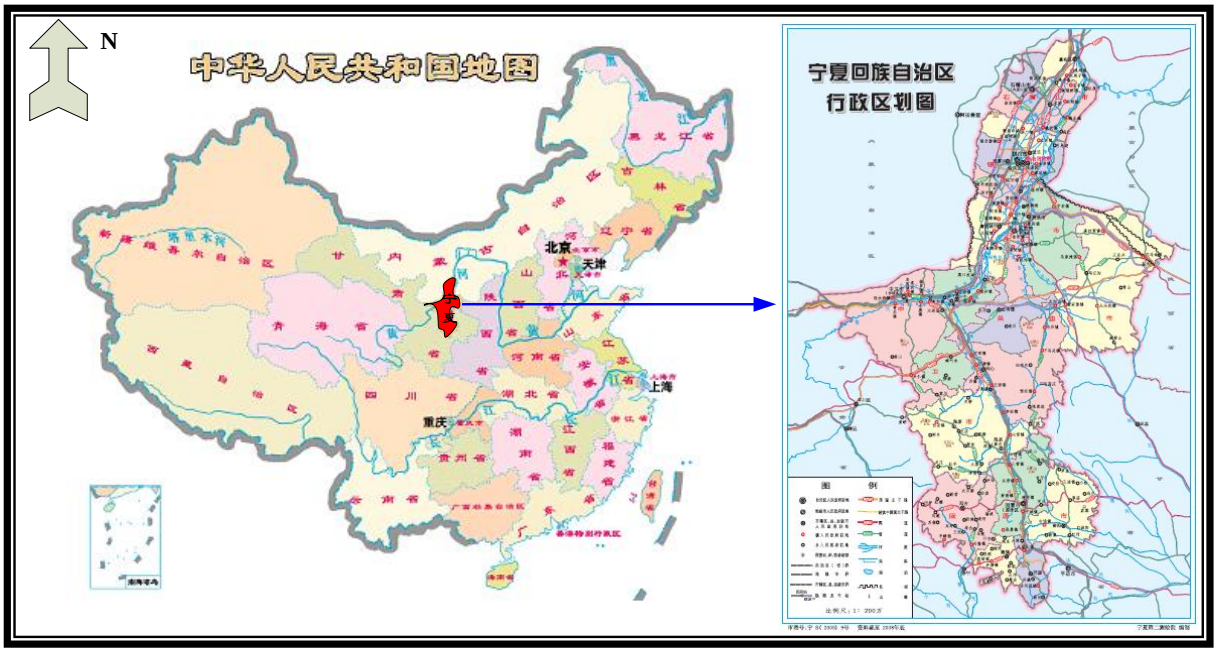


Figure 2-3 Position of Ningxia Hui autonomous region in China

Figure 2-4 Sketch map of Ningxia Sand Control Ecological Protection Program

Table 2-1 Afforestation plan in different counties(cities,districts) of the project area(ha)

Number	Programs		Acreage	Percentage(%)
1	Shifting dune fixation	artificial straw checkboard shrub forest	20096.96	26.44
2	Degraded land control and vegetation restoration	shrub forest	4423.96	5.82
		Enclosure sand vegetation	44303.53	58.29
3	Shelter forest construction	arbor forest	6086.58	8.01
4	Intergrated management	Eco-economic forest	866.67	1.14
Total			76000	100

2.3 Plan of forest types and tree species

2.3.1 Plan of forest types

There are three types of forest: windbreak and sand fixation forest, farmland protection forest and artificial grssland, which can be dividied five specific kinds, including arbor forest, shrub forest, artificial straw checkboard shrub forest, artificial grssland and enclosure sand vegetation.

2.3.2 Plan of tree species

The planed afforestation tree species：*Pinus sylvestris* var. *mongolica*，*Elaeagnus angustifolia*, *Populus alba*, *Salix matsudana*, *Fraxinus chinensis*, *Alianthus altissima*, *Robinia pseudoacacia*, *Euonymus bungeanus*, *Populus tomentosa* and *Populus nigra* var. *thevestina.*

The planed afforestation shrub species：*Hedysarum scoparium*, *Salix psammophila*, *Hedysarum leave*, *Caragana korshinskii*, *Calligonum mongolicum* and *Periploca sepium*.

The planed ecological economic forest species：*Vitis vinifera*, *Ziziphus zizyphus*.

The plant species of enclosure sand vegetation: *Populus euphratica, Ammopiptanthus mongolicus, Zygophyllum xanthoxylum, Nitraria tangutorum, Glycyrrhiza uralensis,Reaumuria soongonica, Salsola passerine, Achnatherum splendens, Sophora alopecuroides, Oxytropis aciphylla,Cynanch um komarovii, Psammochloa villosa, Astragalus adsurgens, Hippophae rhamnoides, Agriophyllum squarrosum, Oxytropis racemosa,Corisperum declinatum,Caragana stenophylla, Artemisia frigida, Artemisia ordosica* and *Artemisia sphaerocephala*.

2.4 Technical modes of afforestation and desertification control

According to the stand conditions of the project area, five afforestation and desertification control modes are designed, they are：

(1) 【Mode 1】Control mode for windbreak and sand-fixing forest

Status description: dune up to 70% of the total land, being about 30m wide, about 40m long.

Construction sites: Gaoshawo and Yehujing in Yanchi county, Gaoren and Taole in Pingluo, the east bank of the Yellow River in Xingqing district, Baijitan forest farm in Lingwu, Daquan forest farm, Xijiao forest farm in Zhongwei.

Indicator plants: *Artemisia ordosica, Hedysarum scoparium, Salix psammophila,* etc..

Suitable forest type: grass pane sandfence shrubs.

(2) 【Mode 2】Enclosure mode

Status description: low fixed and semi-fixed dune in some regions, water table ≥2m.

Construction sites: Hongdunzi in Xingqing district, east area of Taole in Pingluo county, Wanglejing town in Yanchi County, Baitugang and Majiatan in Lingwu, Mahuanggou and Gangou in Litong district.

Indicator plants: *Nitraria tangutorum*、*Artemisia sphaevocephala* Krasch、*Reaumuria soongonica*、*Ammopiptanthus mongolicus, Zygophyllum xanthoxylum*, etc..

Suitable forest type: closure forestation and grass.

(3) 【Mode 3】Shrub afforestation mode

Status description: smooth terrain, water table ≥3m.

Construction sites: Wanglejing and Gaoshawo town in Yanchi county, Baijitan forest farm in Lingwu city, Hongdunzi forest farm in Xingqing district, Mahuanggou in Litong district, etc..

Indicator plants: *Glycyrrhiza uralensis*, *Cynanchum komarovii*, coverage ≤10%.

Suitable forest type: shrubs.

(4) 【Mode 4】Afforestation mode for conifer-broad trees mixed forest

Status description: two sides of the road, relatively smooth terrain, water table <3m.

Construction sites: Baijitan forest farm in Lingwu city, Wanglejing in Yanchi county, Shabagou, Mahuanggou and Xigouyan in Litong district, etc..

Indicator plants: *Artemisia ordosica, Artemisia sphaevocephala*.

Suitable forest type: tree and shrub mixed forest.

(5) 【Mode 5】Farmland protective afforestation mode

Status description: smooth terrain, low lying near the bank of Yellow River.

Typical sites: the project area in the west bank of the Yellow River in Qingtongxia

Indicator plants: Agropyron cristatum, Stipa, Artemisia halodendron Turcz, *Achnatherum splendens*, etc..

Suitable forest type: farmland protective forest.

(6) 【Mode 6】Artificial grassland mode

Status description: water table >3m, coverage 5-8%.

Typical sites: Sunjialou of Yanchi near to the Yellow River irrigated area, Linhe town in Lingwu city, desertification control forest farm in Pingluo county, Hongdunzi forest farm in Xingqing district, Hedong ecological horticulture center, etc..

Indicator plants: field crops, etc..

Suitable forest type: grasses and herbs.

The planting density is included into the Feasibility Study and will be determined during detail design.

2.5 Layout of project division and construction deadline of the project

2.5.1 Layout of project division

The whole project is divided into two categories of control area: sandy desertification land and Yinchuan plain salinized desertification control area. The control of desertification in the former region should be paid more attention because of the sever desertification, while, the latter located in the Yellow River irrigatin area of Yinchuan plain, the control of salinized desertification is more important. The specific layout of the seven subprojects is as follows：

Ⅰ. Control area for sandy desretification land

1. The project area in Lingwu

①Daliumao subproject area; ②Changliushui subproject area; ③Baitugang subproject area; ④Yinhu subproject area; ⑤ Baishawo forest farm subproject area; ⑥Rencundu subproject area; ⑦Longkenzi subproject area.

2. The project area in Yanchi

①Wangerdaohu subproject area; ②Nanhaizi subproject area; ③Yehujing subproject area; ④Weizhuangzi subproject area; ⑤ Xingwuying subproject area; ⑥Lizhuang subproject area, ⑦Wanjigou subproject area.

3. The project area in Litong district

①Xigouyan subproject area; ②Mahuanggou subproject area; ③Shabagou subproject area; ④Gangou subproject area.

4. The project area in Pingluo

① No. 1 subproject area; ②No. 2 subproject area; ③No. 3 subproject area; ④No. 4 subproject area; ⑤ No.5 subproject area.

5. The project area in Xingqing

①Hongdunzi forest farm subproject area; ② protective forest subproject area in two sides of 203 provincial road; ③sand subproject area in two sides of 203 provincial road; ④Shilipai subproject area; ⑤Binggou subproject area; ⑥Yueyahu subproject area; ⑦Shuangchazigou subproject area; ⑧Toudaodun subproject area; ⑨Huangshagudu subproject area; ⑩Ecological horticulture center subproject area.

6. The project area in Zhongwei

①Xijiao forest farm subproject area; ②North side of Baolan railway.

Ⅱ Control area for salinized desertificated land in west bank of the Yelllow River of Yinchuan plain

7. The project area in Qingtongxia

① grape production base subproject area; ② Mingzhuyuan subproject area; ③Dabaliang subproject area; ④Zhongtan subproject area; ⑤Prolongation section of east circle subproject area; ⑥Shuxin forest farm subproject area; ⑦109 national road subproject area; ⑧Huashigou subproject area; ⑨Guangwu subproject area.

2.5.2 Deadline of the project construction

Allotted time of the project construction is five years, from 2012 to 2016.

2.6 Supporting infrastructure projects and capacity building

2.6.1 Supporting infrastructure projects

Following infrastructure facilities and seed bases will be completed, including 555.5

km of access tracks, 16 towers, 37 guard forest points, 32 project nameplates, 87 forest fire warning signs, 9 sets of office equipment, and 7 monitoring points.

The width of access tracks is 4m, the road surface will be paved with 20-30 cm gravel. The gravel roads serve for transportation of seedling materials to sites and for supervision and fire control. The road alignment will be determined during the detail design.

2.6.2 Capacity building

Following activities will be carried out including international exchanges of 16 persons; in-country training 650 people; basic training 11,100 people; hiring eight consultants.

2.7 Summary of the project planning and design

In the 50th anniversary of the Ningxia Hui Autonomous Region, the State Council issued the programmatic document of "Several observations to further promote economic and social development in Ningxia", which clearly stated "to support to construct Ningxia into a national comprehensive demonstration area of prevention and control of desertification, and to build west key ecological security barrier". ""Prevention and Control of Desertification and Ecological Environment Protection Project in Ningxia" upholds the spirit of this document to carry out ecological construction, so it is necessary to carry out.

The project area is rich in land resources, and has many years of successful experience in control of desertification. Building conditions are met, and project planning and design are available and technically feasible, which ensure the project "Prevention and Control of Desertification and Ecological Environment Protection in Ningxia" to process smoothly.

3 Laws, regulations and plans obeyed by the project implementation

This EIA work is based on the relevant laws and regulations issued by People's Republic of China and Ningxia Hui autonomous region and the requirements of World Bank documents. The documents and data the report obeyed, analysis of the plan conformability are as follows.

3.1 National/Ningxia laws and regulations related to environmental protection

(1) Environmental Protection Law of The People’s Republic of China

(2) Forest Law of the People’s Republic of China

(3) Law of the People’s Republic of China on the Protection of Wildlife

(4) Law of the Peoples Republic of China on Prevention and Control of Desertification

(5) Water Law of the People's Republic of China

(6) Law of the People’s Republic of China on the Protection and Control of Water Pollution

(7) Law of the People's Republic of China on Water and Soil Conservation

(8) Law of the People's Republic of China on Environmental Impact Assessment

(9) Regulations of the People's Republic of China on Nature Reserves

(10) Regulations of the People's Republic of China on Wild Plants Protection

(11) Regulations on the Administration of Construction Project Environmental Protection (State Environmental Protection Administration)

(12) Classification Management of of Construction Project Environmental Protection (State Environmental Protection Administration)

(13) The State Council’s Decision on Implementing the Scientific Development Outlook and Strengthening Environmental Protection

(14) Inform on Strengthening the Administration of Environmental Impact Assessment on International Financial Oganizations Loans Projects

(15) Regulations on the Prevention and Control of Forest Diseases and Pests (State Forestry Bureau)

(16) The Interim Measures on Afforestation Quality Management（State Forestry Bureau）

(17) Measures for the Disclosure of Environmental Information (Trial Implementation)

3.2 Technical guidelines of environmental impact assessment

(1) Technical Guideline for Environmental Impact Assessment

(2) Technical Guideline for Environmental Impact Assessment--- Non-polluted Ecological Impact

(3) Technical Guideline for Environmental Impact Assessment ---Afforestation Project

(4) Comprehensive Control Standard of Water and Soil Conservation

(5) Technical Regulation on Water and Soil Conservation Plan of Development and Construction Projects

3.3 Requirements of the World Bank

(1) 《the World Bank OP4.01》(Environmental Assessment)

(2) 《the World BankOP4.09》 (Pest Management)

(3) 《the World Bank OP4.12》(Involuntary Resettlement)(4) 《the World Bank OP/BP4.04》(Natural Habitats)

3.4 The natiaonal and Ningxia relevant plans

(1) 《National Prevention and Control of Desertification Plan》

(2) 《Water Resources Protection Plan》(Water Resources Division of Ministry of Water Resources)

(3) 《The National Ecological Environment Construction Plan》

(4) 《the Eleventh Five-Year Plan for State Environment Protection》

(5) 《Outline of the Eleventh Five-Year Plan for National Economy and Social Development of People's Republic of China》

(6) 《Outline of Protection Plan for the National Fragile Ecosystem》

(7) 《The National Ecological Environment Protection Outline》

(8) 《Guideline for State Industrial Structure Adjustment》

(9) 《the Eleventh Five-Year Plan for Forestry Development in Ningixa》

(10) 《The Master Plan for the Construction of National Prevention and Control of

Desertification Integrated Demonstration Area in Ningxia》

(11) 《Execution Program of Natural Forest Conservation Programme in Ningxia》

(12) 《Regional Distribution and Development Planning of Preponderant & Characteristic Forest Products of Ningxia》

(13) 《The Fourth Stage Project Planning of 'Three-North' Shelter Forest Project in Ningxia》

(14) 《the Eleventh Five-Year and Mid-term and Long-term Science and Technology Develpoment Plan on Ecology and Environment in Ningixa》

(15) 《Overall Plan of Land Use (1997-2010) in Ningxia Hui Autonomous Region》

(16) Technical Guidelines for Setting Apart Hills (Sand Area) for Tree Growing (National Standards of People's Republic of China GB/T 1563-94)

(17) The Law of Grassland Administration of the People's Republic of China

(18) Guide Rules for Construction of Forests of Ecology and Commonweal (National Standards of People's Republic of China GB/T 18337.1-2001)

(19) Certain Opinions Concerning the Further Promotion to Develop the Ningxia Economy and Society

(20) Request on Annual Commercial Plan of Alternative Projects about National Usage of WB Loan in 2010-2012 (National Development and Reform Committee, (D.R.C. foreign capital [2009] Document No.1924)

(21) National Integrated Verification Method of Forestation Actual Performance, National Forest Bureau, F. B. capital [2003] Document No.92;

(22) Regulations on the Nature Protection Regions of the People's Republic of China (Decree of the State Council No.167, People's Republic of China, 9th ,Oct.,1994)

(23) Planning of Desert Prevention and Control of Desertification in Ningxia Hui Autonomous Region

(24) 12th 5-year Plan of Forestry Construction in Ningxia

(25) Planning Scheme for 5th Project of "the three Norths" Protection Forest Construction in Ningxia

(26) Scheme of Natural Forest Resource Protection Engineering in Ningxia

(27) Regulation on Control of Grassland in Ningxia

(28) Plan of the 12th 5-year and Medium to Long-term Development of Ecology and Environment in Ningxia

(29) Technical Regulation of Agricultural Protection Forest in Yellow River irrigation Area in Ningxia (DB64/T200-1998)

(30) Technical Regulation of forestation in Saline-alkali Land in Ningxia (DB64/T534-2008)

(31) Standard for main germchit in forestation in Ningxia (DB64/T051-91)

(32) Laws, technical regulations and policy documents about forestation, ecological environment protection and so on, in autonomous region, each city and each county

(33) Identification Memorandum of the Project that Desertification Control and Ecological Protection in Ningxia 2010-04-23

(34) Working Memorandum for Study Group on Preparation of the Project that Desertification Control 2010-10-18~28

(35) Memorandum of Desertification Control and Ecological Protection in Ningxia for Preparation/Pre-evaluation Groups 2011- 06-13~7-1

3.5 Conformability between state and Ningxia relevant plans and industrial structure adjustment

3.5.1 Conformability analysis at state level

As a project on ecological protection forest construction, "Prevention and Control of Desertification and Ecological Environment Protection Project in Ningxia" belongs to agricultural type'Shelter Forest Engineering'encouraged by the state according to <Catalogue of Industrial Structure Adjustment Guidance> (2005) and conforms to national industrial policies. (National Development and Reform Commission)

(1) 《National Prevention and Control of Desertification Plan》

Planning objectives: during the planning period, on the basis of protecting the existing forest and grass vegetation, designate a number of the enclosure-conservation region of desertified land, enclosure protection area 3,720,000 hectares, fulfill 13,000,000 hectares of the control area.

Two relevant construction tasks are as follows: ① the constructin of the

enclosure-conservation region of desertified land. Among the existing desertification land in China, there are large deserts (eight), sand dunes (four) and Gobi formed in geological period, with harsh natural conditions, very low vegetation coverage and few or no human activities, where total enclousure will be carried out. At the same time, the desertification land around the desert that should be controlled but without the control conditions at present, where artificial devastating is serious, desertification enlargement aggravates, ecological division is important, will be designated to the enclosure-conservation region of desertified land. Through cutting banning, grazing prohibition, cultivation banning, hunting prohibition and resettlement in a planed way, protect the existing forest and grass vegetation, promote the vegetation natural recovery, contain desertification enlargement and preserve the ecological security.②Afforestation is one of effective measures to prevent and eliminate desertification land. According to the types of desertification land, using artificial afforestation, closing hill for afforestation, afforestation by aerial seeding, and tree, shrub and grass combination, establish base forest belt, farmland and pastures forest network, windbreak and sand fixation forest, water and soil conservation forest around the oasis, and implement returing cultivated land to forests to prevent land desertification and contain desertification spreading.

(2) 《The National Ecological Environment Construction Plan》

Environmental protection goals: firmly control new soil erosion resulted from the human factors, strive to curb the desertification expanding. In serious soil erosion areas in upper and middle reaches of the Yellow River and Long River where the ecological environment is very harsh and severe desertification region, the control effect appears. The specific objectives: ①Increase soil erosion control area of 600,000 km^2 and desertification land control area 2,200 ha; ②Increase forest area 39,000,000 ha, with the forest coverage more than 19%; ③Transform hillside field 6,700,000 ha, returning cultivated land to forests 5,000,000 ha, build farmland with forest netwok 13,000,000 ha; ④ Construct artificial grassland or improve grassland 50,000,000 ha, control “degeneration, sandification and salification”grassland 33,000,000 ha; ⑤Build a number of water-saving agriculture, dry-farming and ecological agriculture projects;⑥Improve the wildlife habitats, with the wildlife reserve area up to 8% of the state land; ⑦Establish a prevention

monitoring and protection system in the key ecological environment area.

(3) 《the Eleventh Five-Year Plan for State Environment Protection》

Target in 2010: by 2010, the key areas of environmental pollution has been brought under effective control, the urban ambient quality has improved, environmental quality in the countryside remains generally stable; the trend of environmental degradation has been curbed and the important ecological functions begin to resume.

Target in 2010: by 2020, the industrial pollution will be controlled comprehensively, urban and rural environmental pollution has been effectively ruled; the ecological environment quality in most areas will be improved, generally meeting the demands of building well-off society and achieving the coordinated development of economy and environment.

(4) 《The National Ecological Environment Protection Outline》

One of the main tasks is to protect and recover the ecological functions. Following the principles of ‘urgent task first, stressing focal points, conservation priority, active harnessing, adoption of measures suited to local conditions and setting up defences because of damage, combining the ecological protection projects that have been implemented or will be implemented, fortify regional natural ecosystem protection and recovery, restore and maintain the regional ecological features. (10) Improve the water conserving ability of water source, (2) Restore water and soil conservation functions, (3) Enhance windbreak and sand fixation function, (4) Improve reservoir flood routing and storage capacity, (5) Increase biodiversity maintaining ability, (6) Protect ecological functions of important seas.

(5) 《Water Resources Protection Plan》

“Water Resources Protection Plan” issued by Yellow River Conservancy Commission of the Ministry of Water Resources pointed out "With the rapid increase of population and improper human activities, the environmental pressure of Yellow River valley is continously increasing. Among the many environmental problems in the Yellow River valley, the most serious problems are: the soil erosion in the upper and middle reaches of Yellow River has not been effectively controlled; the threat of flood and icicle damage in the lower reaches of Yellow River is still very serious; the contradictions between water supply and demand of the Yellow River are becoming increasingly prominent; water pollution in some main

and branch stream is severe. At the same time, after the control measures implemented in the realignment of Ningmeng river and Sanmenxia reservoir region, the pressure and disaster of flood will be effectively controlled or reduced in these areas. Building irrigation works and water-electricity project, further developing and utilizing hydropower resources will forcefully promote national economic development and provide a solid material foundation for environmental protection and control.

3.5.2 Conformability analysis at provincial level

Conformability with several professional plans at provincial level is analyzed as follows.

(1) 《the Eleventh Five-Year Plan for Forestry Development in Ningixa》

The construction emphasis in the Yellow River irrigated area: ①Based on 'the Three-North Shelter Forest Programme'，speed up the high standard construction of afforestation in plain region, pay more attention to implementing the green channel construction project, improve the farmland shelter forest system; implement unban field large environment's landscaping and village greening project to improve the level of afforestation in urban and rural areas; accelerate the construction of ecological protection system in east of Zhongwei mountain, the construction of ecological shelter system in western area of Yinchuan and windbreak and sand fixation system in the lower area of Lingyan tableland to reduce the danger of sandstorms; implement conservation project of the Yellow River wetland to protect and recover the wetland ecosystems②Implement the construction plan of advantageous fruit production industrial belt, speed up the industrial belt development of distinguished economic forest characterized by kuko, grape, jujube planting, make great effort in developing high quality forest seedling and flowers industry, and develop short period pulp planation and fast growing and high yield plantation in a planned way, increase forestry production and farmers' income.③Research on red jujube and grape storage fresh-keeping technology and harmless production technology, dissembinate techniques for high standard shelter forest construction and fast growing and high yield plantation cultivation, thus provide technology support for forestry development.④Foster and expand leading enterprises for forest product further processing,

advance forestry localization, industrialization and scale development.

The construction emphasis in the middle arid sandy area: ①Implement returing cultivated land to forests, particularly for the cultivated land with serious sandstorm hazards, construct sand fixation forest mainly formed by *Caragana Korshinskii* Kom. and forage forest that combines shrube with grass.②Implement the project of returing grazing to grass, enclosure and man-made grass planting, develope barn feeding culture, and recover grassland vegetation.③Implement the project of prevention and control of desertification, take the governance mode combined enclosure with afforestation governance, focus on the control of shifting and semi-fixed dunes in the region and sand sources in the edge of desert and farming-pastoral zone.④Strengthen and improve the construction of nature reserves in Baijitan of Lingwu, Habahu of Yanchi and Luoshan. Protect natural forest resources conscientiously, restore and expand forest and grass vegetation in the peripheral area of nature reserves, enhance their ecological functions, such as windbreak and sand fixation, water conservation. ⑤Develope sand industry, and put emphasis on the process and use of psammophyte herbal medicine, *Salix psammophila*, *Caragana Korshinskii* Kom.

(2) 《the Eleventh Five-Year Plan for Ecological Construction and Environment Protection in Ningixa》

The main target of ecological construction in 2010: firmly grasp the national construction of socialist new countryside and the regulation of western development macro-strategy, strengthen the safety of drinking water, rural town-class roads, rural household biogas, the rural public medical, health and education, implement the forth phase of water conservation afforestation, build the ecological economic network in Shiliupan, continue to promote the projects leading strategy with emphasis on the ecological construction projects, such as the 'Three-North Shelter Forest Programme', returning cultivated land to forest, natural forest protection, returning grazing to grasses, etc. By 2010, the forest coverage reachs 18% in the total area, enclosed grassland area increases by 10,000,000 mu, soil erosion control area increase by 5,000 km^2, another five nature reserves (two of them belong to state-class), another ten wetland reserves (four of them

belong to state-class) and another 13wetland parks are built.

Long-range tasks by 2020 are：under the condition of GDP quadrupling, the production and consumption patterns will be fundamentally changed in the ecological environment vulnerable area. The ecological and environmental quality improved remarkablely in the whole region. A number of demonstration areas with the ability of sustainable development, harmony development of society, economy and ecological environment will be fulfilled. Energy construction, industrial structure, industry structure tend to be reasonable, the main pollutant emissions will be controlled within the national total control limits and even reduced, environmental pressures decrease significantly. Legalization system of environmental management is basically established, the abilities of industrial pollution prevention and interagated environmental harness improve significantly. The forest coverage reaches 20% or more, days of urban ambient quality in the whole year meet the national second class standard, treatment rate of domestic sewage reachs 93%, harmless disposal rate of urban garbage will be up to 94%.

(3) 《Overall Plan of Land Use in Ningxia Hui Autonomous Region(1997—2010) 》

Contents related to the project are: ①By 2010, increase new tracts of forest 424,905 hectares, plant 60,000,000 trees all around, increase garden 113,734 hectares, the forest coverage reaches 13.0%. Construct artificial grassland 82,674 hectares, improve grassland 59,399 hectares.②Strengthen land control and environmental protection and try to improve the ecological environment of land. During the planning period, control 4000 km2 soil erosion area, build water and soil conservation forest 2,460,000 ha; govern desertification land 3549 km2, construct windbreak and sand fixationforest 20,130,000 ha, artificial grassland 15,360,000 ha.

(4) 《The Master Plan for the Construction of National Prevention and Control of Desertification Integrated Demonstration Area in Ningxia》

The plan is planning to afforest 7,690,000 mu with a total investment of 11.3 billionYuan through 13 years. The implement areas involved include 16 counties (cities, districts): Yanchi county, Qingtongxia city, Tongxin county, etc. According to the distribution of desertification land in Ningxia, expansion tendency, the control direction and the characteristics of regional ecological environment construction, the demonstration

area is divided into four governing tupes, southwestern fringe of Mu Us Desert, southeastern fringe of Tenggeli Desert, sandy land in central irrigated area and destetificated land in middle arid region. The focal construction task is to build ecological protection and conservation of forest 2,730,000 mu, ecological economic forest 790,000 mu and forest and medicine plants intercropping 1,100,000 mu, closing of hillsides for facilitating afforestation 3,070,000 mu (including 1,800,000 mu area where Tongxin migrants resettled). After the completion of demonstration area, the forest coverage in this region will increase by 13.7 per cent, the shifting dunes in interior irrigated plain will be generally controlled, the trend of ecological deterioration will be curbed in southeastern fringe of Tenggeli Desert, Mu Us Desert and middle arid region. Windbreak forest network surrounding the desertification area will be completed basically, deserticulture make significant progress.

In short, "Prevention and Control of Desertification and Ecological Environment Protection Project in Ningxia"is in accordance with the above regulations, consistent with the above plans.

4 Natural and social environment of the project region

4.1 Natural environment

4.1.1 Geographical position and adminstrative division

The project area consists of seven counties (cities, districts), belonging to three administrative regional cities respectively: Yinchuan city, Wuzhong city and Shizuishan city. Among the seven subproject areas, except Yanchi County, the other six areas are located in the near bank of the Yellow River in mid-north of Ningxia. As to their geographical position, five county-level administrative divisions (Pingluo county, Xingqing district of Yinchuan city, Lingwu city, Yanchi county and Litong district in Wuzhong city) exist in the east bank of the Yellow River, while, two county-level administrative divisions (Qingtongxia city and Zhongwei city) exist in the west bank of the Yellow River. The specific geographical position and administrative division of the seven project areas are shown in Table 4-1. Among the seven counties (cities, districts), 76,000 ha are assigned for the project.

4.1.2 Landforms

Ningxia is located in the boundary between south and north of geomorhopologic forms that is the north area of Zhongwei Mountain-Liupan Mountain-Longmen Mountain-Ailao Mountain belonging to the transitional terrain zone changing from first ladder to second ladder in China. An elevation in the whole area is above 1000m, and the relief decreases in a ladder-like way, higher in the south but lower in the north, the height difference about 1000m. Mountainous regions occur repeatedly，the plains scatter here and there with rolling hills, dunes and sandy land scatterly distributed in the region (Table 4-2).

As for this project area, there are three landform units, diluvial-alluvial plain, Lingyan tableland and Yinchuan plain. Qingtongxia subproject area belongs to Zhongwei Mountain diluvial-alluvial plain, being piedmont sloping plain with slope gradient about 3° and gravel mixed. Five project areas (Pingluo, Xingqing district of Yinchuan, Lingwu village, Yanchi and Litong district of Wuzhong city) belong to Lingyan tableland, with an elevation of 1200-1700m, the relief inclining from east to west, and water resources extreamly

Table4-1 Geographical positions and administrative divisions for each subprogram region

Subproject region	Geographical position	Administrative division
Xingqing district	E 106°15'-106°32', N 38°20'-38°32' Total area:828.3 km^2	Belong to Yinchuan city, being political and economical center of Yinchuan, including two towns (Daxin and Zhangzheng), two villages (Tonggui and Yueyahu), eleven subdistrict offices (Yuhuangge north street, Jiefang west street, Fenghuang north street, Wenhua street, Funing street, Qianjin street, Xinhua street, Zhongshan south street, Shengli street and Yingu street), total 86 resident committees and 32 village committee.
Zhongwei city	E 105°53'-106°36', N 38°26'-38°53' Total area:1527.2 km^2	Contain Shapotou district, Haiyuan county and Zhongning county. In the whole city, including forty towns, twenty nine resident committees and 443 village committees.
Lingwu city	E 106°11'~106°51', N 37°30'~38°38' Total area:4529.0 km^2	Governed by Yinchuan city on behalf of Wuzhong city since 2002, 48 km away fromYinchuan city, including six towns (Chongxing, Haojiaqiao, Dongta, Linhe, Ningdong and Majiatan), two villages (Baitugang and Wutongshu), one subdistrict office, 17 resident committees and 76 village committees.
Pingluo county	E 105°58'-106°30', N 38°36'-39°07' Total area:2648.9 km^2	Belong to Shizuishan city, only designated county in north of Ningxia, including seven towns (Chonggang, Yaofu, Chengguan, Huangquqiao, Baofeng, Touzha and Taole), six villages (Tongfu, Qukou, Gaozhuang, Lingsha, Hongyazi and Gaoren), 21 resident committees and 141 village committees.
Litong district	E 106°03'-106°22', N 37°28'-38°04' Total area:1316 km^2	Belong to Wuzhong city, including eight towns (Jinji, Gaozha, Jinyintan, Biandangou, Gucheng, Jinxing, Shengli and Shangqiao), four villages (Dongtasi, Banqiao, Malianqu and Guojiaqiao), 17 resident committees and 95 village committee, the location of Wuzhongcity government.
Qingtongxia city	E 105°39'-106°21', N 37°36'-38°15' Total area:2337.3 km^2	Belong to Wuzhong city, including eight towns (Shaogang, Yesheng, Qujing, Xiaoba, Chenyuantan, Daba, Qingtongxia and Xiakou), four villages (Wanglejing, Fengjigou, Qingshan and Mahuangshan), 18 resident committees and 108 village committees.
Yanchi county	E 106°03'～107°47', N 37°04'-38°10' Total area:8557.7 km^2	Belong to Wuzhong city, including four towns (Gaoshawo, Huamachi, Huianbao and Dashuikeng), four villages (Wanglejing, Fengjigou, Qingshan and Mahuangshan), 11 resident committees and 98 village committees.

Table 4-2 Main types of landforms in Ningxia

Indicator	Mountainous region	Hilly region	Tableland	Plain	Desert
Acreage(km^2)	8179.4	19678.4	9121.2	13897.4	923.6
Propotion(%)	15.8%	38.0%	17.6%	26.8%	1.8%

Table4-3 General situation of landforms for each subprogram region

Subproject area	Features of landforms
Xingqing district	The western part is mountainous region (Zhongwei Mountain), the central part is plain (Yinchuan Plain), eastern part is semi-desert mountainous land. Average elevation is 1,100m. The plains comprise Alluvial plain of the Yellow River and the alluvial plain in the eastern foot of Zhongwei Mountain, and dune lands are distributed in their transition zone.
Zhongwei city	General trend within the terrain is sloping from southwest to northeast, elevation of 1102-1400 meters, from west to east, there exist six landscape units as follows: Zhongwei mountain, piedmont alluvial fan, the modern Yellow River alluvial plain, alluvial plain lakes, valleys plains, river flood plain.
Lingwu city	Shizuishan-Guyuan fault known as the boundary, Lingwu is divided into two major terrain areas. The western plain is in the southeastern edge of Yinchuan Plain, with the general elevation of 1120 meters. The east is a part of southwestern margin of Ordos plateau, 1300 meters above sea level. The platforms undulate, about 50 meters height difference, while the west is located in north-south mountainous region of Maan Mountain, Yangjiayao Mountain and Mianzi Mountain, etc., the mountains are low and flat, dunes widespread, mainly distributed in the middle-lower reach of Xitian River basin in Ningdong.
Pingluo county	Geomorphological units from west to east include mountainous region of Zhongwei Mountain, piedmont alluvial fan, Xidatan dish depression, the Yellow River alluvial plain and flood plain. The terrain appears southwest high and northeast low, complex and diverse landscape. Zhongwei mountains withstand the cold and wind from Siberia and Mongolia, making it less victims of sandform.
Litong district	Low-lying South than in the north, generally composed of two parts: the southern part, loess hills region confluenced by Niushou Mountain and remaennt Luo Mountain, north and south forms ridge-like long mountain peaks with gentle slope steep; the northern part, the Yellow River alluvial plain area along Qin, Han and the Yellow River drainage.
Qingtongxia city	Terrain is characterized by the distribution ladder of rendering from southwest to northeast from high and low-level, respectively topography include 6 landscape types, mountainous, hilly, gentle hills, alluvial fan zone, the Yellow River alluvial plain and the reservoir. Mountains occupy 70%, 10% water district and irrigation plains account for 20%, commonly known as "70% mountains, 10% waters and 20% fields".
Yanchi county	Located in the transition zone of Ordos platform and the Loess Plateau, the terrain is high in the south than the north, with an average elevation of 1,600 m. The south is hilly region with rolling hills, ravines crisscrossing, forming spaced in-between unique landscapes of hills, beam, hilly, ditch and side. The north is gentle hilly area of Ordos, where the terrain is gently undulating, composed of the high erosed hills, gentle hills, sand dune plains, lakes and other landscape units.

deficient. Soil texture is sandy, main types of dunes include Reticulate dune, barchan chain, tiled sandy land, ixed sandy land. Zhongwei project area belongs to Yinchuan plain, the landforms is Yellow River alluvial plain，terrain is flat, inclining from southwest to northeast，slope decreasing about 1/4000. The plain are crisscrossed by irrigation canals and ditches, there are a lot of lakes, and the land is fertile. The landforms of different counties (cities, districts) in the project area see Table 4-3.

4.1.3 Climate

Ningxia is located in deep interior of the plateau and belongs to a typical continental climate (continentality 52~68). Since controlled by Mongolia high pressure in winter and as the major crossroad of freezing air flowing southward and the end of southeast monsoon in summer, Ningxia forms a typically continental climate. The basic features of the climate are： winter is long and cold, summer is hot and short, the spring becomes warm quickly, and the autumn becomes cold early; drought and little rain, and strong vaporization, dry climate, heavy wind and much sand, sufficient sunshine, big temperature difference between day and night, the north cold and south warm, etc. The temperature increases from south to north, while, the precipitation declines from south to north. The climate in Ningxia can be divided into three areas of regional climate: the southern part of Guyuan is the temperate zone semi-humid region, the area of northern of Guyuan to Yanchi and Tongxin is in the semi-arid region of temperate zone, and Ningxia Plains is in arid region of temperate zone.

In the region, if the north fringe of Mahuangshan-Qinglong Mountain, south of Luoshan-Liwang-Guanqiao-Yahnchi is regarded as the dividing line, climatic resources differd markedly between south and north. The middle and north of Ningixa, located in the north of the dividing line, with rich sun energy, medium heat and rare precipitation, belongs to arid district of temperate zones, where no agriculture exists if without irrigation. Major climatic resource indicators are: annual total solar radiation 5,711 ~6,096 MJ/m2, annual hours of sunshine about 3000 h, average annual air temperature 8-9 ℃, >0℃ accumulative temperature about 3700 ℃, >6℃ accumulative temperature about 3500 ℃, >10℃ accumulative temperature 3200~3700 ℃, the average frost-free 150~195 d, average annual precipitation less than 300 mm, annual aridity degree> 3. The south of Ningixa, located in the south of the dividing line, with a little rich precipitation and insufficient heat, belongs to semi-arid region and semi-humid region of temperate zone, where dryland farming preponderate. Major climatic resource indicators are: annual total solar radiation 4,932 ~5,661 MJ/m^2, annual hours of sunshine 2200-2700 h, average annual air temperature 4-7 ℃, >0℃ accumulative temperature 2550-3100 ℃, >5℃ accumulative temperature 2450-2900 ℃, >10℃ accumulative temperature 1900-2400 ℃, the average frost-free 127~155 d, average annual precipitation 300-677 mm, annual aridity degree 1- 3.

Tabe 4-4 Climatological characteristics for each subprogram region

Subproject area	Drought index	climatic region	1 (℃)	2 (℃)	3 (℃)	4 (℃)	5 (℃)	6 (mm)	7 (mm)	8 (m/s)
Xingqing	3.06	Arid area	8.5	32.4	39.3	-30.2	3330.3	202.8	1583.2	1.8
Zhongwei	3.15	Arid area	8.3	32.4	36.2	-27.7	3265.0	193.1	1747.1	2.4
Lingwu	2.99	Arid area	8.9	31.7	41.4	-28.0	3362.6	212.1	1928.3	2.6
Pingluo	3.24	Arid area	8.2	32.4	37.9	-28.4	3241.6	183.6	1758.8	2.0
Litong	3.19	Arid area	8.8	30.4	36.9	-24.2	3257.7	193.3	2013.7	2.7
Qingtongxia	3.32	Arid area	8.8	30.5	36.7	-23.7	3258.3	185.4	2085.9	2.9
Yanchi	1.78	Semi-arid area	7.7	31.2	38.1	-29.6	2944.9	296.5	2131.7	2.8

*** Note: 1-** Average annual temperature; 2- Temperature annual range; 3- extreme maximum temperature; 4-extreme minimum temperature; 5-Accumulated Temperature; 6- precipitation; 7-amount of evaporation; 8-Average wind speed.

Tabe 4-5 Main meteorological data of the project area in 2008

Subproject area	Air temperature(℃)			Precipitation	Hours of sunshine	Wind speed(m/s)	
	Mean	Max	Min	(mm)	(h)	Mean	Max
Xingqing district	9.9	16.4	4.2	194.6	2824.2	1.8	11.0
Zhongwei city	9.1	16.4	3.0	194.2	2736.6	1.5	12.2
Lingwu city	9.1	16.8	2.2	205.4	2835.0	2.4	13.3
Pingluo county	9.9	16.6	4.1	212.5	2950.5	1.8	13.2
Litong district	10.3	17.0	4.8	186.2	2820.7	2.0	12.9
Qingtongxia city	9.5	16.7	3.4	185.8	2941.8	2.1	13.4
Yanchi county	7.8	15.5	1.0	266.7	2760.2	2.2	14.1

Table 4-6 Monthly precipitation distribution in the project area in 2008 (unit: mm)

Subproject area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall year
Xingqing district	8.1	1.1		16.3	0.2	2.3	79.4	35.8	44.1	7.3			194.6
Zhongwei city	8.0	0.9	0.1	15.9	0.4	6.6	73.6	34.6	40.6	13.5			194.2
Lingwu city	7.6	2.3	0.2	20.3	0.3	4.5	55	45.8	57.4	11.9	0.1		205.4
Pingluo county	7.5	0.9	0.2	10.3	1.3	4.0	90.1	56.3	35.6	6.3			212.5
Litong district	6.0	1.8	0.5	13.4	0.1	3.1	45.6	45.9	62.4	7.4			186.2
Qingtongxia city	5.8	2.3		14.3	0.3	1.9	52.8	42.3	56.5	9.6			185.8
Yanchi county	7.6	5.8	4.2	10.1	1.5	0.4	27.4	107.8	93	6	1.4	1.5	266.7

Referred to the project area, the climatic and meteorological characteristics in different counties (cities, districts) are shown in Table 4-4, Table 4-5 and Table 4-6. Natural calamity includes gale, sandstorm, dry hot wind, hail, frost and low temperature and chilling injury.

4.1.4 Soil

Although the land area of Ningxia is not large, the land types and distribution appear complexity and diversity, characterized by small areas of plain and large area of mountains snd hills. Mountainous area in Ningxia is 12.269 million mu which accounts for 15.79% of the total area, mainly distributed in Zhongwei Mountain, Xiang Mountain, Luo Mountain, Niushou Mountain, Liupan Mountain and so on; the area of hills is 29.518 million mu, accounting for 38%, mainly distributed in Guyuan city, south of Wuzhong city and southeast of Zhongwei city; the area of plain is 20.846 million mu, accounting for 26.8% of the total area, mainly distributed in the central and north of Ningxia including Yinchuan plain, Weining plain and Qingshui river valley plain and Weizhou plain; the rest land is tableland and desert.

The soil of Ningxia includes 10 soil orderes, 17 soil classes, 37 subgroups, 75 soil generas. The soils with area above 1,000,000 hectare contain 11 classes, dark loessial soils, sierozems, cultivated loessial soils, alluvial soils, aeolian soils, skeleton soil, fluvo-aquic soils, solonchak, irrigation-silting soils, grey-cinnamon soils and desert soil.

Except the 3 classes, cultivated loessial soils, skeleton soil and grey cinnamon soil, the rest soil types all exist in the project area, such as follows：

① Dark loessial soils. The area is 0.3278 million hectares, distributed in 7 counties including Haiyuan, Xiji, Guyuan, Pengyang, Tongxin, Yanchi and Longde. Except that the content of rapidly-available phosphorus is low, the contents of organic matter and other nutrients of soil are relatively high, with block structure, strong capacity of fertility maintaining, very low total salt concentrations and serious soil erosion.

② Sierozems. The area is 1.3181 million hectares, distributed in three counties (Yanchi, Tongxin and Haiyuan) and the mountainous reagions of 12 counties in the Yellow River irrigation area and the eastern foot of Zhongwei Mountain. Sierozem is divided into 4 subgroups, sierozems, light sierozem, meadow sierozem and salinized sierozem. Sierozem is characterized by big grittiness, little soil water stable aggregate, low fertility, low retention capacity of water and fertility and being very liable to wind erosion.

③ Alluvial soils. The area is 0.3708 million hectares, distributed in the low land between hills, high terraces in east of Zhongwei Mountain and banks of river. Alluvial soil

is divided into 2 subgroups that are Fluvents and alluvial soil. Using alluvium, diluvium and colluvium recently accumulated or artificially heaped contents as the soil parent materials, alluvial soil endergoes litter or no biological function and has no obvious developmental characteristics.

④ Aeolian soils. The area is 0.5978 millon hectares, distributed in Lingwu, Taole, Yanchi, Zhongwei and other counties. Aeolian soil has no obvious soil genesis, discrete particles loose, no structure, the contents of organic matter and other available nutrients of soil are very low except relatively high content of potassium, and the wind erosion is extreamly easy to happen.Aeolian soil is divided into 4 forms that are shifting dune, semi-fixed dune, fixed dune and cover sand land .

⑤ Fluvo-aquic soils. The Area is 0.1311 million hectares, mainly distributed in the flood land, low land and the margin of low-lying lacustrine beach where have flowing rivers, such as the Yellow River irrigated area, Qingshui river and Hulu river. The content of soil organic matter is low, but the content of available K is relatively high. Fluvo-aquic soil is divided into 5 subgroups that are fluvo-aquic soils, Gleyic cambi soils, salinization fluvo-aquic soils, table rust fluvo-aquic soils and cumulated irrigated fluvo-aquic soils.

⑥ Solonchaks. The area is 0.137 million hectares, except 3 counties (Jingyuan, Pengyang, Longde), solonchak is distributed unevenly in the rest counties or cities. Since solonchak is formed in the region with high underground water table, the average content of salt in surface soil is up to 5.36% and only halophytes or salt tolerant plants can grow. Solonchak is divided into 3 subgroups that are meadow solonchaks, bog solonchaks and relict saline soil.

⑦ Irrigation-silting soils. The area is 278.9 thousand hectares, concentrately distributed in the 12 counties, cities or suburbs in the Yellow River irrigated area in north of Ningxia. The irrigation-silting soil is mainly characterized by having a certain thickness irrigation-silting plough horizon, good physical and chemical properties and high soil fertility. Irrigation-silting soil is divided into 4 subgroups: irrigation-silting soil, aquic irrigation-waping soil, surface-rust irrigation-warping soil and saline irrigation-silting soil.

⑧ Desert soils. Desert soil comprises 3 soil groups：gray desery soils，gray-brown desrt soils and brown desert soils. Gray desery soils is developed in the desert margin of

temperate zone, distributed in the juncture plateau region between north of the Tengery desert and Inner Mongolia, also a little area of desert soil exists in Pingluo county. The gray desert soil is characterized by low content of organic matter, common salinization and pH value usually more than 8. Gray desery soils is divided into 4 subgroups: gray desery soils, calcareous gray desert soils, meadow gray desert soils and salinization gray desert soils.

The most important soil in this project area is aeolian soils, secondly sierozems, thirdly gray desery soils and cumulated irrigated soils. Among them, the cumulated

Table 4-7 Soil types and distribution in this project area

Project area	**Soil types**
Xingqing district	Main soil types: Cumulated irrigated soils, Sierozems, Fluvo-aquic soils, Aeolian soils, solonchaks, Grey-cinnamon soils, etc..
Zhongwei city	Cumulated irrigated soils account for 37.6%, Sierozems 21.8%, solonchaks 15.9%, Fluvo-aquic soils 13.3%, Aeolian soils 7.0%，Fluvo-aquic soils 3.3%， Albic soils 1.1%.
Lingwu city	Cumulated irrigated soil is the main type of soil in irrigation region, accounting for 70.0%, the main soil types in east of mountain region are Sierozems and Aeolian soils, accounting for 51% and 20.7% of the total area of mountain region, respectively.
Pingluo county	Main types: Sierozems, Cumulated irrigated soils, Meadow soils, solonchaks, Solonetzs, Fluvo-aquic soils, Grey-cinnamon soils,Gray desery soils, etc..
Litong district	Soil types: Sierozems, Cumulated irrigated soils, Fluvo-aquic soils, Aeolian soils, solonchaks, etc..
Qingtongxia city	The contents of nutrients of cumulated irrigated soils in irrigation region are: hydrolysable nitrogen is 61.1mg/kg, Olsen-P is 17.2mg/kg, average available K content is124.3mg/kg. Sierozems soil is the mian type of the natural soil.
Yanchi county	Aeolian soils account for 36.3%, Sierozems 37.3%, Dark loessial soils 17.7%， Alluvial soils, solonchaks and the others 2.5%.

Table4-8 Macroelements in mian soil tpyes of the project area

Soil types	Organic matter(%)	Total content(%)			Effective part(%)		
		N	P	K	N*	P	K
Dark loessial soils	1.81	0.11	0.12	1.81	74.2	6.4	138
Sierozems	0.78	0.05	0.05	1.90	33.6	5.5	146
Gray desery soils	0.62	0.04	0.06	1.58	27.6	3.8	167
Alluvial soils	1.06	0.07	0.06	1.97	34.3	8.1	192
Aeolian soils	0.35	0.01	0.05	2.02	20.8	4.4	95.4
Skeletol soils	2.54	0.15	0.19		81.1	4.0	92.4
Cumulated irrigated soils	1.19	0.08	0.07	1.79	20.0	16.3	239

* alkali-hydrolyzed nitrogen

Table4-9 Microelements in mian soil tpyes of the project area

Soil types	Organic matter	Total contents(ppm)						Available parts(ppm)					
	(%)	Zn	Mn	Cu	Fe%	B	Mo	Zn	Mn	Cu	Fe%	B	Mo
Dark loessial soils	1.81	63.8	5.7	23	2.57	67.6	0.89	0.22	3.38	0.68	3.66	0.74	0.09
Sierozems	0.78	56.4	453	21.3	2.47	61.2	0.83	0.25	4.62	0.72	5.56	0.69	0.08
Gray desery soils	0.62												
Alluvial soils	1.06	655	500	24.5	2.64	78.0	0.97	0.30	5.66	1.36	9.06	1.11	0.21
Aeolian soils	0.35	37.5	284	12.8	1.73	46.9	0.47	0.07	2.75	0.47	4.69	1.03	0.04
Skeletol soils	2.54												
Cumulated irrigated soils	1.19	66.7	529	26.7	3.08			0.64	10.2	2.41	3.79	1.33	0.12

irrigated soils is gradually anthropogenic mellowing and developed from farmland soil in Yinchuan plain through many years' reclaiming, cultivating, warping and fertilizing, etc. The soil types and distribution and characteristics of soil nutrients in this project are shown in Table 4-7, Table 4-8 and 4-9, respectively.

4.1.5 Water resources and water quality conditions

4.1.5.1 Surface water resources and quality

(1) Surface water resources

The water resource of Ningxia is least among the prinvinces of China, characterized by little amount of surface water resources, uneven spatial distribution, great change with time. Average annual runoff of surface water is 9.71×10^8 m^3 (the Yellow River transiting water amount not included), only being 0.03% of the whole country. Annual water output per square kilometer is 1,870,000 m^3, only 6% of the national average level. From both total amount of surface water resource and average amount per arable land or per capita, Ningxia is one of the least provinces in China.

The Yellow River is the main river in the project area. Monitoring sections of state control and province control see Figure 4-1. The Yellow River enters from Nanchangtan of Zhongwei city, then turns flow direction from east-west to north-south, winds its way to Weining plain and Yinchuan plain, and flows out from Toudaogang Beimahuanggou of Shizuishan. The whole distance of the flow water is 397km, 7.3% of the Yellow River total length. According to observations, the average annual volume entered is 317×10^8 m^3, while, the volume of transregional water is 294 m^3. According to the information of Qingtongxia hydrological station, the annual average maximum flood peak is 3640 m^3/s, the observed

value is 6230 m^3/s; before the conctruction of Qingtongxia reservoir, annual average of sediment concentration is 6.97 kg/m^3, sand transport up to 2.37×10^8 tons, while after the construction, annual average sediment concentration is 3.14 kg/m^3, sand transport only 0.98×10^8 tons, average mineralized degree 0.4g/L.

Figure 4-1 Monitoring sections of state control and province control for water position and water quality of Yellow River within NIngxia

As far as the Yellow River basin in Ningxia, among all the Yellow River and its different tributaries, 102 tributaries have the basin area bigger than 100 km^2, 27 bigger than 500 km^2, 14 bigger than 1000 km^2, only two, the Yellow River and Qingshui River, have the basin area more than 10,000 km^2. Qingshui River, Zuli River and Kushui River flow northwards into the yellow river, with the characteristics, such as much water volume, relatively low mineralized degree, less mud and sand, and a little change of runoff, etc. In

the Heishanxia –Qingqongxia section of the Yellow River, the fall is big and water resources are rich; in the yellow river branches, only water of Jing River is relatively plenty, with relatively rich water resources.

Although there are rare surface water resources in Ningixa, there is the superiority of the Yellow River diversion (annual transiting runoff 317×10^8 m^3), with annual available water 4 billion m^3, which provide the most important support for the socioeconomic sustainable development and ecological construction, thus basically ensuring Ningxia has been one of the national 12 commercial grain production bases.

In fact, the Yellow River is the only effective surface water resource among the surface rivers in project area.

(2) Surface water quality

①the main Yellow River

The monitoring data from the Xiaheyan monitoring station in the entering secton of the Yellow River indicated that the water quality of all the year round was good and belonged to class Ⅱ~Ⅲ. The monitoring data from the Shizuishan monitoring station in the secton of the Yellow River flowing out indicated that the water quality of all the year round belonged to class Ⅲ~Ⅳ, the water quality in the high flow period is superior to that in the low flow period.The water pollution in the left bank of Ningxia section of the Yllow River was heavier than that in the right and ammonia nitrogen and chemical oxygen demand are the main pollutants.

②Drainage ditches in Ningxia Yellow River irrigation region

The third ditch in the Yellow River irrigation region, Yinxin ditch, Zhonggan ditch, Jinnan trunk drainage ditch, East ditch, Qingshui ditch and the fourth ditch in Zhongwei, undertake the drainage of farmland, also accept the industrial waste water, residents domestic sewage and agricultural non-point source sewage water which finally flowed into the Yellow River. The sewage flowed into the ditches resulted in the water pollution of ditches, and the water quality was inferior class Ⅴ, very serious pollution. Basically, the other ditches mainly accept the agricultural irrigation return flow and little sewage, and among the main chemical indexes, sulphate, chloride and mineralized degree exceed the water quality standard, mianly due to the relatively their high natural water chemical

indexes.The water quality of severely polluted ditches is obviously better in irrigation periods than that in the period without irrigation.

4.1.5.2 Groundwater resources and quality

(1) Groundwater resources

The geological structure of Ningxia is complex with many kinds of topography, the climate is drought, the Yellow River flows over north of the plains, the geological condition is complicated, which forms the three notable characteristics of the groundwater resources.

First, regional distribution imbalance, total groundwater resources about 31.95×10^8 m^3/a, amount of groundwater mining about 24.41×10^8 m^3/a, about 82.9% of the total amount and 92.3% of the amount of groundwater mining are mainly distributed in the north area of Ningxia plains that covers less than a quarter of the total area, while, only 17.1% of the total amount and 7.7% of the amount of groundwater mining are distributed in the large middle and southern hillside regions of Ningxia.

Secondly, the water quality is worse and change greatly. The water is high mineralized, and high-fluorine groundwater is widely distributed, wtith the mineralized degree of 14.9% of the total groundwater > 3g/L, covering Qingshui River basin and the Yellow River irrigation region. High-fluorine groundwater is widely distributed in three counties (cities), Yanchi, Lingwu and Tongxin, and Hilly and Gully Region of Loess Plateau, hundreds of thousands of people are injured by fluorine.

Third, there is a close transfer relationship between the groundwater and surface water. The shallow groundwater in the Yellow River irrigation region rely mainly on the supply of the Yellow River irrigation channel and field leakage, the average groundwater recharge modulus in Yinchuan plain is more than 300,000 tons km^2/a, the groundwater varies with the irrigation period. The Yellow River water and the groundwater form a unified and balanced circulaton system.

According to the characteristics of water-bearing media and storage conditions, the groundwater in Ningxia can be divided into four types: loose rocks type hole water, carbonate type crevice limestone cave water, clastic rocks type hole water and bedrock type crevice waterporous water.

The first type, loose rocks type hole water, is the main types of groundwater in Ningxia, characterized by continuous water-bearing media, wide distribution, low buried depth and convenient mining, and mainly distributed in Yinchuan plain and Weining plain. The section of Pangbao-Sanying in the upper reaches of Qingshuihe valley, Hulu river valley, the puluvial fan in northern foot of of Nanhua Mountain, Xianzhou senke, Xingren plain, Hongcheng senke in eastern foot of Luo Mountain and Shuishang aulacogen, are freshwater concentrated areas in widespread salty bitter water areas, with important value of development and utilization. The loose accumulation in Yinchuan plain and Weining plain is very thick and has sufficient supply from the channels of Yellow River irrigation region and field leakage. The groundwater resources are rich, up to 2,230,000 m^3 and 2,550,000 m^3 per square kilometers

The second type, carbonate type crevice limestone cave water, is mainly distributed in the middle of Zhongwei Mountaion and around the area of Qinglong Mountain-Goukou of Yuanzhou district(in geology, usually named the region of "the Archaic Lithosphere Upheaval") . The rate of flow of Taiyang Spring in north of Qinglong Mountain is 6,000,000L/d，propablely implying that there is considerable fracture-karst water resources in the region of the Archaic Lithosphere Upheaval.

The third type, clastic rocks type hole water, is generally distributed in the artesian basins formed in the Tertiary or Cretaceous. The interlayer crevice and pore water in the Tertiary basins generally belongs to moderately water-rich or water-poor, with high minerialized degree, only in the margins of the basins, the fresh water or slight saline water is rich and significant in water supply. The artesian basins of Cretaceous are dirtributed in Yanchi county and east of the region of the Archaic Lithosphere Upheaval, located in the western edge of Shan-Gan-Ning-Meng artesian basins of Cretaceous. The depth is less than 500m in Yanchi county, the water yield of well in most drillholes is 100-500,000L/d，mainly micro-saline water; in the eastern area of the Archaic Lithosphere Upheaval, the water yield of well is more than 200,000L/d, the fresh water and micro-saline water are the main parts; the water resource in local area is rich and the water quality is good, such as near the Pengyang county city, The satatic water level of artesian water borehole is 8.94 above the surface of the earth, with the rate of flow up to 2,302,000/d and the mineralized degree

<1g/L.

The fourth type, bedrock type crevice waterporous water, is scatterly distributed in hill bed rock fracture, generally the water yield property is weak, and the water quality is good. In artesian basins of Cretaceousnorth in slope of Yueliang Mountain and Mountains group, the water yield of well is 100-1,000,000 L/d, being freshwater and micro-saline water.

Table 4-10 Natural groundwater resources and the amount of groundwater mining in the project area

Underground water system division		Total caculated area km^2	Total amount of groundwater $10^8m^3/a$	Amount of groundwater mining $10^8m^3/a$
Region	Subregion			
Yinchuan plain underground water system	Western plain of the Yellow River underground water subsystem	5589.97	17.0660	13.5008
	Eastern plain of the Yellow River underground water subsystem	855.36	3.8225	3.3700
	Huabu Mountain tableland underground water subsystem	614.21	0.1914	0.0101
	Shizui Mountain tableland underground water subsystem	235.46	0.1015	0.0507
	Sub-total	7295.0	21.1814	16.9316
Taolingyan tableland ground water system	Eastern wavy terrace underground water subsystem	6040.92	0.3899	0.2880
	Western low hilly land underground water subsystem	2575.39	0.0564	
	Taole high terrace underground water subsystem	624.55	0.0121	
	Sub-total	9240.86	0.4584	0.2880
Ningzhong hills and intermontance plain underground water system	Beishan of Weining underground water subsystem	1326.83	0.0210	
	Weining Plain underground water subsystem	794.13	4.3166	4.0301
	Niushou Mountain-Luo Mountain-Qinglong Mountain underground water subsystem	3609.14	0.1517	0.1794
	Xiang Mountain underground water subsystem	4324.93	0.4292	0.0461
	Sub-total	10055.03	4.9185	4.2556

The groundwater is divided into seven hydrologic geology areas, they are Zhongwei Mountain hydrologic geology area, Yinchuan plain hydrologic geology area, Taolingyan

tableland hydrologic geology area, Ningzhong hills and intermountain plain hydrologic geology area, north margin of Tenggeli Desert hydrologic geology area, loess hill in south of Ningxia hydrologic geology area, hills in south of Ningxia hydrologic geology area.

The groundwater of the project area mainly belongs to Yinchuan plain hydrologic geology area and Taolingyan tableland hydrologic geology area. The groundwater belongs to loose rocks type hole water and bedrock type crevice waterporous water, which is shown in Table 4-10 in detail.

(2) Groundwater quality

The buried depth of shallow undergroundwater in the Yellower River irrigation area of the project area is not deep and the mineralized degree is high, which varies with the irrigation. In the project area of Taolingyan tableland, the mineralized degree of most shallow undergroundwater is mora than 3g/L, with bad water quality; a little part of the undergroundwater quality is good, and the supply water quality conforms to the standard 《Standards for Drinking Water Quality》(GB5749-2005).

4.2 Ecological environment

4.2.1 Components of flora and characteristics of community

4.2.1.1 Components of flora

The constituent of natural vegetation flora is simple and poverty in Ningxia. Seed plants of Ningxia have 1811 species in 119 families of 593 genus, (including cultivated vegetation), only account for 39.5%, 72.73% and 19.9% of families, genus and species of the seed plants, respectively. The average species per family or genus is far below the national average. The proportions of monotypic genus and monotypic family of the total number of genus and families are 49.4% and 26.5%, respectively. Except 63 genus being worldwide element, the temperate parts account for 81.9% of the other seed plants genus, and the northern temperate genus 37.5%. Among 120 or more kinds of the main constructive and dominant plants, the temperate parts account for 79.4%, with north temperate parts of 49.6%. The most plant species in the vegetation of Ningxia are characterized by remarkable xeromorphism and of ecological biology.

Main plants in the project area include *Ammopiptanthus mongolicus, Oxytropis*

aciphylla, *Caragana stenophylla*, *Reaumuria soongonica*, *Ziziphus jujuba var.spinosa* (Bunge)Hu, *Nitraria tangutorum*, *Tamarix chinensis*, *Cynanchum komarovii*, *Glycyrrhiza uralensis*, *Artemisia sphaerocephala*, *Agriophyllum squarrosum* (Linn.) Moq, *Achnatherum splendens*, *Zygophyllum xanthoxylum*, *Stipa plareosa* P. Smirn, Lespedezadavurica(Laxm.)Schindl., *Artemisia ordosica*, *Agropyron cristatum*, *Artemisia halodendron* Turcz, *Xanthium sibiricum*, *Setaira viridis*(L.)Beauv, *Agropyron mongolicum* Keng, *Psammochloa villosa*, *Pennisetum centrasiaticum* Tzvel., etc. Cultural plants mainly consist of field cereal and oil crops, particuliar grain crops, while, little man-made forest, orchard farm, vegetables and artificial grassland are dispersely distributed, main crops including wheat, *Panicum miliaceum* L.,potato, *Sesamum indicum*, rice, corn, *Helianthus annuus*, etc.

Flora in the project area mainly consists of temperate types, but a few types of other ingredients play an important role in the construction of community. Among these, old continental temperate types include *Hippophae rhamnoides*, *Leymus secalinus* (Georgi) Tzvel, *Achnatherum splendens*, *Cleistogenes* Keng, *Melilotus officinalis* (Linn.) Pall, *Serratulacentauroides* L, *Atraphaxis manshurica*, etc. The Asia Temperate Zone types have *Caragana sinica*, *Axyris amaranthoides*, *Gueldenstaedtia verna* (Georgi) Boriss, *Swainsonia salsula*, etc; Mediterranean, East Asia-Central Asia types have *Kalidium foliatum* (Pall.) Moq, *Calligonum mongolicum*, *Reaumuria soongonica*, *Zygophyllum xanthoxylum*, *Nitraria tangutorum*,*Erodium stephanianum* Willd, *Resina ferulae*, *Glycyrrhiza uralensis*, *Bassia dasyphylla*, *Peganum nigellastrum* Bunge, etc; central Asia types include *Agriophyllum squarrosum*, *Sympegma regelii* Bunge, *Ammopiptanthus mongolicus*, *Artemisia sphaerocephala* krasch, etc; Cosmopolitan types have *Plantago asiatica* L, *Xanthium sibiricum*, *Carex tristachya*, *Phragmites australis*, *Suaeda heteroptera* Kitog, *Typha orientalis* Presl, *Cyperusrotundus* L, etc.

4.2.1.2 Features of plant community

The project area goes across two natural vegetation zone, desert steppe vegetation and semi-desert steppe vegetation, where there are many intrazonal meadow vegetation and marsh vegetation (Table 4-11).

(1) Desert steppe vegetation zone

Desert steppe vegetation zone mainly exists in Yanchi subproject area. The average

Table 4-11 Types and characteristics of main natural vegetation in the project area

Vegetation type group	Vegetation type	Vegetation subtype	Formation group	Formation	Main characters and distribution
shrub	Deciduous shrub	sandy land thermophilic deciduous shrub		*Caragana davazamcii Sancz* shrubs *Salix psammophila* shrubs	Under the extream conditions, such as saline land and sandy land, the shrub community usually shows the characters of steppe or meadow.
		saline land diving deciduous shrub	saline land deciduous shrub	*Nitraria tangutorum* Bobr. shrubs *Tamarix ramosissima Ledeb* shrubs	
			saline landDeciduous dwarf shrub	*Halocnermum strobilaceum* (Pall.) Bieb shrubs	
meadow	meadow	flood plain thermophilic mesophytic meadow	rhizomatous grasses mesophytic meadow	*Calamagrostis pseudophragmites* Koel meadow *Leymus secalinus* (Georgi) Tzvel.meadow	Flood plain meadow and otherlow-lying meadows, mainly distributed in the northern flood plain of Yellow River in north of Ningxia and low-lying uncultivated land or wasteland in Qingtongxia irrigation areas. At the sections with high underground water table and serious salinization soil, lowland swamp meadow and Saline meadow develope.
			mesophytic forbs meadow	*Melilotus dentata* Pers. meadow	
			Annual grasses meadow	*Echinochloa crus-galli* var. mitis L. meadow	
		lowland Saline meadow	High tufted herbs meadow	*Achnatherum splendens* meadow	
			Annual grasses salt meadow	*Suaeda corniculata* meadow	
			mesophytic forbs meadow	*Kareliniacaspia* (Pall.) Less meadow *Ixeris chinensis* (Thunb.) Nakai meadow	
			rhizomatous grasses meadow	*Phragmites australis* (Cav.) Trin.ex Steud meadow	
		lowland swamp meadow		*Carex heterostachya Heterostachys* Sedge + *Halerpestes ruthenica* (Jacq .) Ovczmeadow	
				Eleocharis valleculosa Ohwi meadow	
Steppe and psammophytic vegetation in steppe zone	steppe	Desert steppe	Dwarf shrub desert steppe	*Oxytropis aciphylla* steppe	Ningxia steppe vegetation is mainly composed of dry steppe and desert steppe, and tends to change from steppe to desert.
			Dwarf semi-shrub desert steppe	*Convolvulus tragacanthoides* Turcz steppe, *Ajania achilloides* steppe, *Lespedeza potaninii* Vass steppe	
			xerophytic forb desert steppe	*Iris bungei maxim* steppe *Allium polyrhizum* Turcz.ex Regel steppe	
			Dwarf shrub, semi-shrub desert steppe	*Caragana tibetica* + *Artemisia sacrorum* Ledeb steppe	
	psammophytic vegetation in steppe zone	Semi-shrub psammophytic vegetation		*Artemisia ordosica* community *Periploca sepiumBge* community *Artemisia sphaerocephala* Kraschen community	The psammophytic vegetation in Ningxia steppe vegetation zone is mainly distributed in the large scale

		Dwarf semi-shrub psammophytic vegetation		*Cynanchum komarovii* Al community	sandy land areas in Yanchi, Lingwu and Taole of central or south of Ningxia, scattered in local sites among farmlands in the Yellow River irrigation, belonging to desert steppe vegetation zone.
		Mesoxerophytic forbs psammophytic vegetation		*Radix Glycyrrhizae* community *Sophora alopecuroides* community	
		rhizomatous grasses psammophytic vegetation		*Pennisetum centrasiaticum* Tzvel community *Agropyron mongolicum* Keng community	
		Annual herbs psammophytic vegetation		*Agriophyllum squarrosum* community *Salsola ruthenica* Iljin community	
desert	desert	super-xerophytic dwarf shrub, dwarf semishrub desert	super-xerophytic dwarf shrub desert	*Reaumuria soongonica* desert, *Oxytropis aciphylla+Polygonaceae Atraphaxis pungens* desert, *Oxytropis aciphylla+Reaumuria soongonica* desert, *Caragana tibetica* desert	Ningxia desert is distributed in the northern margin neighbored with western desert of China, located in the transitional zone from steppe to desert. The average annual rainfall is about 200mm and the soil type is light sierozem. The landforms include stony low-lying hills, proluvial fan and beach, with gravels on the soil surface.
			super-xerophytic dwarf semishrub desert	*Salsola passerine* desert, *Sympegma regelii Bunge* desert	
		super-xerophytic shrub desert	Deciduous shrub desert	*Salsola arbuscula* desert *Caragana Korshinskii* Kom desert	
			Evergreen shrub desert	*Ammopiptanthus mongolicus* desert	
		Super-xerophytic forb desert		*Peganumnigellastrum* Bge desert	
Swamp and aquatic vegetation	Swamp	Herbs marsh	rhizomatous grasses marsh vegetation	*Phragmites australis* marsh	The main constructive species of marsh vegetation are perennial helophytes, such as *Phragmites australis*, *Scirpus tabernaemontani*, *Scirpus planiculmis* Fr.Schmidt, *Typha angustifolia.T*he plant community grows luxuriantly with high productivity.
			Cyperaceae marsh vegetation	*Scirpus tabernaemontani* marsh *Scirpus planiculmis* Fr.Schmidt marsh	
			Forbs marsh	*Typha angustifolia* marsh	
	aquatic vegetation	submersed vegetation		*cedar moss+Myriophyllumspicata* community *Potamogeton pectinatus* community	
		floating vegetation		*Nymphoides peltatum shield hoatingheart* community, *Potamogeton malaianus* community, *Potamogeton perfoliatus* community	
		Emergent vegetation		*Sagittarias trifolia* var.angustifolia Kitag. community	

annual rainfall in the distribution area is 200-300 mm and the main soil is light grey desert soil. The plant community is mainly composed of perennial grasses, such as *Stipa breviflora, Stipa glareosa, Gramineae synusium, Cleistogenes gracilis, Cleistogenes squarrosa* (Trin.) Keng, *Leymus secalinus* (Georgi) Tzvel, *Pennisetum centrasiaticum* Tzvel. Due to the arid climate and greatly changed interannual rainfall, the abundance proportion of perennial small grasses in the community changes largely, and sometimes being sub-dominant place in the community.

(2)Semi-desert vegetation zone

Except Yahnchi, the other seven subproject areas all belong to this zone. The distribution area is located in the northwest margin of Ningxia, mostly connected with the eastern margin of temperate desert in Alashan Zuoqi of Inner Mongolia. The annual precipitation in the distribution area is below 200 mm, the main soil type is light sierozem, the plant community is mainly composed of the constructive species, such as *Reaumuria soongonica, Salsola passerine, Oxytropis aciphylla* and other super-xerophytic dwarf shrubs and dwarf semi-shrubs, characterized by having synusia of many steppe plants, such as *Stipa breviflora, Stipa gobica*, *Convolvulus tragacanthoides* Turcz, *Ajania achilloides, Artemisia frigida, Cleistogenes gracilis, Gramineae synusium*.

(3)Intrazonal plant community

In a locally specific ecosystem, some hygrophytic or salt-tolerant communities appear with a mosaic distribution, which belong to azonal intrazonal community. Most of them are distributed in local sites with low relief, usually the area is small and scattered among the whole vegetations in the Yellow River irrigation areas, especially concentrated in Yinbei, become spots of the natural plant communities in large agricultural areas. The compositions of plant species and community structure differ from those of natural plant communities at the same horizontal belts.

4.2.1.3 Characters of steppe vegetation

The area of psammophytic vegetation in Ningxia steppe vegetation zone is about 543.9 thousand hectares, accounting for 17.8% of the total area of natural vegetation, mainly distributed in the large scale sandy land areas (the project area) in Yanchi, Lingwu and Taole of central or south of Ningxia, scattered in local sites among farmlands in the Yellow River

irrigation. The plant community of steppe mainly consists of constructive species with different life forms, such as semishrub, dwarf semishrub, xerophytic and mesophytic forbs, rhizomatous grasses and xerophytic forbs, among which semi-shrub Artemisia ordosica community is the dominant species with strong adaptability to sand land. There are 93 species of psammophytic vegetation plants of steppe zone in Ningxia, Gramineae, Leguminosae and Compositae plants form the main parts, plant species of Chenopodiaceae and Zygophyllaceae also account for some percentages. Seen from growth form, the perennial herbs account for 52.7% of the total plant species, annual herbs account for 29.0%，shrubs and semi-shrub plants is 11.8%. According to the ecological biology，*Artemisia ordosica*, *Artemisia blepharolepis*, *Salix psammophila*, *Phyllostachys propinqua* and A.*mongolicum* Bgl have typical characteristics of adaptation to sandy land，*Stipa bungeana* Trin, *Cleistogenes squarrosa* (Trin.) Kengand *Lespedeza potaninii* Vass have the characteristics of steppe species， plants such as *Reaumuria soongonica* and *Atraphaxis pungens*, have the super-xerophytic character, which fully reflects the double features of sand-adaptabilty and nature of prairie of floristic ingredients.

The characteristics of natural grassland in the project area include:

(1) Drought is prominently shown in a dry desert steppe (strong xerophilous) and revealed in: ①Dry desert steppe accounts for 55.0% of the total grassland acreage; ②xerophilous plants makes up the main plant components of the steppe vegetation. xerophilous perennial herbs account for 74.3% of total plants in dry desert steppe, 63.1％ of total plants in desert steppe. Among the components of constructive species in desert steppe, there exsist some xerophilous or super-xerophytic undershrubs and semishrubs that can reflect the feature of desertification; ③simple community structure, no obvious stratification;④low community numerical characteristics, generally, the coverage degree 30%-60％, the yield of fresh grass per hectare 750-1050kg(Table4-12) ， 12-15 plant species per square meter.

(2) Degradation of natural pasture

Degraded grassland accounts for 97% of the natural pasture, among these, sever, moderate and light degraded grassland account for 16.4 %, 58.8% and 21.7%, respectively. The degradation of pasture leads to the decline of forage grass yield, accompanied by the decrease of good forage grass, the increase of forbs and harmful plants.

(3) Interannual variability and seasonal imbalance of the grassland yield

The yield of grass is controlled by precipitation. Among different years, the yield of grass is high in wet years，but sharply decline in drought years. Within one year, the forage grass flourish in summer and autumn but wither in winter and spring. The livestock presents a situation“strong in summer, fat in autumn, lean in winter, weary in spring”.

(4) Low grade and level of grassland

The pasture acreage of Grade three or Grade four (including a lttle Grade two), Class six, Class seven and Class eight, is more than 90％of the total grassland(Table4-12) , implying that the grass yield of main natural grassland belong to middle level or medium or low in the project area. Grade of grassland appears some regularity at horizontal distribution: the grassland of meadow steppe mainly belongs to Class one or Class two, Grade three and Grade four, with medium or low quality and high yied; the grassland of dry steppe mainly belongs to Class six or Class seven, with high quality and low yied; the grassland of desert steppe mainly belongs to Class six or Class seven, Grade three, with medium quality and low yied; Steppe desert belongs to Class seven or Class eight, Grade four, with low quality and low yied.

Table 4-12 Characteristics of natural grassland in the project area

Type	Acreage		Coverage (%)	Grass height (cm)	Grade and Class of grassland		Available fresh grass per hectare	Carrying capacity of stocking	Stocking rate
	10,000ha	(%)			grade	level	(kg)	ha/sheep	sheep
Meadow steppe	5.44	1.8	67-95	35-50	Third,Fourth	1,2	2880	0.32	173462
Desert steppe	166.07	55.0	20-50	10-50	Third,Fourth	6,7	792	1.17	1237000
Steppe desert	26.19	8.7	10-30		Fourth	7,8	525	1.78	127402
Dry desert	5.5	1.8	15-30	10-40	Fourth, Fifth		525	1.67	30394
Lowland meadow	3.17	1.1	40-80	50-120	Second		1860	0.5	55830
marsh	0.75	0.3	60-90	>50			3705	0.25	10410
Shrub meadow	1.12	0.4	90-95	20-40			4725	0.22	58213
Shrub steppe	15.06	5.0	15-70	5-22			750	1.25	117339

Because of the climate and season, over grazing seriously, unsuitable exploitation and wood cutting in certain areas, the serious deterioration of grassland in the project area has happened. In order to radically solve the problems of ecological environmental degradation and the degradation and desertification of pastures and to restore the grassland resources, the

government of the autonomous region decided to implement "returing the husbandary to grass" and “rearing livestock in pens” for grazing livestock in arid region in central Ningxia and all regions of Ningxia from 2003. After the implementation of "returing the husbandary to grass" for four years, remarkable results have been achieved.

4.2.2 Distribution of rare plant *Ammopiptanthus mongolicus* in the project area

Ammopiptanthus mongolicus is an old survived species in desert and a rare endangered plant species of national key protection. In the control area of Hongdunzi in Xingqing subproject, the natural distribution area of *Ammopiptanthus mongolicus* is about 30,000 mu，with height 80~150 cm and average diameter of canopy 1.27m. *Ammopiptanthus mongolicus* grows better, and the community can naturally propagate and regenerate and is suitable for enclosure protection.

4.2.3 Fauna and varieties of terrestrial wild animals

There are 415 kinds of wild vertebrates in Ningxia，belong to 5 classes, 30 orderes and 84 families. Among them pisces include 3 orders, 5 families and 31 Species. Amphibia include 1 order, 3 families and 6 species; Reptilia include 3 orders, 8 families and 19 species; Aves include 17 orders, 52 families and 285 species and Mammalia include 6 orders, 16 families and 74 species. Birds are the largest species and quantities of wildlife in Ningxia.

As for animal geographic division in the loess plateau, Ningxia across loess plateau subregion of north China region, steppesubregion of Mongolia-Xinjiang Region and western desert subregion.The territory was divided into four geographical animal provinces as follows: Zhongwei Mountain provinces, Jianshan hills and mountain in middle of Niangxia and northern plain provinces, loess hills provinces in south of Ningxia and Liupan Mountaion province. The corresponding ecological geographic flora consists of temperate mountain forest ~ forest grassland ~ semi-desert flora, temperate semi-desert flora and fluviolacustrine-agricultural flora, temperate grassland flora, temperate mountain forest ~ forest grassland flora.

There are 51 national first-class and second-class protective animal species in Ningxia. The eight first-class protective animals are: *Ciconia nigra*, *Mergus squamatus*, *Aquila chrysaetos*, *Haliaeetus albicilla*, *Gypaetus barbatus*, *Otis tarda*, *Otis tetrax*, and *Panthera pardus*. 43 second-class protective animals are: Podicipedidae, *Pelecanus philippensis*, *Platalea*

leucorodia, *Aix galericulata*, *Cygnus Cygnus*,*Cygnus columbianus*, *Milvus Korschun*, *Accipiter gentilis*, *Accipiter nisus*, *Accipiter virgatus*, *Buteo hemilasius*, *Aquila rapax*, *Eurasian Griffon*, *Circus cyaneus*, *Falco peregrinus*, *SakerFalcon*, *Falcosubbuteo*, *Falco vespertinus*, *Falco tinnunculus*, *Crossoptilon auritum*, *Satyra macrolopha* Lesson, *Chrysolophus pictus*, *Grus grus*, *Anthropoides virgo*, *Sterna niger*, *Asio otus*, *Asio flammeus*, *Otus thilohoffmanni*, *Stone Marten*, *Cuon alpinus*, *Felis manul*, *Felis bieti*, *Felis lynx*, *Moschus sifanicus*, *Moschus berezovskii*, *Red Deer*, *Pseudois nayaur*, *Procapra gutturosa*, *Ovis ammon*.

Main economical animals are as follows:(1) Fish: *Cyprinus carpio*, *Carassius auratus*, *Hypophthalmichthysmolitrix*, *Ctenopharyngodon idellus*, Catfish, piceus and so on, mainly distributed in the Yellow River, the Qingshui river and Hulu river;(2) Bird: Cygnus, *Crossoptilon auritum*, *Grus grus*, *Anthropoides virgo*, raptor, Anatidae and gamebirds, distributed in all of the region but mianly distributed in Liupan Mountain and the Yellow River irrigation areas;(3) Beasts: the fox, *Citellus dauricus*(Brandt), *Mustela eversmanni lesson*, *Mustela sibirica*, *Stone Marten*, *Meles meles*, *Canis lupus laniger*, *Felis Manul*, *Prionailurus bengalensis*, *Felis bietilynx*, *Panthera pardus*, *Noschus noschiferus* Linnaeus, *Capreolus capreolus*, *Red Deer*, *Ovis ammon*, *Sus scrofa*, *Lepus tolai* and so on, mainly distributed in Zhongwei Mountain, Liupan Mountain and Luo Mountain. Among them, the birds migrate from the south to Ningxia in spring and return to the south in winter.

There are 2 orderes(Rodentia, Lagomorpha) , 8 families(Sciuridae, Muridae, Dipodidae, Circetidae, Spalacidae, Ochotonidae, Leporidae and Laridae) and 36 species of noxious animal in Ningxia. Among them, *Meiiones Unguiculataus* Milme-Edwauds, *Myospalax smithi* Thomas, *M.fontanieri*, *Citellus dauricus* (Brandt), *Cricetulus triton* Winton, *Microtus fortis*, *Allactaga sibirica*, *Ochtona daurica* Pallas and *Lepus tolai* can harm agriculture, forestry and husbandry seriously. Animals borne disease include *Citellus dauricus* (Brandt), *Meiiones Unguiculataus* Milme-Edwauds, *Allactaga sibirica*, *Rattus norvegicus*, *Mus musculus* Linnaeus and so on.

Due to ecological environment deteriorating, and mismanagement, the wild animals in Ningxia are serious damaged, the number of some animals is reduced. *Panthera pardus*, *Ovis ammon*, *Noschus noschiferus Linnaeus* and other rare animals endangered. Since 1980s,

Ningxia began to value the protection work of wildlife resources and adopted a series of measures in resources protection.

This fauna of terrestrial animals belongs to 3 fauna, semi-desert fauna, temperate semi-desert fauna and fluviolacustrine-agricultural region fauna and temperate grassland fauna. The rodents, birds and fish are distributed in this project.

4.2.4 Flora and varieties of insects

Geographical fauna of insects in sandy land of the project area belong to central Asian fauna with less insect species. According to our previous research, the main components include Curculionidae (Bothynoderes punctiventris Germar and Chloebius psittacinus Boheman), Tenebrionidae (Penthicus lenezyi, Gonocephalum riticulatum Motsh, *Gonocephalum reticulatum* Motschulsky, *B.fopsrugolosa* Gebler, *Microdera elegans* Reitt, Anatolica sp., etc.), *Cuora aurocapitata* (*Trematodes tenebrioides* Pallas, *Trematodes grandis* Semenov, *Serica orientalis* Motschulsky, *Chioneosoma reitteri* Semenov, Gumnopleuius mopsccs, etc.), Chrysomelidae (*Chrysolina aurichalcea*, *Diohabda rybakowi* Weisa, *Parnops glasunowi* Jacobson, *Chrysochus chinensis* Baly, etc.), Cicadellidae (*Cicadella viridis*, *E. bipunctata* Oshida, etc.), moths(Cerura Vinula felina Butler, *Clostera anachoreta*, *Apopestes specrum*, *Smerinthus planus* Walker, *Callambulyx tatarinovi*, *Mythimna separate* (Walker), *Apocheima cinerarius*, etc.) .The most typical insects among them are *Gonocephalum reticulatum* Motschulsky, *Microdera elegans* Reitt of Tenebrionidae, distributed everywhere in sandy land. The dominant species in *Caragana Korshinskill* community include *Adelphocoris suturalis* Jakovlev and *Orgyia ericae* Germar, and *Hoplia shibatai*, *Trematodes Faldermann*, darkling beetle, *Chrysolina aurichalcea* are most common species with large number and greatly dependment on plants; As for low-lying humid saline land, it is almost dominated by humidity-requiring flies.

As for pests, *Cerura menciana* Moore, *Apocheima cinerarius* Erschoff, *Kytorhinus immixtus* Motschulsky, *Rhynchaenus alni* Linnaeus, *Euleanium Ruwanai* and *TriozamagnisetosaLog* are the main projecting pests in the artificial forest, occurre periodically and result in disasters, especially *Eulecanium Kuwanai*(Kanda) and *Cerura menciana* Moore, they occurre with so high densities that their hosts can be destructed; pests

in fruit tree also happen rampantly, such as *Tetranychus cinnabarinus*, *Myzus persicae* and *Aporiacrataegi* Linnaeus; crop pests such as wheat aphid and *Lipaphis erysimi* (Kaltenbach) are common; storehouse injurious insects include *Tenebrioides mauritanicus* Linne, etc..

4.3 Social environment

4.3.1 Population in the project area

As an important foundation for major infrastructure construction, important resource development and utilization, ecological and environmental protection, the public sector development and related industrial development, population growth has significant and far-reaching influences on national economy and social development. Therefore, the statement of the situation of local population can help to clarify the background of related issues.

Ningxia is a more concerntrated province of Hui nationality, particularly in the project area. According to statistic yearbook of Ningxia in 2009, at the end of 2008, in addition to Yinchuan city, Litong district and Lingwu city are the cities or counties where the Hui people concentrately gather together. There are also many Hui people in Pingluo County, while there are least Hui people in Yanchi county.

As for population density in the project area, Xingqing district is the most densely populated area, being 550 person/ km^2, the population density of Yanchi county is least, 20/km^2; the birthrate in seven subproject areas varies from 8.45 ‰ to 14.7 ‰, the least in Xingqing district, the highest in Litong district; the natural population growth rate in the seven subproject areas varies from 4.35 ‰ to 9.99 ‰, also the least in Xingqing district, the highest in Litong district.

Table 4-13 The situstion of populationin for each subprogram region

Region	Birth rate(‰)	Natural growth rate (‰)	Population density (person/ km^2)	Total population in 2008(person)
Yinchuan city	8.48	5.59	550(Xingqing district)	1024922
Zhongwei city	12.46	5.99	120	190339
Lingwu city	14.01	9.68	51	232968
Pingluo county	10.7	6.07	109	273754
Litong district	14.7	8.87	275	373887
Qingtongxia	12.07	6.97	113	276143
Yanchi county	14.37	9.99	20	159653

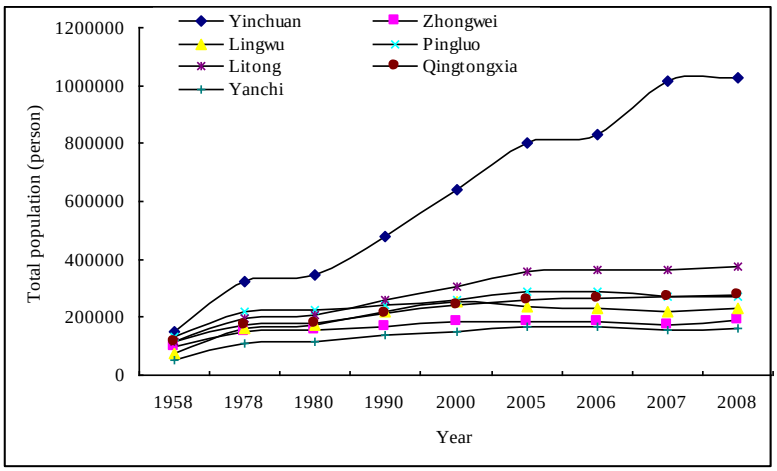


Figure 4-2 Yearly changes of total population for each subprogram region

From the population statistics, the population increase in Yinchuan city presents booming growth, the slope was near 0.45 (Figure 4-2); the population in Litong district has increased rapidly, while the population growth are relatively slow in other counties (cities, districts), which is the result of urbanization in recent years.

According to the population development plan (2006 ~2020), generally speaking, the current population in the project area is characterized by：(1) the population growth are under effective control, the population growth rate of ethnic minority is higher than that of Han and the total average all over the Ningxia; (2) the birthrate is going down year after year, births keep stable, the fertility level of women tend to down in a stationary spectrum; (3) the mortality rate maintains a low level, natural growth rate drops year after year and inter-provincial migrant changes little; (4) the non-agricultural population increases greatly, the speed of urbanization is fast and the floating population keeps incresing; (5) the average life expectancy and cultural qualities improve; (6) the types of population age structure continue to change, generally being adult-type. Meanwhile, there are also some problems, such as: (1) the total population continues to increase; (2) the contradictory of population structure is becoming increasingly acute; (3) the sex ratios at birth rises continuously; (4) the population quality can not be changed fundamentally in a short term; (5) floating and migrating population continued to increase; (6) the population and family planning work is weak inrural grassroots unit; (7) the contradiction between

population with resource and environment is becoming increasingly acute; (8) the construction of public administration and social service system which match with the population development lags behind, the operational mechanism and management system of administering population problem comprehensively need to be established and improved urgently.

4.3.2 Situation of the economic development in the project area

In terms of industrial output in this project area, according to the statistical yearbook of Ningxia, the year-on-year increase in Pingluo County and Litong district is most, increasing by more than 65% in 2008 than in 2007. The gross industrial output value in both of the area achieved 9.186 billion yuan and 6.048 billion yuan respectively in 2008 (Table 4-14), which mainly attributed to the growth of heavy industry, the year-on-year increase of the heavy industry in both of the areas being 71.05% and 103.52%, respectively. Then followed Yanchi county and Zhongwei city, the year-on-year increase rates were relatively high, being 47.84% and 39.76%, and the gross industrial output value reached 1.102 billion and 3.768 billion

Table 4-14 Total industrial and agricultural output value for each subprogram region in 2008

Region	Total output value of agriculture(10,000 Yuan)						Total output value of industry(10,000 Yuan)		
	Agriculture	Forestry	Husbandry	Fishery	Agricultural service industries	Sub-total	Light industry	Heavy industry	Sub-total
Yinchuan city	97754	1420	62335	7316	15404	184229	259335	3404670	3664004
Zhongwei city	95278	750	22738	17211	4250	140226	149349	227406	376754
Lingwu city	53558	5198	34538	1284	4328	98905	486346	407281	893627
Pingluo county	121361	1736	32833	11324	5037	172292	35469	882827	918296
Litong district	68093	2897	98653	626	8036	178305	249882	354951	604832
Qingtongxia	87175	2613	64053	3025	4183	161049	79566	1485569	1565135
Yanchi county	21127	9497	33892	12	3333	67861	9093	101122	110215

Table 4-15 Main indexes of national economy for each subprogram region in 2008

Region	Total output value per captia (Yuan)	Agricultural total output value per captia(Yuan)	Cultivated area per captia (Mu)	Grain yield per captia (Kg)	Oil crops yield per captia (Kg)	Pork, beef and nutton yield per captia(Kg)	Aquatic product yeld per captia(Kg)
Yinchuan city	34635.0	1805.0	0.51	212.2	1.8	7.9	13.0
Zhongwei city	18650.0	7669.2	3.12	1324.2	9.8	35.7	117.6
Lingwu city	37202.0	4351.0	1.59	808.7	9.7	46.6	6.6
Pingluo county	22248.5	6306.2	3.01	1210.7	58.1	39.6	54.3
Litong district	15466.6	4827.6	1.19	514.4	11.4	31.9	2.1
Qingtongxia	11595.0	5884.6	1.79	1013.3	2.9	81.5	15.7
Yanchi county	27183.0	4286.5	8.42	438.0	24.7	69.4	0.1

yuan, respectively (Table 4-14), but which mainly attributed to the growth of light industry, with the year-on-year increase up to 122.01% and 53.52%. In Xingqing district and Lingwu city, light industrial and heavy industry increased at the same pace in 2008 with the rate of increase ranged from12.92% to 23.82%. Since the large base, the increase rate of industrial output value in Qingtongxia city was only 2.12%, but the gross industrial output value reached 15.651 billion yuan (Table 4-14), highest among the 7 subprojects.

The total output value of agriculture in the seven project areas increased by 7.3%~9.2% from 2007 to 2008. Except that of Yanchi county and Lingwu city relatively low, the total output value of agriculture is basically identical in all other areas being 1.299 ~ 1.783 billion Yuan (Table 4-14) .

As far as the total output value per captia in Ningxia, the national average is 22,698 Yuan in 2008, but the average of the whole Ningxia is 17,892 Yuan. Among the seven subproject areas, the total output value of Qingtongxia and Litong district is below the national average and the average of Ningxia, the total output value of Zhongwei city and Pingluo county is higher than the average of Ningxia and below the national average, and the total output value

of Xingqing district, Lingwu city and Yanchi county is higher than both the national average and the average of Ningxia (Table4-15) 。

4.3.3 Situation of finance and employment in the project area

Since 1978, the overall fiscal revenue has increased steadily in the seven subproject areas (Table 4-16). As far as the local fiscal revenue per capita, among the seven subprojects, that inYanchi county is lowest, less than 1,000 Yuan, being 783.8 Yuan; the revenue per-capita in Zhongwei city, Pingluo county, Litong district and Qingtongxia city is the middle level, being 1057.0 ~ 1391.6 yuan and that of Xingqing district and Lingwu city is relatively high (Table 4-17)

The net income per farmer in Qingtongxia city and Yanchi county is minimum in the seven subprojects, the average per capita income is about 3,000 Yuan, and the net income per farmer in other five subproject areas is at lower level, 5,000 Yuan (Table 4 -17).

As shown in Table 4-18, except Xingqing district, in the other six subprijects，the rural labor force makes up a big percentage of the employed persons，being 79.07%, 73.44%, 83.40%, 70.60%, 67.55% and 83.45% in Zhongwei city, Lingwu city, Pingluo county, Litong district, Qingtongxia city and Yanchi county, respectively. Therefore, in some extent, the implementation of the project will also increase farmers' income.

Table 4-16 Local revenue for each subprogram region

Region	1978	1980	1985	1995	2000	2005	2006	2007	2008
Yinchuan city	5466	2396	10545	20868	68290	154739	197721	217706	270820
Zhongwei city	375	365	614	1673	4218	7325	9259	13279	23145
Lingwu city	1025	709	1409	2187	6257	11452	19168	31149	44065
Pingluo county	1000	712	1306	2360	6194	21036	26079	27119	36666
Litong district	1598	783	1504	3401	9444	20927	30720	77314	39041
Qingtongxia	1346	917	964	4052	11162	20856	24687	30813	38085
Yanchi county	213	224	290	539	2549	4971	7749	10267	12409

Table 4-17 Receipts and expenditures per captia for each subprogram region in 2008

Region	Revenue per captia (Yuan)	Expenditure per captia (Yuan)	Urban fixed assets investment per captia (Yuan)	Volume of retail sales of social consumer goods per captia(Yuan)	Average salary of workers (Yuan)	Average net income of farmers (Yuan)	Average living expenses of farmers (Yuan)
Yinchuan city	2653.4	4019.0	12389.0	12974.7	35481.1		
Zhongwei city	1265.8	3542.2	10084.5	6714.4	21455.0	4910.9	4386.6
Lingwu city	1938.5	4056.8	74545.2	2653.2	24230.9	5184.2	3813.3
Pingluo county	1342.0	3845.2	10683.3	3798.4	22291.2	5004.9	4387.5
Litong district	1057.0	4005.3	9874.7	5361.6	26254.0	5613.2	3510.6
Qingtongxia	1391.6	3284.2	17766.7	2775.0	31668.7	3002.2	2978.8
Yanchi county	783.8	4151.2	5881.6	2734.1	30505.5	2576.8	2620.8

Table 4-18 Status of employment for each subprogram region in 2008

Region	Total employee	Urban employee					Countryside labor
		Sub-total	State unit	Collective unit	Other units	Private and individual enterprise	
Yinchuan city	419504	334213	119443	1242	118852	94676	85291
Zhongwei city	106312	22251	7845	467	5812	8127	84061
Lingwu city	107989	28686	13586	606	1935	12559	79303
Pingluo county	138499	22988	11315	470	3283	7920	115511
Litong district	185861	54647	23167	334	6286	24860	131214
Qingtongxia	151878	49287	16861	508	12596	19322	102591
Yanchi county	79925	13231	6723	233	212	6063	66694

4.3.4 Dynamic of industrial structure in the project area

Considing the GDP as 100% in areas, at the national scale, the national average GDP of primary industry accounts for 11.3%, the secondary industry 48.6% and the tertiary industry 40.1%; at the provincial scale, the average GDP of primary industry in Ningxia accounts for 10.9%, the average GDP of secondary industry 52.9% , the average GDP of tertiary industry 36.2%. In this project area, the GDP of primary industry in the 8 subprojects accounts for 2.95%-21.49%, the second industry 39.02%-81.45%, the tertiary industry 12.31%-58.02%. Among them, the proportion of primary industry GDP in Zhongwei city and Yanci county is highest, accounting for 21.49% and 18.62%, respetivrly; the proportion of secondary industry GDP in Lingwu city and Qingtongxia city is highest, accounting for 69.16% and 81.45%, respectively; the proportion of tertiary industry GDP in Xingqing district and Yanchi county is highest, accounting for 58.02% and 39.22%, respectively (Figure 4-3).

In fact, the industrial structure in the project area is changing all the time. Here, on the basis of China statistical yearbook and statistical yearbook of Ningxia, the changes of industrial structure with time at national scale and at the project area scale (total of the seven subprojects) are calculated since 1978. K value, the fluctuation velocity of the industrial structure, is selected as an index, and measured by summing the absolute value of the difference between the composition of industry in report period and that in base period as the following formula.

$$K = \sum_{i=1}^{n} \left| q_{it} - q_{i0} \right|$$

In the formula, index K refers to the fluctuation velocity of the three industrial compositions during a certain period, implying that big K value means the fluctuation velocity fast, on the contrary, small K value means the fluctuation velocity slow. q_{it} means the GDP ratio of industry i in the report period; q_{i0} means the GDP ratio of industry i in the base period.

The results show (Table 4-19) that, on the whole, the evolution of industrial structure in the project area underwent four stages simlar to that of the whole country. Specifically, at the

first stage, the three industries in the project area went up and down greatly. Compared with the national industries, the primary industry rose rapidly, by contrast, the proportion of the secondary industry dropped more rapidly, and the proportion of the tertiary industry changed with the opposite direction of the country, which was due to the changing of national investment focus toward the eastern coastal area after the reform and opening-up

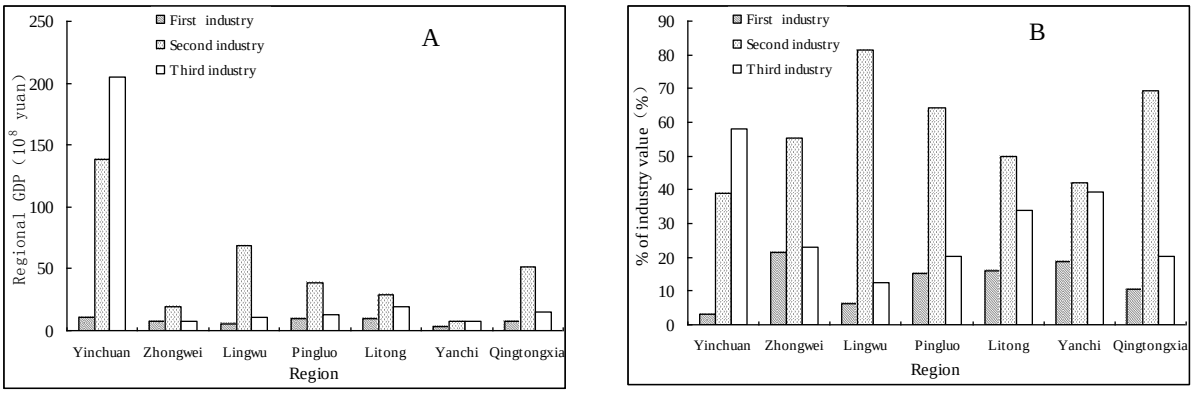


Figure 4-3 The industrial structure for each subprogram regions

Table 4-19 Comparison of industrial structure between the project areas with the whole country

Development stage	Primary industry (q_{1t}-q_{10})		Secondary industry (q_{2t}-q_{20})		Tertiary industry (q_{3t}-q_{30})		*K* value	
	Project area	State	Project area	State	Project area	State	Project area	State
First stage(1978-1985)	5.8	0.3	-10.7	-5.3	4.9	-5.0	11.4	10.6
Second stage (1986-1996)	-8.7	-5.9	2.1	-3.0	6.6	8.9	17.4	17.8
Third stage(1997-2003)	-7.5	-7.0	4.1	4.4	3.4	2.6	15.0	14.0
Forth stage(2004-2008)	-1.0	-3.1	3.8	0.4	2.8	2.7	7.6	6.2

Data from 'Statistic yearbook of Ningxia in 2008', 'Statistic yearbook of Ningxia in 2009', 'Statistic yearbook of China in 2007' and 'Statistic yearbook of China in 2008'

policy started, before the industrial development in the project area mainly relied on the external condition such as national investment and policy orientation, lacking of inner motivation of investment. At the second stage, the proportion of the primary and secondary industry declined rapidly, and the proportion of the tertiary industry rose above the nation levels. At the third stage, the proportion of the primary industry dropped nearly to the national level, while the proportions of the secondary and tertiary industry rose faster than the national level, suggesting that the industrial structure at this stage changed ramarkablely and the

adjustment and optimization of industrial structure was quickened. At the forth stage, with the help of the investment the proportion of the secondary industry rose rapidly, far more than the national level, the proportion of the primary industry had a slight decline. According to the above analysis, it is most important in the adjustment of industrial structure to continue to consolidate and strengthen the position of the secondary industry in the project area and develop the tertiary industry at the same time.

4.4 The desertification land in the project area Ningxia

The sandy land in Ningxia mainly consists of the following eight areas:①sever desertification land in Lingyan tableland; ②sever desertification land in west of Weining; ③sever desertification land in Taole of the east of the Yellow River;④scattered desertification land in Yinchuan irrigation region; ⑤diluvial-alluvial plain desertification land in west side of Yinchuan Plain; ⑥desertification land in low mountaion and low-lying hills;⑦desertification land of gentle slope hills in west of Luo Mountain and Qingshui River valley; ⑧desertification land of loess plateau with thin layer sand in south of Ordos tableland. The desertification land in the project area belongs to that in east of the Yellow River, including①, ③, ④ and ⑤.

4.4.1 Historial desertification of Hedong Sandy land in Ningxia

Mr. Hou renzhi, a historical geographer made some historical geographical investigation on the Hedong sandy land of Ningxia in 1960s. In his studies, the ancient city ruins of Tiezhu Spring and the gullies of Hongshanbao were considered as frame of reference of the spatial and temporal changes, he put forward that except for a little area of shifting land, the majority of Hedong sandy land in Ningxia was vast plains before the Ming Dynasty, and the wantonly settlement after the middle period of Ming was the underlying causes of the development of regional desertification and soil erosion (Hou Renzhi, 1964). This conclusion is consistent with reality, which can be illustrated with the following examples.

First, take the desertification process of Tiezhu Spring as an example. Tiezhu Spring city was constructed in the south 50km away of Huamachi camp that Tiezhu Spring guarded in Ming Jiajing dynasty (1536), whose scale was bigger than ordinary Ming frontier cith wall. Tiezhu Spring which can spurt great mounts of water is located in the intersect that was all 45

kilometers away from southwest of Huama pool, from southeast of Xingwu campsite and from northeast of Yanchi. More than ten thousand horses drank here every day and it has never dried up. Fertile soil available for plantation was distributed in circumference several kilometers away from the spring. It's the only spring for drinking for armed force suppressing bandit on the north, so, it was a neessary for to occupy it in order to attack Lingxia and Pinggu". Accordingly, Liu Tianhe, censor of the court of censors of Shanxi province and ministry of military department, gave orders to construct a city there. The newly built Tiezhu Spring city has such architecture scale as followings: perimeter 2 km, height 10 m and circumvallation quite thick. In order to protect Tiezhu Spring better, a dry channel was dug through around the city and meanwhile 5000 soldiers and some local people was dispatched there to guard the city. Local authorities and army also did military exercise there to avoid assault from others. Soldiers selected there was brave enough and excellent in military skill. As regard to guys mentioned above, local government offer them houses, lands, foodstuff and cattle. In this way not only would the residents there accumulate enough financial savings but also the foodstuff of local government would be abundant several decades later. Consequently, everything would be better dealt with and no one would be suspicious of the method arising in the beginning (see:《Record of Ningxia, Jiajing》). When scientist Hou Renzhi investigated Tiezhu Spring in the beginning of 1960s, Tiezhu Spring had become shifting sand land, and he recorded his feeling of this investigation in his composition <Record of Dessert Visiting>. At present, Sand accumulated is more than 3 m thick at the outside parts of west-wall of Tiezhu Spring City, and the sand table is near to the bottom of city wall. Accordingly, Human factors accelerate the land desertification of Tiezhu Spring.

Secondly, take the desertification process of ancient city Zhangjichang as an example. Ancient city Zhangjichang was located in Zhangjichang village of Huamachi town of Yanchi county, and was the oldest ancient city with abundant remains in desertification land of east of the Yellower River in Ningxia Hui autonomous region. Zhangjichang was a ruin before Dong Han dynasty, and Juyan County and Juyan Road existed here. When the ancient city was constructed, this area should have been a place with abundant water and vegetations, or beach meadow or meadow steppe. Serious degeneration made the ancient city surround by shifting dune and semifixed dune during the 2000 years, and the dune had the tendency to move from

side far from Beida Lake to side near the lake, which implied that the dune around the ancient city was gradually formed from the outer side to center and the lake dwindling related largely with desertification. The area between Zhangjichang and Beidachi mainly consisted of *Nitraria tangutorum* Bobr. fixed dune, *Kalidium foliatum* (Pall.) Moq steppe and saline-alkali soil. The desertification degree of land located in down windward of the village is far less serious than that located in up windward. According to the relative investigation, Zhangjichang village and other surrounding villages were all established during the grazing and reclaiming period at the end of Qing dynasty. The human' influence on the desertification land was not enough to form this kind of distribution layout.

Thirdly, take the desertification process of City BeiPo and City Xipo as examples. City BeiPo and City Xipo located in northwest of Huianbao of County Yanchi. The distance between the two cities was quite close and one of them should be County Wenchi in Tang dynasty. Since County Wenchi was established in the former site of County Hongjing in Sui dynasty, while Hongjing County adopted Cangcheng of Town Bogulv in late Wei dynasty, only if in the process of rebuilding County Hongjing and County Wenchi the origin address of the old city was not used but a new city was established, the phenomenon of two cities constructed in simialr era located in one area would appear. According to the records about Lingzhou in <Picutures and Aanals of Yuan and Counties >, "there were salt lakes located in the sides of Wenchi County, which was 90 kilometers from northwest of County Wenchi to Lingzhou", which indicated that the place for building the city was beach meadow definitely. Now, City Beipo and City Xipo are both laminated by semi-fixed dune, so the so-called "salt lake" at that times would be a part of small salt lake in Huianbao. Nowdays, some small scale lakes catchment located in southwest of City Xipo sould be the ruins of "salt lake". At present, *Nitraria tangutorum* Bobr, *Artemisia ordosica* and *Achnatherum splendens* fixed dune are distributed in the ruin, and some semi-fixed dunes exist in the surrounding of the ruin. Alkali appears on the surface in even interdune lowland, particularly in the area of City Xipo, there are albic soils distributed in interdune lowland, implying that ground water level is quite low now. The desertification of City Beipo and City Xipo hugely relates with the lake drying up, but the desertification should have happened after Tang dynasty.

Fourthly, take the desertification process of Great Wall of Ming dynasty as an example.

The froniter city wall of Ming dynasty in the north of the desertification land of Hedong, the local name in Ningxia “East Great Wall” , had two parts, the outside part called “Hedong wall” and inner part called “deep trenches and high ramparts”, “The outside wall is constructed in the sandy land.”. Sand accumulation has occured lightly in East Great wall and all other castles currently. There are 1-2m high dunes accumulated leaning to walls in the north of frontier wall, north wall of castle and the outside of west wall. Sand also accumulated after going across the wall, but the height of sand accumulation in inner side of the wall is lower than that of wall outside. Together with the accumulation of the collapsed wall, the middle of the ancient city generally assumes low and even, while the outside stands towerling. Standing on the higher part of the frontier wall between Castle Heng and Xingwu campsite and overlooking to north, either incessant dunes or nearby fixed dunes and saline-alkali bottomland in which *Nitraria tangutorum* grew, incessant shifting dunes and semi-fixed dunes in far away place. Looking south, there existed flat dunes with rolling ridge and beach land. The scene differences between inner side and outer side of the frontier wall conform to the principle of site selection ‘The outside wall is constructed in the sandy land’ by Yu Zijun

All in all, Hedong sandy land of NingXia has experienced the process of sand accumulation during Sui dynasty, Tang dynasty, Song dynasty and Xia dynasty. Before the construction of the frontier wall in Ming dynasty, dune or flat sandy land had already formed in some areas. Since the lake-wetland greatly shrinked after Ming dynasty, especially after Ming and Qing dynasty, large area of wetland beach becomes dry beach land, the accumulation of sand has become increasingly serious and the acreage of desertification land has expanded obviously. Consequently, before the strong interference of human activities, Hedong sandy land was already there, the acreage became bigger or smaller and changed with the climate, thus, the human activitives can only be deemed as an additional factor affecting the changing process of land desertification in this area.

Definitely speaking, a large-scale investigation of desertification prevention and control was carried out in Ningxia Hedong sandy land and Mu Us desert by desertification prevention group of the Chinese Academy of Sciences in 1959. The relevant research report published later also supports the viewpoint on the formation of Ningxia Hedong sandy land (Li xiufen, 1962).

Since 1980s, by using evidence from archaeology and combining with field investigation, Jingai (1999) got the result that Ningxia Hedong dene emerged in Tang dynasty and Song dynasty and desertification became serious when boundary wall of Ming dynasty was constructed and large scale gazing and land reclamation developed during the period of Late Qing to Early Republic of China. By combining historical geography method with field inveastigations, Wang Yiming(2005) reported that, the three times large-scale development t at Han, Tang, Ming and Qing was the main driving force to form sandy land (including Heong sandy land) of Ningxia. Through the analysis on the dynamics of natural factors in sandy area of central Ningxia during historical periods, the study showed that, until now, every large-scale grassland reclamation at different historical periods, was related to the wet weather at the time, whereas the " overall stronger and stronger human activities does not timely adjust with the environmental change" promotes the development of desertification in this region; The research of Shan Pengfei et al (1994) indicated that the formation of Hedong sandy land in Ningxia was a geomorphic process controlled by climate, led by natural feedback and enhanced by negative feedback of human activities.Zhang Weishen(2005) studied the influence of agricultural modes on the formation of Hedong sandy land and suggested that “The development of the traditional agriculture of Ninxia had three peaks: Qin and Han, Tang and Song, and Ming and Qing dynasties. Controversially, the three peaks were regarded as the bad time when the forest resources were severely destroyed. The soil desertification was one of the disastrous consequences caused by the continuous destroys of forest and grasslands”.

4.4.2 Desertification of sandy land in Hedong of Ningxia in the recent years

According to the research of Zhi Xingmin, et al(1982)，in desertification land of Hedong in Ningxia, there are three types of desertification land: light desertification land, moderate desertification land and sever desertification land, with the total area of the three kinds 16762.8 km^2，accounting for 25.21% of the total area of Ningxia Hui autonomous region (Table 4-20).

Table 4-20 Areas of desertification land in Hedong of Ningixa

Type Potential desertification	Area(km^2)	The proportion of desertification land area (%)	The proportion of Ningxia total land area(%)
light desertification	10577.32	63.1	15.9
middle desertification	3754.86	22.4	5.64
Heavy desertification	2430.62	14.5	3.67
Total	16762.8	100	25.21

According to the study of Zhu zhenda and Liu Shu (1981), among the reasons that resulted in the formation of Dedong sandy land, over cultivating of the grassland, over-grazing and cutting of firewood are the main factors, while, some in Yinchuan Plain formed because of the destruction of vegetation for fixing sandy land. From the development of desertification land, Yahnchi and east of Lingwu changed most significantly, taking the area in northwest Great Wall of Yanchi County as an example, the propotion of serious desertification land has increased from 19.8% of the total area in 1956 to 59.2% in 1977, and the distribution of desertification land was characterized by the distribution of platy shifting dune and concentrated dunes crisscrossing, thus forming several belts of desertification land, such as the belt of Ciyaobao of Lingwu-Hanahu of Yanchi-Maotouliang and the Great Wall belt of Hengshanbao of Lingwu-Andingbao of Yanchi, etc. Among these belts and the surrounding area, some small scale desertification land is scatterly distributed.

Since the foundation of new China, especially since the reform and opening, under the national great support, people of different nationalities in Ningxia have make great efforts to improve the ecological environment and have controlled 390,000 hectares of wind erosion land, the desertification land decreased from 1,650,000 hectares in 1949 to 1260,000 hectares, and historic changes occure with the rate of control bigger than the rate of desertification. There are many typical examples of the control of desertification, such as in Yanchi County, the demonstration areas of comprehensive control of desertification land and sustainable development of agriculture were built in 1996. Through the regulation of land-use structure, by combining trees, shrubs and grass, combining aerial seeding, enclosure and afforestation, until 1999, the total area of afforestation in the experimental area was 85,000 hectares, the

forest coverage increased to 34.8%, the construction area of grassland was 98,000 ha, the 67,000 ha desertification land was controlled, and 13,000 hectares of shifting dune were preliminary controlled.

However, restricted by manpower, financial and material resources, environment and population pressure, the desertification of Hedong sandy land is not optimistic, the situation of desertification land remains severe (Figure 4-4), the task of prevention and control of desertification land is still very heavy.

4.4.3 Situation of desertification land in the project area

According to the third desertification land monitoring result, if divided on the basis of desertification land types, the seven counties(cities, districts)in the project area, shifting dune 77,070 ha, accounting for 8.6% of the total desertification land area 891,203 ha in the project area, semi-fixed dune 71,489 has, accounting for 8.0%; fixed sand area 549,762 ha, accounting for 61.7%; gobi area 57,460 ha, accounting for 6.4%; wind-erosion infertile land area 1,512 ha, accounting for 0.01%; desertification cultivated land 133,963 ha, accounting for 15% of the total desertification land area. In the project area, the land area with an obvious trend of desertification 93,126 ha, accounting for 5.2% of the total desertification monitoring land 1,798,327 ha in the project area.

Here, seven subproject regions, Xingqing district of Yinchuan, Pingluo County, Lingwu city, Yanchi county, Litong district of Wuzhong city, Qingtongxia city and Zhongwei city, are specificly divided into three control areas: near bank of the Yellow River desertification control area, Lingyan tableland desertification control area and sanilized plain desertification control area (Table 4-21).

As described above, since much desertification land distributed in the project area, the desertification degree is very severe, damage caused by wind and sand must be controlled and the ecological environment has to be improved urgently.

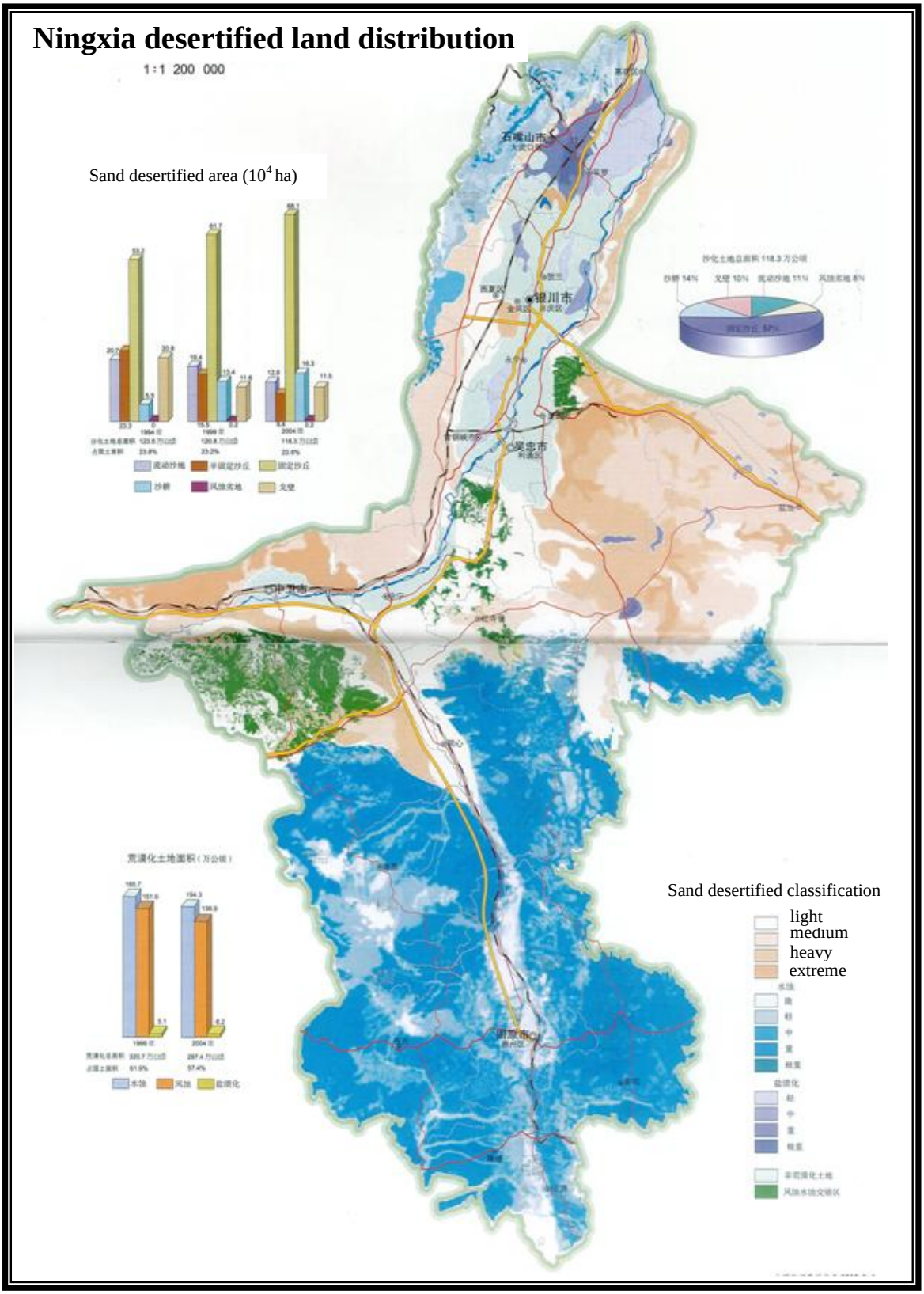


Figure 4-4 Hedong sand desertified land distribution of Ningxia

(After Chinese Map Press, Ningxia Economic and Social Development Map Collection, 2007)

Table 4-21 The situation of desertification in different branch areas of the project

Division	Subproject area	Total land acreage of the project area (ha)	Shifting dune (ha)	Semi-fixed dune (ha)	Fixed dune (ha)
Near bank of the Yellow River desertification control area	Including Pingluocounty and the project area in Xingqing district, Yueyahu, Taole and some other towns.	381600	21204	7965	31904
Lingyan tableland desertification control area	Including Lingwu city, Yanchi county and Litong district. Four towns, Ningdong, Majiatan town, Linhe and Dongta, and Baijitan nature reserve in Lingwu, Weizhuangzi, Yaergou, Dadunliang and Yehujing in Yanchi, Sunjiatan in Litong district.	1093200	51955	50173	488528
Sanilized plain desertification control area	Including the subproject areas of Qingtongxia and Zhongwei. Xijiao forest farm and north side of Baolan railway in Zhongwei city, Tangjiatan and Chenyuantan in Qingtongxia.	240630	3857	13350	29329

5 The positive impacts of the program implementation on environment

5.1 Impacts of the program implementation on carbon sink/source

As the source and sink of CO_2, carbon cycle of terrestrial ecosystem plays an important role in global carbon balance. At present, a lot of scientist focus on the size, distribution and variation of carbon source/sink in different areas.

To evaluate the role of Chinese terrestrial ecosystem in global or regional carbon cycle, Chinese scientists estimate carbon storage and carbon density and value the carbon source/sink of forest and grassland in China (Liu *et al*., 2000; Zhou *et al*., 2000; Fang *et al*., 2001; Wang *et al*., 2001; Zhao & Zhou, 2004; Ni, 2002, 2004; Hu *et al*., 2006; Ma *et al*., 2006; Fang *et al*., 2007; Zhang *et al*., 2009). In this report, we estimate the carbon storage of vegetation and soil of different subprogram regions before and after the program implementation.

5.1.1 Carbon density and carbon storage of vegetation

After the program implementation, the structure and composition of different ecosystem in the program region may take place changes to some extent. Especially the vegetation cover and its biomass may change, while variances of the biomass can influence the changes of carbon storage, which include aboveground part and underground part.

Here, we calculated the vegetation carbon storage depending on the forest mode, tree species and their areas in the program plan design. In the estimate, at first, we calculated the vegetation carbon storages before and after the program implementation, and hence calculated their carbon sequestration.

As for the aboveground carbon storage of vegetation, it was calculated using average vegetation biomass (vegetation productivity, NPP) according to the investigation *in situ* and previous research results. Before the program implementation, the land of program region is waste sand land and partly tilled earth. The investigation results of ours suggested that, before the program implementation, the vegetation cover of Gaoren area in Taole town of Pingluo county was 4.3% (Figure 5-1A), 2.5% for Liumaozi area in Baijitan town of Linwu city (Figure 5-1B), 37% for Yaergou area in Wanglejing town of Yanchi county (Figure 5-1C) and,

25% for Hongdunzi Forest Factory in Xingqing district (Figure 5-1D).

A-Gaoren in Taole town of Pingluo county

B-Liumaozi in Baijitan town of Liuwu city

C-Yaergou in Wanglejing town of Yanchi county

D-Hongdunzi Forest Factory in Xingqiang district

Figure 5-1 Main enclosure sand vegetation areas of this program

Depending on the relationship between vegetation cover and NPP, the NPPs of every subprogram region were calculated. Last, the vegetation carbon storage was estimated in the basis of the relationship between NPP and carbon sink proposed by Fang *et al*. (2007).

The formula of the relationship between NPP (x, g C ha^{-1} a^{-1}) and carbon sink (y, Mg C ha^{-1} a^{-1}) is $y = -4.0 \times 10^{-6} x^2 + 0.0026x - 0.243$, $R^2 = 0.64$.

Meantime, the crop carbon storage of tilled earth before the program implementation was calculated relying on the formula proposed by Fang *et al*. (2007), which is $B = (1 - W) \times \frac{P}{E}$, where B is crop biomass, W is water content of crop harvest, P is yield of crop harvest, E is harvest coefficient.

After the program implementation, the waste sand land will change into shrub forest, artificial straw checkboard shrub forest, arbor forest and enclosure sand vegetation. The aboveground vegetation carbon storage of the arbor forest is calculated as poplar tree, the

calculated method is referred to Fang *et al*. (2007), namely, the average biomass is 88.3, the transition coefficient of average biomass is 0.58, parameter *a* is 0.4969, *b* is 0.4202. The carbon storage of the shrub forest is also referred to Fang *et al*. (2007).

Table 5-1 Proportional coefficient of above-/ underground biomass for grasslands

Grassland	Coefficient	Literature
Temperate meadow steppe	5. 26	Fang *et al*. (1996)
Temperate steppe	4. 25	Fang *et al*. (1996) ; Li *et al*. (1998)
Temperate desert steppe	7. 89	Li *et al*. (1998)
Alpine meadow steppe	7. 91	Li *et al*. (1998)
Alpine steppe	4. 25	Fang *et al*. (1996) ; Li *et al*. (1998)
Alpine desert prairie	7. 89	Li *et al*. (1998)
Temperate grassland desert	7. 89	Li *et al*. (1998)
Temperate desert	7. 89	Li *et al*. (1998)
Alpine desert	7. 89	Li *et al*. (1998)
Hot grassland	4. 42	Li *et al*. (1998)
Hot bush-grassland	4. 42	Li *et al*. (1998)
Warm grassland	4. 42	Li *et al*. (1998)
Warm bush-grassland	4. 42	Li *et al*. (1998)
Lowland meadow	6. 31	Farrier Deparment of Agricultural Ministry of the People Republic of China *et al*. (1994); Li *et al*. (1998)
Mountain meadow	6. 23	Farrier Deparment of Agricultural Ministry of the People Republic of China *et al*. (1994) ; Li *et al*. (1998)
Alpine meadow	7. 92	Li *et al*. (1998)
Swamp	15. 68	Farrier Deparment of Agricultural Ministry of the People Republic of China *et al*. (1994) ; Li *et al*. (1998)

As for the underground carbon storage of vegetation, it occupies the greater proportion in the carbon storage of vegetation in arid and semiarid areas, which results from plant allocation of biomass. Generally, the underground biomass of vegetation is calculated according to proportional coefficient of above-/underground biomass. In fact, the proportional coefficient of above-/underground biomass changes with vegetation type, age, habitat, climate and artificial grazing. Because of limited formation in this aspect, the proportional coefficients of above-/underground biomass of different vegetation type of the program region are ascertained relying on open literatures (Table 5-1). For example, the coefficient adopted 4.25 for the enclosure sand vegetation in Yanchi county, and 7.89 for the enclosure sand vegetation in Xingqing district, Pingluo county and Lingwu city.

The calculation results suggested that, after the program implementation, the carbon sink

function will be raised to great extent (Table 5-2, Table 5-3). In whole program region, the aboveground carbon storage of vegetation will increase 7528.4 t C, the underground will increase 57759.7 t C, while the whole carbon storage will increase 65288.1 t C. As to forest type, the decrease order of carbon storage of vegetation is arbor forest, enclosure sand vegetation, artificial straw checkboard shrub forest and shrub forest. As to the subprogram region, the decrease order of carbon storage of vegetation is Lingwu city, Qingtongxia city, Yanchi county, Zhongwei city, Pingluo county, Xingqiang district and Litong district.

Table 5-2 The changes of vegetation aboveground carbon storage of this program (Unit:t C)

Vegetation	Type*	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei	Increment
Arbor forest	B	0.0	44.9	90.9	9.9	69.0	201.9	47.5	
	A	0.0	366.9	743.3	81.2	564.6	1651.6	388.3	
	Increment	0.0	322.1	652.4	71.2	495.6	1449.7	340.8	3331.8
Shrub forest	B	0.0	24.0	48.3	208.9	18.1	58.6	44.7	
	A	0.0	78.6	158.2	684.3	59.3	192.1	146.3	
	Increment	0.0	54.6	109.9	475.4	41.2	133.5	101.7	916.3
Straw checkboard shrub forest	B	19.5	1.2	37.8	10.4	0.0	0.0	11.5	
	A	278.5	16.5	538.5	148.8	0.0	0.0	163.2	
	Increment	259.0	15.4	500.7	138.4	0.0	0.0	151.7	1065.1
Enclosure sand vegetation	B	469.3	235.3	1158.8	419.6	32.7	15.8	149.5	
	A	888.3	445.5	2193.5	794.2	61.8	30.0	282.9	
	Increment	419.0	210.1	1034.7	374.6	29.2	14.1	133.5	2215.2
Increment		678.0	602.2	2297.6	1059.6	566.0	1597.3	727.6	7528.4

* Note: A-after program implementation, B- before program implementation.

As for the changes of carbon density, after the program implementation, the aboveground carbon density for the arbor forest, shrub forest, artificial straw checkboard shrub forest, ecological economic forest and enclosure sand vegetation will be 0.728, 0.249, 0.057, 0.802 和 0.106 t C ha^{-1}, respectively, and the underground will be 5.744, 1.965, 0.450, 6.328 and 0.836 t C ha^{-1}, respectively.

5.1.2 Soil carbon density and carbon storage

In the calculation of soil carbon storage, there is no popular method up to date, especially sand ecosystem, so we calculated them depending on our previous research results. The study suggested that, the soil carbon storage was an increase process within 50

Table 5-3 The changes of vegetation underground carbon storage of this program (Unit: t C)

Vegetation	Type*	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei	Increment
Arbor forest	B	0.0	353.8	716.7	42.1	544.5	1592.6	374.4	
	A	0.0	2895.1	5864.5	344.9	4454.9	13031.2	3063.4	
	Increment	0.0	2541.3	5147.7	302.8	3910.5	11438.6	2689.0	26030.0
Shrub forest	B	0.0	189.3	381.1	1648.9	143.0	462.9	352.6	
	A	0.0	620.0	1248.1	5400.3	468.4	1516.1	1154.8	
	Increment	0.0	430.7	867.0	3751.3	325.3	1053.2	802.2	7229.7
Straw checkboard shrub forest	B	156.4	9.3	302.3	83.5	0.0	0.0	91.6	
	A	2199.1	130.6	4251.2	1174.7	0.0	0.0	1288.1	
	Increment	2042.7	121.3	3948.9	1091.1	0.0	0.0	1196.5	8400.5
Enclosure sand vegetation	B	3704.1	1857.5	9146.4	1783.2	257.8	125.0	1179.8	
	A	7005.9	3513.2	17299.5	3379.1	487.7	236.4	2231.4	
	Increment	3301.8	1655.7	8153.1	1595.9	229.8	111.4	1051.6	16099.5
Increment		5344.5	4749.1	18116.7	6741.1	4465.7	12603.2	5739.4	57759.7

years when shifting sand was fixed (Figure 5-2), especially soil upper layer with 0~10 cm depth. With the increase of age of fixing sand dune, the vertical changes of soil organic carbon for different sites with different ages of fixing sand dune had same tread. They decreased gradually from the upper to the lower, among which the greatest decrease extent appeared in 0~5 cm depth, while the least appeared in 5~30 cm depth. The soil organic carbon of every layer for fixing sand area all were higher than those for shifting sand area, while the soil organic carbon of every layer for shifting sand area had no changes.

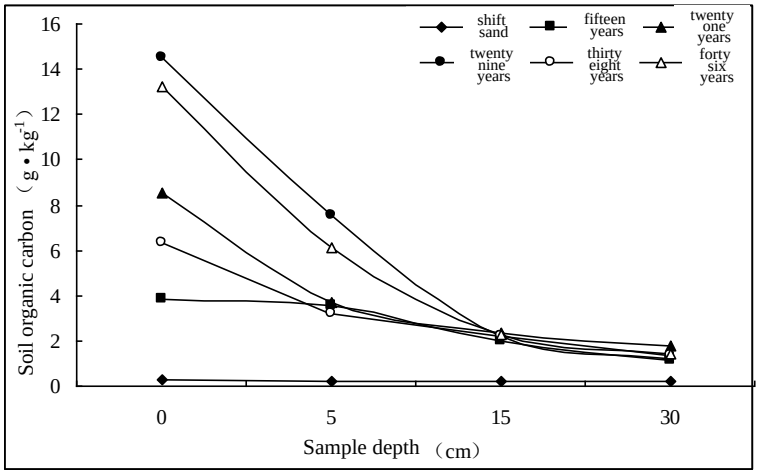


Figure 5-2 Organic carbon changes in soil profile for different ages of fixed sand dune

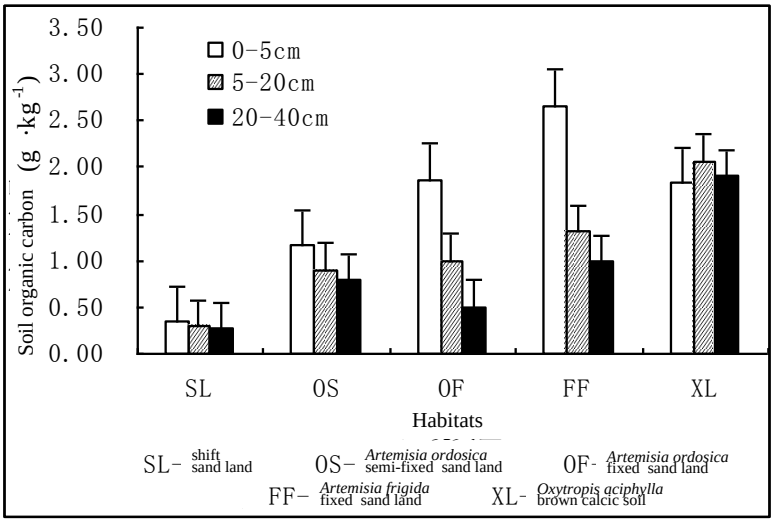


Figure 5-3 Soil organic carbon changes for *Artemisia ordosica* succession series

The results showed that, with the proceeding succession of *Artemisia ordosica* community, soil organic carbon obviously increased (Figure 5-3), especially soil upper layer. The soil organic carbon increased from 0.037 g/kg of shifting sand dune to 2.654 g/kg of *A. frigida* fixed sand dune for 0~5 cm depth, and increased from 0.292 g/kg of shifting sand dune to 2.065 g/kg of *Oxytropis aciphylla* brown calcic soil for 5~20 cm depth, and slowly increased from the shifting sand dune to the *O. aciphylla* brown calcic soil for 20~40 cm depth.

After waste sand land is controlled, soil organic carbon obviously increase, which results from annual wither litter can not decompose in time. We adopted the burring bag method to determine the disaggregating rate of the wither litter for *A. ordosica*, which was greater than 0.6692 g/g/a for the seeds and the leaves of the plant for different sites. Because the decomposition of aboveground litter is a dynamic process, it can be calculated based on Olson's(1963) formula, which is $X/X_0=e^{-kt}$, where t is time, year; X_0 is the initial weight of the litter; X is the remnant weight when it is in t moment; k is decomposing rate, g/g/a. What time it need is $t_{0.95}$ when the litter decomposes to 95%. Under exponential model, when the litter decomposes to 95%, the decomposing rate will reach to stable level.

The losing weight rate for *A. ordosica* was $e^{-k}=X/X_0=$4.24g/8.28g, when the litter decomposes to 95%, it had $e^{-kt_{0.95}}=1-0.95$, combining the both formula, it could obtain

$$t_{0.95}=\ln(1-0.95)/\ln 0.5121=4.48 \quad \text{year}$$

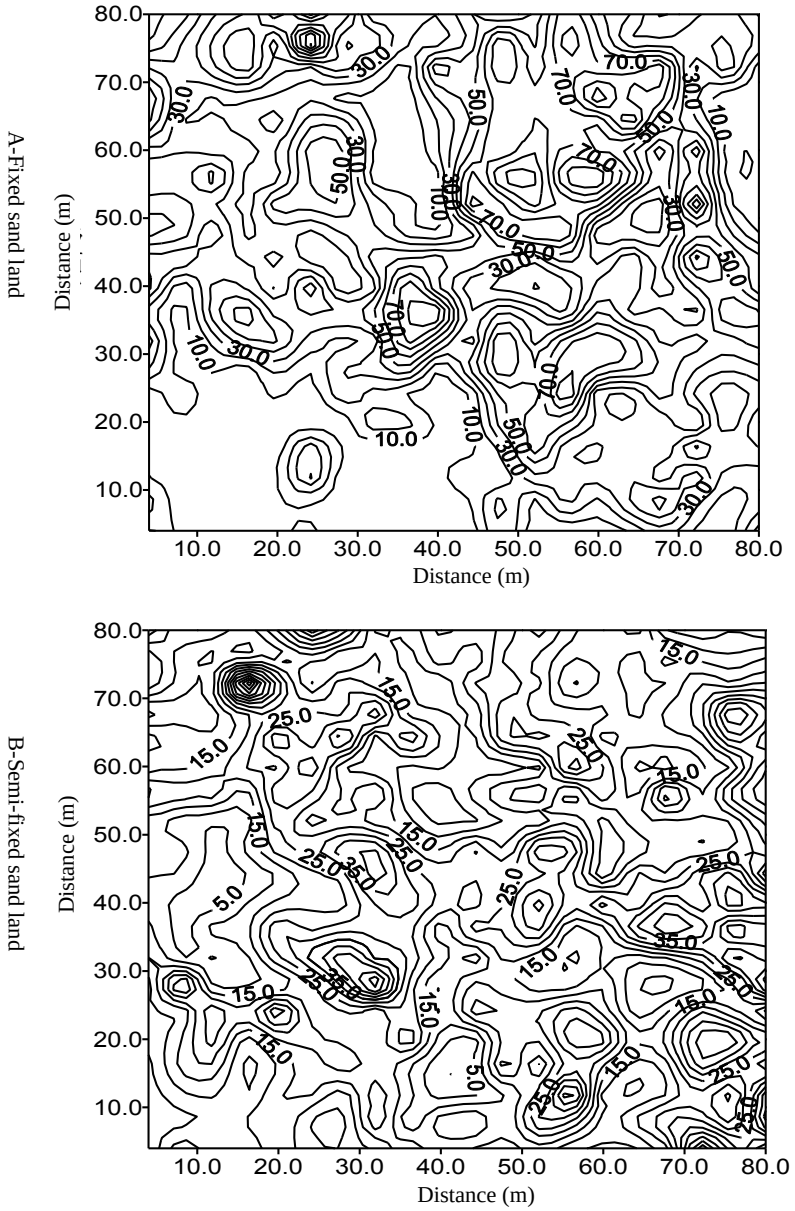


Figure 5-4 Annual wither biomass for *Artemisia ordosica* community on semi-fixed and fixed sand land

Thus, the $t_{0.95}$ is 4.48 year when the litter decomposes to 95%.

However, whether it is the fixed sand land or the semi-fixed sand land for the study area, it can produce a large quantity of wither litter every year for the *A. ordosica* community (Figure 5-4). The annual mean wither biomass for the *A. ordosica* community on fixed sand land was 41.51±1.76 g/m^2, and 32.31±0.92 g/m^2 on semi-fixed sand land. Obviously, behind the waste sand land is controlled, the program region will be a carbon sink process during a long time when the sand dune is fixed, which is resulted from the increase of soil carbon

storage because a large quantity of wither litter can not decompose in time.

Table 5-4 The probable changes of carbon storage of this program (Unit: t C)

Vegetation	Type*	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei	Increment
Arbor forest	B	0.0	2765.6	5602.1	611.6	4255.6	12448.2	2926.4	
	A	0.0	4666.8	9453.2	1032.1	7181.1	21005.6	4938.1	
	Increment	0.0	1901.2	3851.1	420.5	2925.5	8557.4	2011.7	19667.4
Shrub forest	B	0.0	1731.3	3485.3	15079.5	1307.8	4233.5	3224.5	
	A	0.0	2921.5	5881.2	25445.8	2206.9	7143.8	5441.1	
	Increment	0.0	1190.2	2395.9	10366.3	899.1	2910.3	2216.7	19978.4
Straw checkboard shrub forest	B	8962.4	532.2	17325.9	4787.5	0.0	0.0	5249.9	
	A	30870.0	1833.2	59676.9	16489.9	0.0	0.0	18082.5	
	Increment	21907.6	1301.0	42351.0	11702.4	0.0	0.0	12832.7	90094.67
Enclosure sand vegetation	B	15369.4	38910.1	37951.3	41110.8	1069.9	518.6	4895.2	
	A	45982.6	43927.8	113543.5	69372.1	3200.8	1551.6	14645.5	
	Increment	30613.2	5017.7	75592.2	28261.3	2131.0	1033.0	9750.3	152398.7
Increment		52520.7	9410.0	124190.3	50750.5	5955.5	12500.7	26811.4	282139.2

Based on the above statement, we analyzed soil carbon storage with 0~40 cm depth for the program region. The results show that, after the program is implemented, the changes of soil carbon storage are a process of carbon sink during a long time when the sand dunes are fixed. To great extent, it will raise the function of carbon sink for the whole program region, the soil carbon storage will increase 282139.2 t C (Table 5-4). As for the tree species, the decrease order of soil carbon storage is the enclosure sand vegetation, artificial straw checkboard shrub forest, shrub forest and, arbor forest. As for the subprogram region, the decrease order of soil carbon storage is Lingwu city, Pingluo county, Yanchi county, Zhongwei city, Qingtongxia city, Xingqing district of Yinchuan city and, Litong district of Wuzhong city.

5.2 Impacts of the project implementation on wind-sand damage as well as water and soil conservation in project area

5.2.1 Wind prevention and sand-fixation to alleviate wind damage

Ningxia is located in arid and semi-arid area of the northwest with bad natural condition and resource irrational utilization additionally, resulting in the ecological environment deterioration intensified. At present, Ningxia is one of main paths to transport sand from

western to east. The sand in western of Mongolia or northeast of Kazakhstan passes through Xinjiang and Gansu province, and then enters north and southwest or southeast of our country via Ningxia. This project implementation is an important part of ecological barrier construction in western China with special important significance to protect middle and lower reaches of the Yellow River, especially the ecological security of Beijing-Tianjin areas.

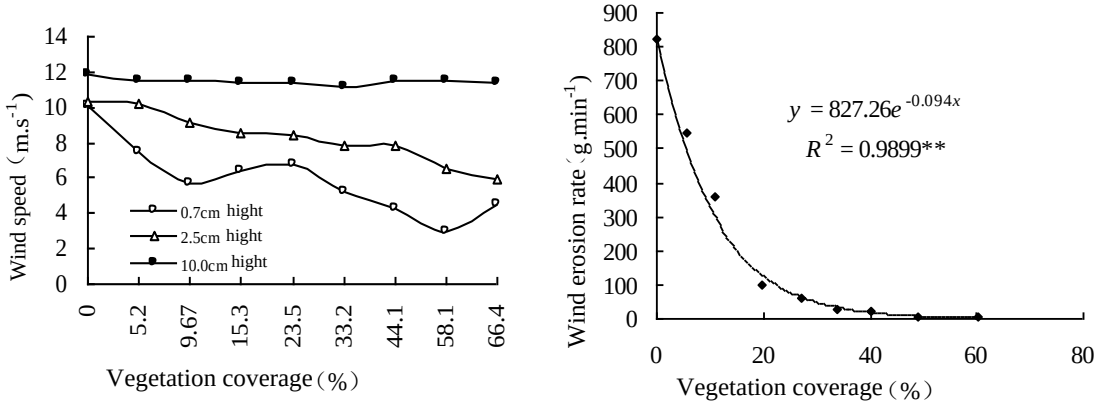


Figure 5-5 The wind speed change and wind erosion rate under different vegetation coveragein wind tunnel

Wind tunnel experiments show that the wind speed of surface layer under 2 m (Figure 5-5A) and wind erosion rate (Figure 5-5B) will decrease significantly with vegetation coverage increasing. After the project implementation, wood coverage rate will increase 4 percent, and the vegetation coverage will also increase, which can decrease wind speed and wind damage. Research study shows that the average amount of sand inhibited by protection forest is 14.2 t/ha, creating benefit of 200￥/ha a. According to these results, the amount of inhibited sand will be 1.09×10^6 t/a, and decrease 1.53×10^7 ￥/a of the loss by wind damage.

On the other hand, as is shown in the above that wind speed of surface layer under 2 m (Figure 5-5A) will decrease significantly with vegetation coverage increasing, which is positive to prevent wind damage in project area. It is often suffered the impacts from sandstorm and dry-hot wind in project area. According to observations, the overall efficiency of windbreak in farmland ecosystem is 22.4%-47%, the wind speed can decrease significantly, and in addition, the relative humidity can increase by 3%-7%, the water evaporation will decrease by 20%-30%. Because wind speed decrease and relative humidity increase within

system, this can not reach the dry-hot wind forming condition. So it is effective to prevent the dry-hot wind occurrence, and reduce it hazards. Besides, sandstorm occurs mainly with the sand getting up on the spot. The increase of vegetation coverage will alleviate sandstorm damage naturally.

5.2.2 Prevention water loss and soil erosion

Vegetation functions of water storage and soil conservation lie in vegetation with huge canopy and thick thicket or litter layer, which can intercept and absorb rainfall, resulting in reducing the raindrops stroke, delaying rain concentration time, reducing the surface runoff velocity, weakening the surface runoff erosion intensity, increasing soil penetration, and improving the ability of soil erosion resistance. It is indicated that the index of water loss and soil erosion is the 4.5-58 times of forestland. Wu et al (2007) showed that the new area of forest or grass for water and soil conservation is 4.5×10^6 ha /a, the amount of soil erosion has decreased of 1.5×10^7 t/a, and the amount of silt accumulation has decreased of 0.4×10^7 t/a (Table 5-5). The project implementation can decrease the amount of sand transportation into the Yellow River, as well as decrease the surface runoff in rangeland of desert steppe, so it also plays a role in water and soil conservation to a certain degree.

Table 5-5 The new area of forest or grass for water and soil conservation and the condition of water and soil conservation in our country from 2002 to 2004

Year	2002	2003	2004
The new area of forest or grass for water and soil conservation (10^4 ha/a)	475.17	479.72	447.62
The amount of soil erosion decreasing (10^4 t/a)	1310.78	1609.27	1501.61
The amount of silt accumulation (10^4 t/a)	382.56	386.22	360.39
Soil fertility value saving (10^8 ¥)	4.87	3.61	3.19

5.3 The impacts of the project implementation on soil

There are positive impacts of project implementation, as well as negative impacts, but the positive impacts are fundamental.

Negative impacts are mainly embodied in early wind erosion, water and soil erosion caused by soil preparation for afforestation and soil ploughing for planting. Soil preparation will change the existing vegetation on surface, soil structure and texture, resulting in surface loose in a small range, and sometimes the wind erosion. On the other hand, in a hard soil site, stirring soil in soil preparation and planting progress will change the original surface, causing

progress of the surface runoff changes and providing a condition for sediment eroded by rainfall directly, so the impacts on water and soil erosion occur in woodland. Especially in summer-autumn with much rain, the infiltration is lower where there is slope on ground, and the short-term surface runoff increases, then surface fertile soil are easily away by rainwater. Generally, the water loss and soil erosion is serious in the first year and second year of soil preparation, but soil erosion will decrease year by year, when in the fifth year, it tends to be stable. With regard to the negative impacts of soil preparation and plough for planting, we can take measures such as soil non-preparation, hole planting and protecting original vegetations to alleviate or eliminate the impacts on environment if possible.

The positive impacts lie in the aspect of improving soil physical properties. Woodland has good effects of improving soil by changing soil structure to increase soil fertility. Soil bulk densities of woodland and bare land indicate that it is lower in 0-40 cm layer than the bare land outside the corresponding woodland. In woodland, soil permeability is good and, soil texture is loose and more conductive to microbial activity and nutrients accumulation activation. The results of soil water content and soil porosity also indicate that woodland is superior to bare land. Trees' growth will activate microbial propagation in soil. Moreover, litter after decomposition will form the resources of soil organic matter, available nitrogen and phosphorus, in favor of soil organic matter increasing. When soil microbes increase, CO_2 released by microbe activity and plant root respiration dissolves in water to form carbonic acid, and organic acids such as citric acid, malic acid et al are secreted by saline plants, these acids play a promoting role in dissolution of soil indissolvable materials, as well as promoting salts of P, K, Ca et al dissolution, thus improve soil fertility. This improvement effect is more obvious in sand substrate.

The research shows that the fineness characteristics of drifting sand have changed by abundance powdery sand accumulation after drifting sand-fixation. Soil mechanical compose in 1m becomes significantly fine followed with the time of sand-fixation (Table 5-6). Although soil particle coarsens with soil depth increasing, the sand content decreases from 99.04% to 66.40% with the time of sand-fixation increasing, the clay content increases from 0.86% to 11.00%, as well as silt content from 0.10% to 22.6%.

Table 5-6 Changes of soil mechanical composition in different years of drifting sand-fixation

The year of sand-fixation (year)	Partial size percentage (%) Clay particle (<0.002 mm)	Silt particle (0.002~0.05 mm)	Sand particle (0.05~0.5 mm)
0 (drift sand)	0.86	0.10	99.04
10	4.45	15.68	79.87
24	4.87	23.59	71.54
35	6.93	24.79	68.28
40	11.00	22.60	66.40

Table 5-7 Changes of soil bacteria biomass and quantity in different years of drifting sand-fixation

The year of sand-fixation (year)	Aerobic bacteria		Anaerobic bacteria		Spore bacteria	
	biomass	quantity	biomass	quantity	biomass	quantity
0(drift sand)	1350	42200	7	161	5	78
11(1982)	2784	87000	8	199	10	78
28 (1964)	16461	514400	8	199	10	178
36 (1956)	27485	858900	8	183	8	133

Note: the unit of quantity ($\times 10^2$ individual/ g dry soil), biomass ($\times 10^{-9}$ g / g dry soil).

Table 5-8 Changes of soil organic matter and total nitrogen content in different years of drifting sand-fixation

The year of sand-fixation (year)	Total nitrogen content (g/kg)			Soil organic matter (g/kg)		
	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation
0(drift sand)	0.012	0.002	0.143	0.240	0.015	0.062
15	0.114	0.134	1.175	2.419	1.282	0.530
21	0.216	0.285	1.320	4.436	2.712	0.611
29	0.353	0.467	1.321	6.244	6.528	1.045

These changes of soil mechanical composition are more obvious in interdune than leeward and windward, resulting in soil hygroscopicity and water-keeping capacity improved significantly.

Soil mechanical composition changes constantly with sand-fixation, causing soil bacteria biomass and quantity change obviously. The results show that the thicker of sand surface crust becomes, the higher are the biomass and quantity of aerobic, anaerobic, spore bacteria (Table 5-7). It is because biomass and quantity of bacteria are positively correlated with sand-fixation degree, the planting years of artificial vegetation, crust thickness and bryophytes

species. That is to say, the longer of artificial vegetation planting, the thicker of the crust thickness, the more bryophytes species are, the larger are the biomass and quantity of bacteria.

The quantity of microbe as bacteria increases with sand-fixation, which accelerates the soil organic matter decomposition and nutrient accumulation (Table 5-8). The results of measurement indicate that total nitrogen contents (0.01-1.02 g/kg) of each soil layer in different years of sand-fixation are higher than drift sand area (0.01 g/kg).

Obviously, the project implementation has effects to improve soil, so the environmental positive effects are prominent.

5.4 The impact of the program implementation on biodiversity

Biodiversity is the complexity of organisms and their environment, and also is the sum of all related ecological processes. It is a basis to maintain sustain productivity of ecosystem, also is the most fundamental condition to human survival. It includes genetic biodiversity, species biodiversity, community biodiversity and landscape ecosystem biodiversity. Because of the key and core functions in ecosystems, the species biodiversity is the most essence and fundamental part in four levels of biodiversity, and plays a bridge role. And because of the species in the four levels of biodiversity is relatively easy to identify and statistics, the number of species in a country or region and the condition of flora largely represent the biodiversity abundance in this country or region. Therefore species diversity is the most important content and the most substantial and core problem in biodiversity research and protection work.

Theoretically, this project implementation could produce bigger positive effect to biodiversity in the project area.

As mentioned before, 76000 hectares ecological shelter forest will be prepared to construct this project, including arbor 5214.05 ha, shrubbery 5296.5 ha, straw checkerboard barrier bush 20096.96 ha, and 44303.54 ha for enclosure sand vegetation. According to the afforestation model, this project is divided into three types: sand-fixation forests, year-round exclusion, forest shelter, and forest shelter includes protective belt of trees along roads and protect farmland. Now we will analyze biodiversity impact on typical area in this four types.

Sand-fixation forests area is usually drifting sand dunes, and also has flat sandy area. It has dry climate, scarce rainfall concentrated, annual precipitation below 200mm, annual evaporation above 2000mm, groundwater level in deep, barren soil mainly in Aeolian sandy, low soil water content, and various kinds of disastrous weather including drought, wind and sand, frost, hail, chilling and dry-hot wind. The primitive vegetation is rare, only has some

pioneer specis, such as *Agriophyllum squarrosum* and *Artemisia sphaerocephala*. Vegetation cover less than 3%. Species diversity is low. These regional governance is setting straw checkerboard barrier and manual planting drought shrub. Setting up sand barrier could increase roughness of earth surface, decrease ground surface wind and shifting sand, create a stable ground surface environment, which created a favorable condition for plant plantation and growth. Furthermore, the survival rate of shrub is high under the protection of sand-protecting barrier. Shrubs shading and transpiration could adjust air humidity, reduce range of sand surface temperature, and regulate the microclimate. Plant litter can increase soil organic matter, nutrient element content, and soil microbial population will increase, which promote the formation of crust horizon making the growth of plant environment relatively stable. After that, the vegetation would consist natural plant such as *Agriophyllum squarrosum, Artemisia sphaerocephala, Artemisia annua, Artemisia ordosica, Psammochloa villosa* and so on, except planted plant for *Calligonum mongolicunl, Salix psammophila, Caragana intermedia, Hedysarum scoparium, Astragalus mongolicum, Salix gordeivii, Astragalus adsurgens*, etc.. Plant species diversity is obviously improved after the governance. Vegetation restoration could attract insects, birds and other animals, and further improve the diversity of species. With the addition of there are all local tree seeds, which adapt to the local natural environment, making this ecological system structure complete and regeneration ability strengthen, landscape heterogeneity and stability strengthen. To sum up, sand fixation afforestation could improve the biodiversity of the project area.

Year-round exclusion area is semi-fixed, fixed sand dunes or grasslands with plant coverage. Take Changliushui Langnan Road in Lingwu project area for example, there were dry and gentle slope fixed dunes, drought, with poor water conditions and barren soil. It had formed crusts, but the site conditions were poor. Trees grow slowly, but the vegetation coverage was large, with field observation was 35%. The mail tree species were *Ammopiptanthus mongolicus* and *Caragana stenophylla*. Companion species were *Cynanchum komarovii, Artemisia ordosica ,Stipa capillata* and so on. All human and livestock destruction and trampled on are eliminated year-round exclusion area. Except some small promotion measures, it relies entirely on natural regeneration. Therefore, the enclosed measure is not like sand-binding and afforestation which have a direct influence on biodiversity. It is main protection, to protect the local ecological environment from damage and make ecological system repaired slowly, thus improve the biodiversity in exclusion area.

Forest shelter includes protective belt of trees along roads and protecting farmland. There are mostly large trees or tree-shrub forest. Farmland forest shelter is located on yellow

river irrigation area and pumping irrigation area. Site conditions are good, with fertile soil and adequate moisture. Selecting trees follow "suitable plants and suitable sites" principle, and the trees have qualities such as tall growth, deep roots, wind-breaking, dense foliage, small negative-effect and strong resistance to pests and diseases. Chosen tree species are *Salix matsudana, Fraxinus chinensis, Populus simonii, Ulmus pumila,* etc.. Shrub species are *Amorpha fruticosa, Salix purpurea,* etc.. For easy management, there is little mixed inter and even trip with mixed in a lot of regions. For example, there is poplar pure forest on Lingwu city. And due to the reasons that weeding, large planting density, high forest canopy, etc., there is almost no forest weed, and biodiversity is low. So the resistance to pests and diseases and landscape heterogeneity decreased, and the stability of ecosystem reduces. Creating farmland protect forest as much as possible to create mixed forest. The main belt could be section or line mixed, and the vice belt could be line mixed. Bushes such as *Amorpha fruticosa*、*Leapedeza bicolor* could be plant between strains. Weeds could be reserved as green manure with *Leapedeza bicolor*. It can not only improve soil fertility, but also improve the forest's biodiversity. Road protect forest is generally created in the large sandy area, with poor site conditions. Take Dongren Road in Lingwu for example, it is dry type flat sand, drought, low groundwater level, barren soil. Vegetation situation was like drifting sand dunes, only had some pioneer specis, such as *Agriophyllum squarrosum* and *Artemisia sphaerocephala*. Biological diversity was very low. After the implementation of the project, mixed forest was created with drip irrigation methods. The main tree species are *Robinia pseudoacacia, Caragana intermedia*, *Euonymus bungeanus, Elaeagnus angustifolia, Pinus sylvestnis, Populus bolleana Lauche,* with dibbling native seeding such as *Melilotus suaveolens, Leapedeza bicolor, Astragalus adsurgens, Hippophae rhamnoides*, which could tolerate drought and improve soil quality. So it can promote the establishment and growth of other species, and improve biodiversity shortly. However, if with unreasonable irrigation, there will be secondary salinization or further decline in groundwater table, increase the degree of soil dryness, environmental degradation, leading to plant death, destruction of ecosystem, biodiversity decrease. Therefore, when creating road protection forests, as far as possible to choose local species with no irrigation and coordinated development of native environment, to prevent adverse effects on biodiversity.

Ecological forest construction is still facing the problem of a single species. Create economic forests could be use a combination of forest and woodland economy. For example, cultivating appropriate Chinese herbal medicines understory, such as *Radix Glycyrrhizae,*

Isatidis Radix, Astragalus membranaceus, Radix Stellariae etc, or planting green manure and forage, such as *Medicago sativa, Astragalus adsurgens, Melilotus suaveolens, Onobrychis viciaefolia* etc, it can improve soil quality, and make full use of resources and improve biodiversity. It also take the form of economic trees and crops intercropping, such as Sunjialou in the Liusi Channel basin Yanchi, take the form of grain intercropping jujube, planting leguminous crops between jujube forest. It can increase the utilization rate of land productivity, make full use of light and heat resources. Furthermore, choose forms of no or less farming for economic forest tending as possible, retain some forest weeds, that can reduce evaporation of ground water, improve the microclimate, and litter can further improve soil quality. It is take the forms of intercropping forest and herbal medicines or crops that can eliminate the negative impact of economic forest species of unity, enhance biodiversity and improve ecological environment, and also adjust the industrial structure to achieve forest-medicine and forest-crop harvest.

Table 5-9 Biodiversity change in different years of fixation of shifting sand

Year of fixing vegetation planting	Simpson index		Shannon-Wiener index		Pielou index	
	range	Average	range	Average	range	Average
1956	0.706~0.822	0.767	1.393~1.893	1.642	0.638~0.961	0.701
1964	0.595~0.856	0.752	1.232~1.814	1.515	0.661~0.862	0.775
1973	0.627~0.777	0.696	1.247~1.633	1.385	0.554~0.743	0.646
1981	0.631~0.788	0.711	1.171~1.690	1.390	0.658~0.877	0.745
1987	0.501~0.788	0.539	0.819~1.074	0.859	0.524~0.712	0.534

In general, vegetation restoration will be accompanied by an increase of biodiversity. Wu Zhibo et al. (2008) studies of influence of different recover measures on species structure and variety in Mu Us sandy land in Ningxia suggested that using different ecological restoration measures can improve the structure of the sand species to a certain degree, and make an increase of vegetation coverage and the number of species. Thus, with the increase of vegetation coverage, the community structure complexity and habitat condition could be improved. It may be possible that the number of plant species increase and habitat improvement can also increase the number of animal and amount.

In fact, it is very significant such as the restoration of biodiversity increased in the fixed sand. Survey results show that the longer sand vegetation established, that is, the longer sand fixed, the bigger Simpson index and Shannon-Wiener index that reflecting diversity, and the

bigger Pielou index that reflecting evenness. It is indicating that sand dune fixation will increase biodiversity.

Moreover, due to the closed project measure, avoiding interference of human activities, it is not only play an active role to protect the biodiversity in the region, but also make a good effect to protect local rare species (such as sand holly, etc.) , which will be detailed in the following analysis.

5.5 The impact of the program implementation on regulation of regional microclimate

The ecological service function on cleaning air main is absorbing CO_2, releasing O_2, holding dust and noxious gas.

Studies shows that photosynthesis of shelter plants per hectare per year absorb CO_2 1000kg and release O_2 730kg. 114 million mu new forest will be construct in this project, which could absorb CO_2 7.7 million tons and release O_2 5.6 million tons. In addition, trees can absorb harmful gas like SO_2, and reduce photochemical smog pollution and purify the role of radioactive materials. Trees dust detention is very obvious, which significantly reduce airborne dust in the air. Therefore, this project construction has significant effects that cleaning air and protect human's health.

On the other hand, the construction of ecological shelter forest has changed the surface roughness and nature of underlying surface, interfered with near surface turbulence, which can regulate micro-climate regions. It is reflected in three aspects: first, affecting surface air temperature because changing heat exchange between air and ground, second, increasing relative humidity due to increasing evaporation of water from tree leaves and stomatal transpiration, third, increasing soil condensate because changes of greenhouse effect and hydrology effect.

In addition, the project area was mobile sand, semi-fixed sandy land, fixed and or wind erosion land that can not be used because of adverse ecological conditions, with sparse ground cover plants, and only some drought tolerant shrubs and herbs growing such as *Salix psammophila, Hedysarum scoparium, Agriophyllum squarrosum*. The surface exposed after grass wilt in autumn and winter. After planting, the local forest cover will be improved, and the landscape pattern and ecological environment will be significantly improved.

5.6 the impact of the program implementation on *Ammopiptanthus mongolicus* community and *Populus euphratica* stand

5.6.1 the impact on *Ammopiptanthus mongolicus* community

Ammopiptanthus mongolicus (leguminosae) is the only broad-leaved evergreen shrubs in central Asia desert. It is an ancient relic species of desert, and a national treasure, protected and endangered species.

Ammopiptanthus mongolicus height is 1m, macimum 1.8m. It is often associated with *Sarcozygium xanthoxylon, Reaumuria soongorica, Caragana intermedia,* or *Artemisia ordosica*to, build a component formation. The community often distribute as small pieces. Vegetation coverage is about 25%~30%. There are other commonly associated species, *Oxytropis aciphylla, Convolvulus tragacanthoides, Caragana stenophylla, Ceratoides lateens, Atraphaxis spinosa, Nitraria roborowskii, Stipa plareosa, Cleistogenes songorica, Peganum harmala and Alliaceae mongolicum* etc, with steppe desert features.

Ammopiptanthus mongolicus is extreme xerophyte, evergreen shrub in Alaskan desert, and endemic steppe desert plant. It is only found in western Inner Mongolia, Ulan Buh Desert, Wolf and Zhongwei mountain defender piedmont desert plain. The growth of the substrate is sandy, gravel or clay quality, deep groundwater level. A small amount of sand is covered in the soil surface in the rocky shallow mountain of Zhongwei mountain. *Ammopiptanthus mongolicus* has developed root system, strong resistance, good sand and soil conservation performance, and its roots have nodules, so it has large soil improvement. and it has better capabilities of drought, cold and sand-fixation, is a soil and water conservation, sand-fixation and ornamental species. *Ammopipanthus mongolicus* is also good nectar plant, and its seeds can be extracted special industrial oil, branches, leaves can be used as medicine, for expelling wind, promoting blood circulation, relieving pain, external use for treating frostbite, chronic rheumatoid arthritis and so on. *Ammopipanthus mongolicus* gradually formed a unique structure and super-xerophytic resilience mechanism, which is long-term evolution in the process, change for acclimatization. It is rare special gene fragment carrier, and of special chemical constiruents (alkaloids and high activity of plant antifreeze proteins) research, extraction and transfer of valuable material. It also the relict dry types specie of ancient Mediterranean flora, and has a very important scientific value in plant systems evolution, environmental change, ancient climate and other scientific research.

Ammopipanthus mongolicus has three distribution areas in Ningxia, mainly in the

northern part of Zhongwei mountain, Binggou in Taole Town, Lingwu Baijitan National Nature Reserve, Majiatan and Ciyaopu in Lingwu, Tongxinhongsipu, Xiangshan and forestry station in Zhongwei. There is only one distribution in Hongdunzi subprogram area in the project area (Figure 5-6).

Because of several factors, the *Ammopipanthus mongolicus* population is in endangered condition now. The growth area climate, landform features, and soil formation and maintenance play an important role in the population maintenance and reproduction, but other factors largely restrict its space distribution and the number of population development. For example, its seeds are large, have hard seed coat, and require higher soil water content for germination. But in the dry sand area of its distribution, rainfall is little and almost

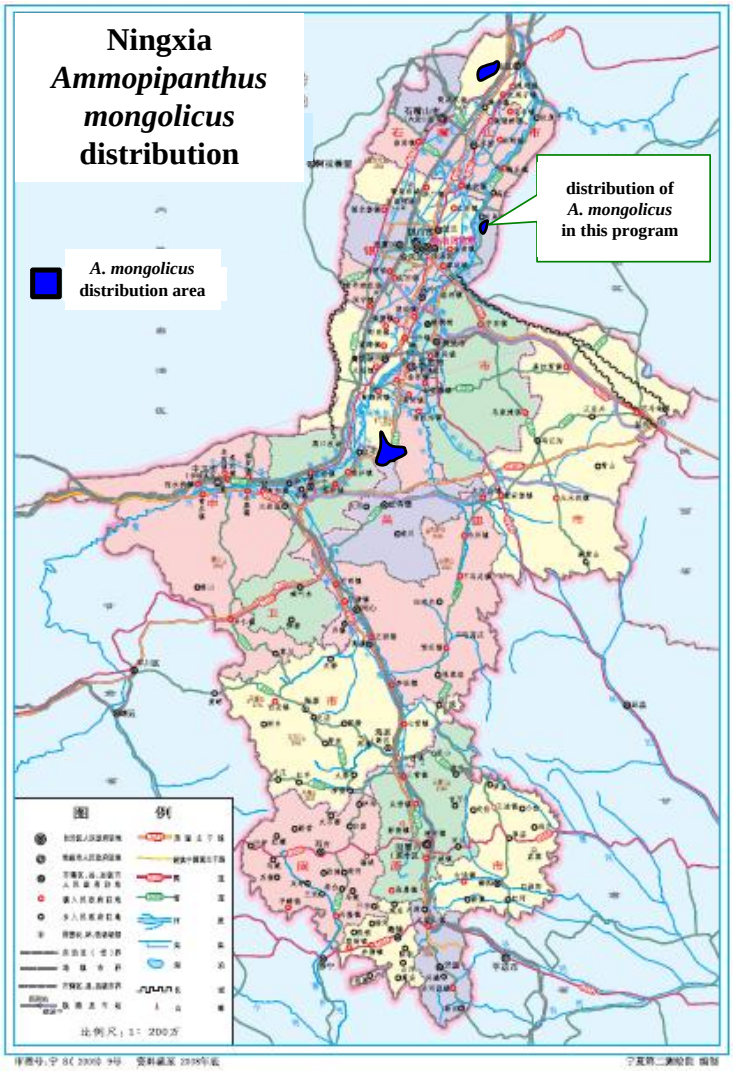


Figure 5-6 The distribution of *Ammopipanthus mongolicus* in this program

Table 5-10 The *Ammopipanthus mongolicus* community survey in Hongyazi Zhalajing Taole town Pingluo county

species	Height cm	Coverage %	Frequence %	Distribution characteristic
Caragana Korshinskii	140	15	100	evenly
Artemisia ordosica	50	8	80	scattered
Ammopiptanthus mongolicus	40	2	10	few
Cleistogenes songorica	3	2	90	few
Tribulas Terrestris	2	1	80	few
Agriophyllum squarrosum	12	0.5	90	few
Parthenocisus tricuspidata	1	0.5	40	few
Enneapogon borealis	1	1	90	few
Setaira viridis	2	0.5	20	few

concentrated in the autumn, water condition has become a limiting factor on reproduction. The seeds get ground not with wind or water, it limits the population spread. Moreover, destruction of pests and diseases, human and animal destroy are the direct factors for population attenuation. For example, large scale production causes habitat destruction, awareness of rare and endangered species protection is not enough due to overgrazing and deforestation, and they are the direct result of the reduction in population.

Part of the closed area in this project involves *Ammopipanthus mongolicus* protection. Take Hongdunzi forestry station for example, in the proposed fencing areas there is *Ammopipanthus mongolicus* + *Oxytropis aciphylla* + *Sarcozygium xanthoxylon* community. The foster measure that natural regeneration rejuvenation with artificial and shrub cutting is to be intended. But its natural reproduction and spread are difficult; it is hard to expand the population with existing measures which requires establishment of artificial population. However, in arid desert areas, scarce rainfall, infertile soil, cause conventional breeding is

easy, but seedling roots are fragile, and the survival rate of transplanted seedlings is low, outplanting afforestation is extremely difficult and direct seeding is controlled by water conditions. In order to save this rare species and expand germplasm gene pool, it is need to protect existing germplasm resource, established excellent resources protection base, popularize scientific and technological achievements, objective analysis master the habits and habitat requirements, strengthen research on breeding, control technical approach of establishing artificial population, further accelerate speed of the introduction and breeding of domesticated, gradually explore a new way of sand-fixing with planting in a large area. Meanwhile, take dynamic monitoring of *Ammopipanthus mongolicus* resources, further strengthen the protection and management, strengthen the law enforcement ranks, crack down on hacking, indiscriminate grazing and exploitation of the wrongful act.

Before the program failure to work, *Ammopipanthus mongolicus* community exists in the situation for nobody attetntion, digging firewood and grazing destruction is rather severity. When the program implementation, the habtat of *Ammopipanthus mongolicus* population will be constructed as the enclosure area, which will be available to the protection of being in severe danger species *Ammopipanthus mongolicus.* Therefore, the project implementation has a positive impact on *Ammopipanthus mongolicus* population reproduction and protection.

5.6.2 the impact on *Populus euphratica* stand

Populus euphratica, another name is euphrates poplar, or diversifolius poplar, is the oldest one in Salicaceae, Populus. And it is the remnant species in Tethyan region, Pliocene epoch. *Populus euphratica* is a kind of deciduous trees, and has a strong adaptability in drought, cold and salinity, with long life, low pest and disease, adaptability and strong sprout characteristics, significantly different from other types of poplar, and is a fine species of riparian areas, Ⅲ level for the state endangered plants. *Populus euphratica* is known as living fossils in desert riparian areas in the northwest. It has good reputation that “born alive a thousand years, death being overthrown in a thousand years, but never broken down a thousand years”.

Local legends say there were several *Populus euphratica* in Lingwu City, Ningxia, but no longer exist now. At present, there is only one *Populus euphratica* forestry station in Yueya Lake Forest in Xingqing District. Thus, it has a positive meaning that enclosure and

protection of this *Populus euphratica* forest for the protection of biodiversity, protecting environment and development of tourism.

Yueya Lake Forest is adjacent to the Yellow River. The terrain is relatively flat, and the most is the mobile dunes and semi-fixed sand dunes. The zonal soil is mainly light gray calcareous clay soil. The water table is below 3 m. This area is located in arid, dry climate, little rain, wind, sand, and the average annual precipitation is 188.9 mm, annual evaporation is 2246.2 mm.

There are 395 mu *Populus euphratica* forest in Yueya Lake Forest, 3270 individuals. The forest form is poor, with serious pests and diseases, and some of the trees have destroyed, severe sand burial. The overall situation faces shrinking. According to local people, this area has become a forest in the 1960s-1970s. Due to later relocation, more and more farmers moved here, accompanied by the felling of *Populus euphratica*. Now there are second and three generation budding trees existing. Since 2000, some conservation and tending have been taken in Yueya Lake Forest, but the forest still needs enclosure and protection.

In this project, plans for enclosing and protecting *Populus euphratica* forest in Yueya Lake l as the core, artificial planting as measure, expand the area of *Populus euphratica* forest actively. Migratory dunes around the forest are used straw checkerboard barriers for fixing, and plant some sandy shrub in the barriers, such as *Hedysarum scoparium, Astragalus mongolicum, Calligonum mongolicunl, Atraphaxis frutescens, Caragana Korshinskii, Tamarix chinensis, Sabina vulgaris* and *Artemisia ordosica*. Build mixed forest of shrub and tree mainly use *Populus euphratica, Hedysarum scoparium*, mainly with container seedling planting for improving the survival rate. These measures can provide good conditions for healthy plant of existing *Populus euphratica* forest.

Enclosure and protection of this *Populus euphratica* forest in Yueya Lake, will continue to expand the forest, dominated by *Populus euphratica*, area in project, rich species composition, improve ecological structure and promote ecological benefits. On the one hand, poplar forest, in Yueya Lake, ecosystem restoration will restore as soon as possible, to block the expansion of Maowusu Desert, prevent water and soil loss to reduce sediment flowing into the Yellow River, prevent the expansion of desertification and ensure ecological security of Yinchuan city and the Yellow River. On the other hand, this poplar forest could be a desert

botanical garden mainly focusing on *Populus euphratica*, as a base for ecological civilization education and eco-tourism to the needs of ecological civilization.

Therefore, the project implementation has a positive impact on the *Populus euphratica* population reproduction and protection in Yueya Lake forest in Xingqing District.

5.7 The impact of the program implementation on ecosystem health

According to Constanza's point of view, a healthy ecological system should be stable and sustainable development, both to maintain the integrity of its structure and function, but also has the ability to resist disturbance and recovery, which can evaluate from three aspects, ecosystem vitality (V), organizational power (O), and resilience (R).

(1) The impact on ecosystem vitality

Vitality refers to the ecosystem of energy or activity. Productivity is the ability of matter and energy transfer outside by ecosystem, which is the function in a concrete manifestation of ecological system. In the study of ecosystem health, productivity is an important indicator of ecosystem dynamic response, and biomass is a concrete manifestation of ecosystem productivity. In this project, it will directly govern sand 76667 hectares, getting treatment or control soil erosion area, increasing total forest resources and cover, and directly or indirectly increase the plant biomass, the land productivity. Therefore, the project can enhance the vitality of regional ecosystem.

(2) The impact on organizational power

Organizational power is the species composition of ecosystem structure and relationships between species, reflecting the complexity of ecosystem structure. Significant positive correlation is between biodiversity and ecosystem health. The more species an ecosystem has, the higher diversity index is, the more complex food web is, the greater ability of anti-interference and restore is, the more stable ecosystem has, therefore, biodiversity and ecosystem stability are closely related. On the other hand, the more complex of community structure is conducive to the maintenance of ecosystem nutrient cycling and energy flow. Therefore, biological diversity serves as an important indicator of response to organizational power. As previously mentioned, the project implementation can increase biodiversity, and

thus, it can improve ecosystem organizational power.

(3) The impact on resilience

Resilience is ability that community or ecosystem return to original state after disruption, including productivity and structure recovery, also known as resilience stability. Resilience aims at resistance force and resistibility. The current more call is resilience. Resilience is mainly derived from redundancy of community and community organ level. In this project, vigorously implement planting grass and trees, redundancy that naturally occurring of species and community level, which makes ecosystem resilience enhanced and self-repair capacity of ecosystem in this region improved.

Therefore, the project implementation has a positive impact on ecosystem health.

5.8 The impact of the program implementation on eco-service value

5.8.1 Evaluation of ecosystem service value

Ecosystem service is obtaining products and services supported by ecological direct or indirect, through ecosystem structure, process and function. These products and services are assurance of human life necessities and quality. And ecosystem service is the foundation of human existence and modern civilization. Its size is closely related with ecosystem biomass. In general, the greater the biomass is, the stronger the ecosystem services. Ecosystem service multi-value lies in its multi-versatility. All ecosystem services are mutually related to each other and mutually restrict each other in maintenance of regional ecological security.

Assessment procedures of the ecosystem service value are tree steps as following. First, determine the ecosystem types and divide quality levels of different ecosystem types. Different ecosystem has its own function and benefits. The size of them is related to not only ecosystem types, but also their own quality levels. Therefore, after determining the ecosystem types, analyze differences in system quality and divide into different hierarchical order, measure all types of different quality levels of the area, establish information systems of regional ecosystem type and quality level. Second, analyze ecological function and benefit of ecosystem types and levels, referring to various ecological service value assessment methods domestic and international, based on the special geographical and climatic conditions in the project area, the ecosystem services of the project area is divided into gas and climate

regulation, water conservation, soil formation and protection, biodiversity conservation, food

Table 5-11 The content of eco-service value considered by the evaluation

Ecosystem service function	Specific content of service function	Examples
Gas regulation	regulation of atmospheric chemical composition	CO_2/O_2balance, O_3 fence UV-B
Climate regulation	biological regulation on temperature, precipitation and other climate process	greenhouse gas regulation and influence on the formation of DMS
Water conservation	water retention and storage	water supply for catchment areas, reservoirs and aquifer
Soil formation and protection	process of soil formation	organic matter accumulation
Biodiversity conservation	providing habitat for settlement and temporary species	playing role on control and asylum for population
Food production	food that can be extracted from gross primary production	fruit of the capture and collection of agricultural supplies
Raw materials	raw materials that can be extracted from gross primary production	timber, fuel and fodder production
Recreation	providing recreation	eco-tourism and other outdoor leisure activities
Culture	providing non-commercial use	aesthetic, artistic, educational value

production, raw materials, recreation and culture, a total of 9 items (Table 5-11). Finally, assess ecological function price and total value of the ecosystem by analyzing, testing, quantitative services function.

The value of ecosystem services can be summarized into four categories. (1) Direct use value, mainly refers to the value of ecosystem products produced, including direct value from raw materials, landscape and entertainment. (2) Indirect use value, mainly refers to ecosystem services that can't be commercialized, such as biogeochemical cycle and hydrologic cycle that can sustain life-substance, maintaining species and genetic diversity, conservation of soil fertility, cleaning environment, maintaining balance and stability of atmospheric chemistry and other functions that support and maintain life support system. (3) Option value, is pay

willingness that people will be able to use some kind of ecosystem services directly and indirectly. (4) Existence value, refers to pay willingness for ensuring the continued existence of ecosystem services. it is the value of ecosystem itself.

Ecosystem service value is calculated by Costanza classic formula:

$$X_{ESV} = \sum A_k \bullet VC_k$$

Where, X_{ESV} is total value for ecosystem services (yuan), A_k is area of land using type in the study area (ha), VC_k is ecological value coefficient (yuan/(ha a))。 *ESV* is a quantitative method of ecosystem function, which although expresses as value specifically, but its absolute value does not refer to the size of creating income, it is only used to indicate ecosystem changes which caused by relative factors changes.

This paper used above method, and calculated the ecosystem services value and ecosystem service value transmission gain before and after the project implementation in project cities (countries, districts).

5.8.2 Ecosystem service value after the project implementation

It shows that (Table 5-12), the total value of ecosystem services is up to 224 million yuan in project area after implementation. Contribution rate of ecological service value in project cities (countries, districts) are very different, because of the combined effects that the distribution of various types of productive asset and per unit area strength of ecosystem services. Among them, the ecological service value contribution rate in Lingwu is biggest, of the total of 39.98%. It because the forest construction area in Lingwu is largest. The total area is 1.14×10^7 mu, and in Lingwu it is 4.8×10^6 mu, of which eco-shelter 14.17×10^6 mu, and enclosure and preserve 31.04×10^6 mu.

The calculated results show that larger contribution to eco-service from soil information and protection, biodiversity conservation and gas regulation after program implementation. In addition, climate regulation and water conservation are also accounted for 24.56% of the total service value.

Therefore, after the program implementation, the value of ecosystem service mainly shows indirect use value in the four kind of service value, that is, has a greater positive effect on the stability and balance of the environment, and life support systems' support and

maintenance.

Table 5-12 The ecosystem service value of different service functions for each subproject implementation (ten million yuan/a)

Service founction	Xingqing region	Pingluo county	Lingwu city	Yanchi county	Litong region	Qingtongxia city	Zhongwei city
Gas regulation	171.3	425.2	1098.1	493.8	132.5	327.7	225.7
Climate regulation	156.6	463.4	1164.7	536.5	118.8	270.0	240.7
Water conservation	160.7	420.0	1080.1	487.5	123.1	301.8	225.9
Soil formation and protection	223.2	672.1	1696.7	777.6	166.5	384.5	329.3
Biodiversity conservation	189.0	915.6	2178.4	1065.9	146.6	223.4	414.1
Food production	177.7	545.5	381.5	635.7	136.5	319.2	170.6
Raw materials	36.6	158.1	372.5	177.3	22.0	27.3	49.8
Recreation	83.3	65.9	239.6	74.8	61.2	204.9	22.5
Culture	42.2	45.6	149.1	52.9	31.6	102.3	15.5

5.8.3 The gain of ecosystem service value

Compare ecosystem services in project area between before and after implementation (Table 5-13, Fig. 5-7). The result shows that there are increases in varying degrees of ecosystem service in project area. Before the project, the total eco-service value is 8.1 million yuan/year, and after the project, it is 224 million yuan/year, an increase of 1.53 times, accounting for 8.39% of financial income of project area. Among them, in Lingwu city and Pingluo county it is particularly significant, and value transmission gain is 63.46 million yuan/year and 32.09 million yuan/year.

The primary cause that eco-service function value has significant increase in project area is that the western, northern and eastern of Ningxia are surrounding by Tengger Desert, Ulan Buh Desert and Mu Us Desert. Before the project, this area is generally desert steppe landscape or a mobile, semi-shifting sandy, vegetation serious degradation, intense desertification, ecosystem obvious degradation, lower value of ecosystem service. After completion of the project, there will be 1.14×10^7 mu new forest land, and meanwhile Yueya Lake and Sand Lake tourist attractions will be improved, three tourist areas that Changliushui, Binggou, Huangshagudu in Lingwu will be developed. Construction of the project will

significantly enhance ecosystem service, promote ecosystem restoration and development, and bring higher ecological results.

Table 5-13 The gain of ecosystem service value after project implement (ten million yuan/a)

Subprogram area	Xingqing region	Pingluo county	Lingwu city	Yanchi county	Litong region	Qingtongxia city	Zhongwei city	Total
The gain	839.6	3209.4	6345.7	2482	708.8	1511.1	1244.1	16340.7

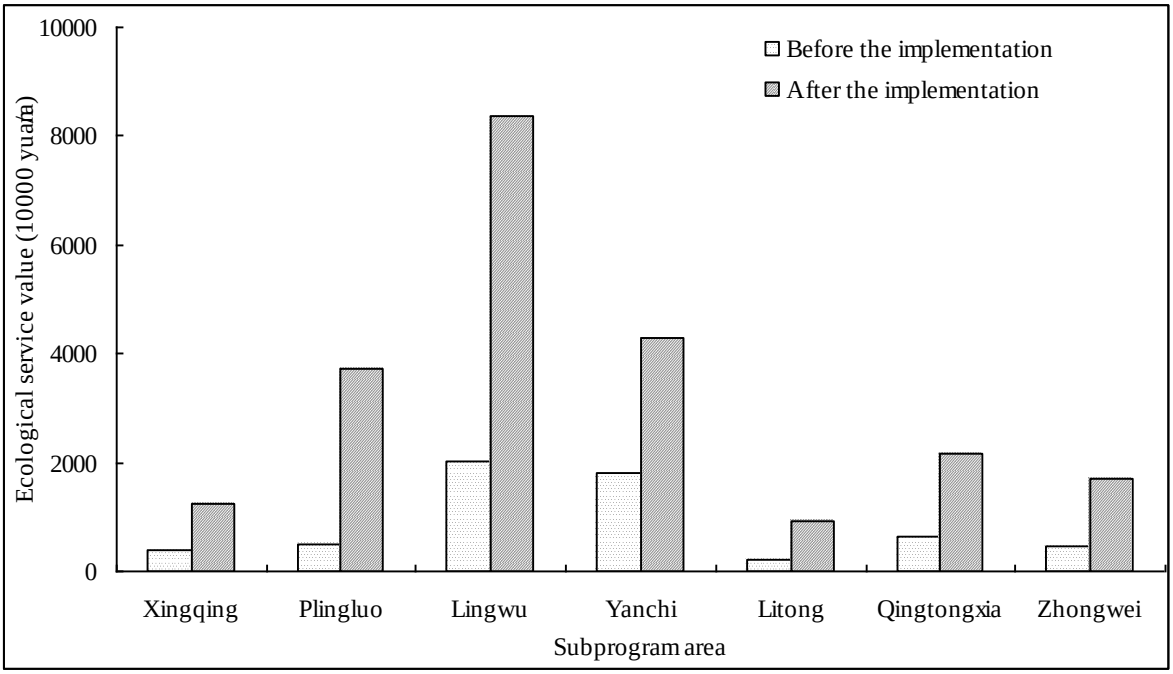


Figure 5-7 Comparison of eco-service value

between before/behind the program implementation for each subprogram regions

At the same time, implementation of the project will make changes on ecosystem services value structure. Among various ecosystem services, the maximum gain is soil formation and protection, reaching 42.5 million yuan, followed by biodiversity conservation and gas regulation, 33.7 and 29.5 million yuan, respectively. It is related with higher forest eco-service value per unit area and lower grassland value, on the other hand, related with local grassland desertification area and ratio is higher under the original landscape. Implementation of this project makes a substantial increase in ground vegetation, which can promote the accumulation of soil organic matter, playing a larger role in soil improvement, thus ecological service value of soil formation and protection is higher; meanwhile, the new 1.14×10^7 mu

woodland can absorb CO_2 7.6×10^8 kg, release O_2 5.6×10^8 kg, for playing a larger role in maintaining CO_2/O_2, so the value of gas regulation is higher. However, the gain and rate of food production are all the least, 1.8901×10^7 yuan and 3.1×10^4 yuan, respectively.

5.9 The effect of the project implementation on social economy

This environmental assessment only analyzed the social effect and economic effect qualitatively and conceptually because there was special team in charge of the effect of this project on the social and economic effects.

5.9.1 The possible social effects of projects implement

(1) improving the ecological environment of minority and strengthening the unite of Hui nationality and Han nationality

The project zones were the centralized areas where the Hui nationality lived. It was good to them to improve the ecological environment.

(2) Improving the technological consciousness and technology level

In course of the project implement, we plan to train 85 national technology staff, 2000 basic level technology backbones and they will be trained on the project management training by the professional people. Thus they will be trained technologically and professionally on the special knowledge, which could improve the production ability and management level of general public drastically. Meanwhile, we will draw into the modern concept, thinking method, production way to civilize the thought and activity of people.

(3) Increasing the income of farmers and promoting the development of agriculture, farmer and rural area

During the project construction, the farmers could acquire the service fee by joining the activity of forestation, improving the economy income of families. After the accomplishment of project, the farmers could acquire the income of economic tree seeds production sales, which could improve the living condition of local people and promote the development of agriculture, farmer and rural area.

(4) Increasing the opportunity of getting a job and promoting the social stability

It is the present situation that the labor force supply is more than demand and the flexible ratio of obtaining employment is in a low level. The economy increase model is lower

increase model, the rate and scale of labor force shift in countryside is on the increase, composing a high pressure of getting a job. The implement of this project, we need to buy mass of seedling, plant trees in a large area, seal a mountain pass and build fireproofing roads and water supply facilities, which need quantitative labor forces providing thousands of job opportunities. This provides new markets for the surplus labor forces, widening the job entering approaches.

(5) Increasing the local financial income and improving social situation

The zones located along the Yellow River create 90 percents of GDP in NingXia. The project regions are on the banks of Yellow River, which are also the mail force of economy in NingXia. After the construction of project, we foresee the financial profit will increase to a large extent, promoting the development of education and health.

(6) Making "golden banks of Yellow River" and ensuring upgrading industry

"Golden banks of Yellow River " are the economy lifeline, sight-seeing line, preventing flood line and ecology safety line. This project comprises the "golden banks of Yellow River" area, so the construction of project is in relationship with "golden banks of Yellow River". At the same time, the implement of this project will provide ecological safety because there are some important industrial locations and basic facilities such as YinChuan HeDong airport, NingXia NingDong resource basic location and so on.

(7) Be good to stable increase on GDP in NingXia

It can promote the regional development, reduce the distance comparing with the modern area and increase the GDP stably to implement the project. It depends on the ecology environment to improve the economy development on the one hand, on the other hand, it also depends on the direct income of project and pulling effect.

5.9.2 The probable economic effect after the implement of project

(1) Injecting development capital and producing snowball effects

According to the forecast, in the western area, 1 yuan could bring 2.5 multiple profits. This project plan to apply 80 millions from the world bank, which will bring 14 billion profit. More important, it will increase the speed of capital mobilization to inject capital and make larger economic effects.

(2) Increasing the production sum of primary industry

In the program, it will plant grape, medlar and red dates. If we take account for the medlar, the production value will be 0.56 billion. Obviously, it can improve the production value to implement the project.

(3) Increasing the production value of second industry

Primary industry could promote the progress of second industry. At present, NingXia Hong, QiNong, ShengQile, ZaoKang have been the main wine production of NingXia medlar. Additionally, the medlar wae also made into medlar soil, fruit juice and tea. NingXia grape that grow in ZhongWei zone have been the famous production material areas for some well-known brands of grape wine. And the local brands such as XiXiaWang, YuMa and so on reach 20, whose production ability nearly come to 60 thousand tons. The grape wine production was about 20 thousand tons. So, the implement of this project will increase the production value of second industry.

(4) Promoting the progress of tertiary industry

The implement of project will provide good ecological protection for YueYa lake, Sha lake, ChangLiushui, BingGou, HuangSha GuDu, BaiJiTan , YanChi HaBa lake reserve and some other travelling base. The improvement of ecology environment will promote the development of tourism.

5.10 The effects of project implementation on the livestock production

The project implementation has positive and negative effects on the livestock production. The main effects are positive.

5.10.1 The positive effects on the graziery

(1) It will provide material safeguard for livestock production to increase the feed supply

Proved by the practice, the livestock farming without grass background is not stable graziery. It is restricted graziery decreasing production. From a view of long time, the project implement will increase grass production per unit area, increasing resources of feed supply and creating condition for the development of graziery.

(2) Promoting traditional mode graziery production transform into intensive mode

Sealing maintains and setting barriers due to the project will decrease the areas of grassland and restrict the stock capacity of grassland, so the farmers would raise the stock

changing traditional mode. Proved by practice, the intensive mode of raising stock in huts will bring better economic effects. Take YanChi country in NingXia for example, the average farmland per person in countryside was 15 Mu in 1998, average grassland per person was 200 Mu, average income was 400 yuan. But after pasture inhibition, the income of everyone goes up to 1600 yuan, feeding on grassland reached 1020 yuan. LiuGuorrong and SuRina made researches on ChiFeng district in Inner Mongolia 20 thousand sheep in six countries, the results showed, the sheep woolen production of feeding in houses and feeding in houses half time increased by 20 percent- 50 percent, the weight increased by 5 percent-10 percent, the rate of breeding increased 5 percent-10 percent.

(3) Developing ecological graziery leading to benefit of ecology and graziery

The type of grassland in research zones were desert steppe and desertification grassland. It is famous for its insufficient water and the grassland degenerated nearly to desertification. Pasture will lead to grass production decrease and good grass to reduce or desertification. If we set barriers, seal sand and plant grass, the capacity of grass will improve, the economic effects will be better and the ecological effects will be improved, which meant the grassland restored. China-German cooperation projects in 1996 toke closure on Zhongwei mountain, 5 years later, the total vegetation coverage fome 35.0% in 1995 to 44.2% in 2000, and animal husbandry output value from 1.63×10^3 million yuan in 1995 to 2.57×10^3 million yuan in 2000. Obviously, ecological animal husbandry development makes ecology and animal husbandry get win-win.

5.10.2 The negative effects on the graziery

(1) Decreasing the areas of pasture and insufficient forage

The project will cover parts of the grassland leading to the decrease on the areas of grassland and insufficient forage, which will do damage to the development of pasture.

(2) Increasing financial input and decreasing profits

Sealing a mountain, setting barriers, pasture inhibition and planting grass compel the farmers to feed the livestock in the houses. However, the feeding in the houses needs a lot of manual labor and materials resources to acquire the forage, increasing production cost.

(3) Conflictimg minds of herdsman and decrease on graziery capacity

Due to setting barriers and pasture inhibition, the herdsmen have to feed the livestock in

the houses, which maybe is not acceptable to them. Because of high input on forage, low profits on graziery, the farmers have a low attitude of breeding livestock, so some of them sell the livestock, and some of them ddcrease the quantities of livestock.

(4) Popular diseases due to the high-density breeding

Breeding the livestock in the houses compels the animals to live in the houses, and the high density of breeding will increase the rates of disease spreading.

Described above, the project will have positive and negative effects on the graziery production, but the main effects are positive. Take the negative effects for example, it does not have much effects. From 2003, it is forbidden to pasture in NingXia. The present fences only increase the areas and not have direct effects on areas of pasture, minds of farmers and graziery capacity. We could improve the technology to solve the problems about feeding, for example, we could set some plastic greenhouses to breed the livestock in houses or half in houses, and we should pay attention to the technology of sheep bred to fat in houses, bred to fat in hot houses in winter, increasing fungus by pasture, and EM ferment shift to straw. We could remit the negative effects by these measures.

5.11 The impact on the site of Ming Great Wall

Ningxia is known as “Guanzhong barrier, Helong throat”. Great Wall has been built in Ningxia, from the Warring States Period to the Qin, Han, Sui, Ming dynasties. This Great Wall has rammed loess, build with sand, buttressed with stone, and thus known as “Chinese Great Wall Museum”. There are West, East, and Guyuan-Inside Great Wall in Ningxia. East Great Wall west Huangshazui, along the Yellow River 1km north of Hengcheng, east Shuidonggou, Hongshanpu, Qingshuiying, past Yanchi county, to Yanpuchang in Ding county, Shanxi, with a full length of more than 400 km. And every 150m is an abutment, Great Wall and abutments, beacon towers, connect around, it possesses some risk.

The total length of Great Wall in Ningxia reached more than 1500 km, located in 20 cities and counties. Among them, the site of Ming Great Wall is the most, which was build on the site of Sui Great Wall. The length of visible Ming Great Wall in Ningxia is more than 600 km, and the number of enemy broadcasting station is more than 500, beacons town is more than 200. Because of destroy by rush of mountain torrent, wind, rain and other natural erosion,

and human damage, there are groove, collapse, wall flake off and peel powder in the wall. Many are thrust by torrent, and the widest gap is more than 100m, the narrowest also has 3m. Most of the wall has become ruins, and some only has roots. From afar, it is difficult to find the grand momentum in those years. The wall that loess rammed less than knee tall. Therefore, the condition of the exiting Ming Great Wall preservation is sorrow, it is imperative to take protection measures.

In the project area, only Xingwuying afforestation site of Yanchi subprogram area is close with the Ming Great Wall, while other subprogram areas have no relation to the Great Wall. With respect to the Xingwuying afforestation site, it has 5 km distance with the Great Wall. When construction, under the condition of doing good propagandizing, the program implementation cannot produce negative effects on the Great Wall.

In the indirect environmental impact, the construction of arbor and shrub forest, enclosure sand vegetation and artificial afforestation on Xingwuying afforestation site, can increase green areas and coverage, make effective control of land desertification around Great Wall, and then play a sand-fixing and maintaining the ecological role of water and soil, which can reduce wind erosion and floods harm the Ming Great Wall.

According to uptodate information provided by the Autonomous Region program office, Yanchi progam office has adjusted to the Xingwuying afforestation site near the Ming Great Wall. Therefore, the project implementation has no any negative impact on Ming Great Wall.

6 The negative impacts of the program implementation on environment and their alleviating measures

6.1 Ecological water consumptions of woodland, shrub land and grassland

Water is the most important limiting factor of ecological construction, as project is performed in arid and semiarid areas. So, it is important to make a distinction among ecological water demand, ecological water use and ecological water consumption before calculating ecological water consumption of different vegetation. Firstly, ecological water demand is the water required to reach a certain ecological level or maintain ecosystem balance, or to expect the ecological function realizing, it includes water requirement of protecting and restoring natural vegetation along lower-middle reaches of continental rivers, water need of forest and grass construction beyond water and soil conservation and, water environment protection range, water demand of maintaining water and sand balance in river, or the base flow of ecology and environment in wetland and aquatorium, water need of diluting pollutants and purifying water body, or filling over-exploited groundwater et al. Ecological water demand can be divided into critical ecological water demand, optimum ecological water demand and saturated ecological water demand based on vegetation ecological system. Critical ecological water demand is the minimum water consumption to maintain plant living, once water consumption of ecology and environment is lower than it, the ecosystem would be destroyed and even crashed. Optimum ecological water demand is the water required by vegetation within normal function, especially preventive function, it is between the maximum and minimum water demand. Saturated ecological water demand is the water consumption when photosynthetic potential reaches the greatest level, once the supplying water is greater than it, ecosystem succession would occur under unbalanced hydrothermal condition. Vegetation ecological water demand may be considered as the water resource amount required and stored to keep plant growing healthily and ecosystem function performing normally under certain environmental condition, so does woodland ecological water demand which includes woodland evapotranspiration and soil moisture content.

Secondly, ecological water use is the water used in a certain ecological level and ecosystem balance, mainly embodied in the water accepted passively by ecosystem under current environment condition, it may not the reasonable and sustainable water amount. Thirdly, ecological consumption water underlines the water consumed by ecosystem especially organisms survival, such as evapotranspiration, needs to replenishment by ways of water cycle and runoff, reflecting periodism and repeat supplies characteristics. The relationship among the above three conceptions is that the ecological water demand is greater than the ecological water use and both of them are greater than the ecological water consumption.

It is thus clear that wood ecological water consumption is the water consumed by wood survival, including canopy interception and evapotranspiration, and evapotranspiration even consists of wood transpiration and woodland evaporation. Because woodland composition is complex, and evapotranspiration is related to many factors, furthermore, wood transpiration and woodland evaporation exist at the same time in vegetation area, and they shift followed by environment condition and woodland structure characteristics changes, so evapotranspiration is quantitatively expressed by water depth consumption of woodland ecosystem transpiration and evaporation, or water consumption amount by transpiration and evaporation per unit area at a certain period generally.

Evapotranspiration plays an important role in water cycle, as it is not only a key component in heat and water balance, but also relevant element between them, it is also a significant indicator of vegetation water condition, related with vegetation physiology activity and biomass forming closely. There are many factors influence woodland evapotranspiration, mainly affected by climatic condition, plant itself physiological ecology characteristic and growing condition, even soil water supply condition. Thus it extends three layers of evapotranspiration, which are potential evapotranspiration, maximum evapotranspiration and actual evapotranspiration. Potential evapotranspiration called reference evapotranspiration is a measurement of the atmospheric evapotranspiration ability, the value of it is not related with vegetation itself and water supply condition, only related with meteorological condition, indicating potential evapotranspiration ability under a certain climate condition, so it is also named climate evapotranspiration force. Maximum evapotranspiration called water demand usually, is the evapotranspiration when vegetation grow and develop normally under the

suitable water and fertility supply conditions, and then give full play to production potential, the value of it is related with atmospheric environment, vegetation ecological characteristics and growth condition. Actual evapotranspiration is the evapotranspiration of plant in soil actual moisture condition, the value of it is not only affected by atmospheric environment, vegetation ecological characteristics and growth condition, but also related to soil water. Some plant community evapotranspiration mainly depends on the water condition under a certain climate condition and growth status.

Project areas are in arid and semiarid zone within less precipitation and dry air, the evaporation of canopy interception is less, and even can be ignored, so wood ecological water consumption refers to wood evapotranspiration in project areas, including wood transpiration and soil evaporation. Thus, it is essential to calculate wood transpiration and soil evaporation in every month during growing season, and then ascertain the woodland evapotranspiration referred to wood ecological water consumption.

At present, the method often used to calculate wood transpiration is Penman-Monteith formula under water shortage condition. This method combines flux equation and energy equation together, including net radiation and saturation deficit, stomata resistance and aerodynamic drag. The result is quite stable by means of stomata resistance parameters measured by steady-state porometer and routine meteorological data. The Penman-Monteith formula is

$$LE = \frac{\Delta R_n + \rho C_p (e_t - e_a)/r_a}{\Delta + \gamma(1 + r_a / r_c)}$$

Among the formula, L — latent heat of vaporization, when temperature is t,L=2498.9-2.33t (J/g). E—the vapor flux of evapotranspiration (kg/m^{2}h). Rn—the net radiation received by canopy (W/m^2). ρ—air density, ρ=1.2837-0.0039t (kg/m^3). C_p—specific heat at constant pressure (1012J/kg·K). Δ—saturation vapor pressure—the slope of the temperature curve, Δ=5966.89× $10^{2.63/241.9+t}$/(241.9+t)^2. γ — constant of dry-wet table, γ=0.6455+0.00064t. r_a—aerodynamic drag (s/cm). r_c—canopy resistance (s/cm). e_a—the actual air vapor pressure (hPa), e_a=e_t×(RH/100). e_t—the saturation vapor pressure when temperature is t (hPa), e_t=6.11×$10^{7.63t/(241.9+t)}$. t—temperature(℃). RH—relative air humidity (%).

To assume differences among boundary resistance of momentum, heat and moisture transmission are small, so $r_{ah} \approx r_{av} \approx r_a$, and use stomata resistance of overall canopy (r_{st}) instead of canopy resistance (r_c), Penman-Monteith formula becomes as below

$$LT = \frac{\frac{P_0}{P}\frac{\Delta}{\gamma}(1-e^{-kLAI})R_n + \frac{\rho C_P}{\gamma}\frac{(e_t - e_a)}{r_a}}{\frac{P_0}{P}\frac{\Delta}{\gamma} + (1+\frac{r_{st}}{r_a})}$$

where, LT — canopy transpiration, LAI — leaf area index of canopy, k — extinction coefficient, P_0/P — barometric correction, $P_0/P = 10LH/18400(1+t/273)$, LH — altitude.

On the other hand, woodland soil evaporation can use the formula to calculate,

$$Q_a = \frac{R_0 \tau}{\pi \rho_{日地}^2}(\omega_0 \sin\varphi \sin\delta + \cos\varphi \cos\delta \sin\omega_0)$$

where, R_0 — solar constant (1353.73W/m^2), τ — time of day and night, $\rho_{\text{sun-earth}}$ — the mean distance between sun and earth based on astronomical unit(1.496×108 km), π — circumference ratio, ω_0 — sunrise angle, φ — geographic latitude, δ — declination.

If we use the above formula to calculate the evaporate and transpiration, we need vast of observed and meteorological data and the computation is more tedious, so we chose a method to estimate wood evaporate and transpiration closely to the actual situation that firstly need to calculate the potential evapotranspiration by meteorological data during every period, and then multiply by plant coefficient, the result is the wood water consumption of every period, the wood annual water consumption is the sum of every period water consumption.

Plant potential evapotranspiration reflects atmospheric evaporation capacity, the essence of it is that the influence meteorological factors have on plant water demand. The potential evapotranspiration is not only an important parameter to calculate plant water demand, but also a significant part of plant water consumption study. Potential evapotranspiration must possess two conditions, one is that soil water can supply sufficiently, resulting in evapotranspiration not decrease as water supply decrease. The other is that the surface must be covered a wide range of similar crop. In general, we called the calculated evapotranspiration under adequate water supply and short green grass growing condition as potential evapotranspiration, recorded as ET_0. There are many methods to calculate potential evapotranspiration, such as experience formula method, moisture diffusion method, energy

balance method and synthetic method et al, but Thornthwait method and Penman method are often used in forestry.

We chose Thornthwait method to calculate potential evopotranspiration in project area as it is suitable for arid and semiarid area. The formula is as below

$$ET_{oi} = 1.6Kd(\frac{10Ti}{I})^{a},\ I = \sum_{i=1}^{12}(\frac{Ti}{5})^{1.514},$$

$$a=6.75\times10^{-7}I^{3}-7.71\times10^{-5}I^{2}+1.792\times10^{-2}I+0.49239$$

Among the formulas, ET_{oi}—potential evopotranspiration of a certain month, T_i—mean temperature of a month, K_d—correction coefficient of average daylength, I—thermal-effect index, equivalent to sum of 12 months', a—experience index.

According to Ningxia yearbook of 2009, we can get the average temperature of the project area in every month as in Table 6-1. The months of average temperature blow zero are wiped off as their evapotranspiration reach to zero. Potential evapotranspirations of the other months are calculated by Thornthwait method, the annual potential evapotranspiration of each project area is the sum of every month's. Because there are differences of average temperature among project areas, so the potential evapotranspiration differs from one another. That is to say, the lower of the temperature is, the lager is the potential evapotranspiration. It is indicated that plant transpiration and soil evaporation is relatively lager in lower temperature, so does the ecological water consumption of woodland and grassland. As is shown in Table 6-2, the annual potential evapotranspiration of Yanchi county is the largest as 762 mm, and Lingwu city is 732 mm, Qingtongxia city 728 mm and Zhongwei city 723 mm, the next, followed by Pingluo county, Xingqing district and Litong district. It is indicated that meteorological factors have different impact on plant water demand, the lager of the impact is, the higher is the potential evapotranspiration.

Table 6-1 The monthly average temperature for each subprogram area(℃)

Region	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Pingluo	7.1	13.4	18.9	23.7	24.7	22.2	17.0	10.6	3.0
Xingqing	7.3	13.4	19.1	23.5	24.6	21.9	17.0	10.7	3.0
Lingwu	6.5	12.8	18.3	22.4	23.8	20.9	15.8	9.4	2.7
Yanchi	5.3	11.1	17.3	21.8	23.1	19.8	15.1	8.4	0.6
Litong	7.6	13.8	19.5	23.8	24.9	22.1	17.1	11.3	3.7
Qingtongxia	6.8	13.2	18.3	22.4	23.6	20.9	15.8	10.2	3.6
Zhongwei	6.5	13.1	18.3	22.6	23.1	21.5	15.1	9.8	3.4

Table 6-2 The monthly and annual potential evapotranspiration for each subprogram area (mm)

Region	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
Pingluo	22.7	53.6	94.0	127.8	147.5	127.6	81.5	42.9	7.0	704.6
Xingqing	23.6	53.8	95.8	126.9	147.2	125.8	81.8	43.6	7.1	705.6
Lingwu	22.5	56.5	100.9	132.7	157.2	131.8	82.7	40.9	6.8	732.0
Yanchi	19.4	52.8	106.0	145.0	171.2	138.9	88.2	39.8	1.0	762.2
Litong	24.0	53.9	94.7	124.1	144.0	122.5	79.3	45.2	9.0	696.7
Qingtongxia	23.5	57.8	99.0	130.2	152.4	129.3	81.1	44.8	9.9	727.9
Zhongwei	23.5	56.7	98.8	131.3	151.3	128.6	81.4	45.3	9.0	725.8

The other significant parameter to calculate wood water consumption is the plant coefficient, which reflects the impact of wood itself biological characteristics, production level and soil condition on wood water demand. The formula is expressed as the ratio of wood ecological water consumption (ET_c) to reference crop evapotranspiration (ET_0) at the same period, i.e,

$$K_c=ET_c / ET_0$$

Among the formula, K_c—plant coefficient, ET_c—wood ecological water consumption, ET_0—reference crop evapotranspiration.

The plant coefficient K_c is the empirical parameter gained by the measured data of three years at least. The plant coefficients of tree, shrub and grass are shown in Table 6-3 according to the reference (Duan, 2008), the relationship of them is tree's > shrub's > grass's depending on themselves own physiological property.

Table 6-3 The plant coefficients (K_c) of tree, shrub and grass

Vegetation type	Tree	Shrub	Grass
Plant coefficient K_c	0.81	0.41	0.28

There is ecological economic forest dominated by jujube, vine and almond tree designed in project area besides protection forest and grassland. The water consumption of ecological economic forest can not be calculated simply by the Thornthwait method, but to use the irrigation quota to calculate.

We can calculate the ecological water consumption of tree, shrub and grass according the

above parameters such as evapotranspiration. The results are shown in Table 6-4. It is found that the relationship of ecological water consumption among different plant types is arbor's >shrub's >grass's.

Table 6-4 The ecological water consumption of grassland and different woodland for each subprogram area (mm)

Region	Arbor forest	Shrub forest	Grassland	Eeconomic forest
Pingluo	570.76	288.90	197.30	518.40
Xingqing	571.53	289.29	197.57	518.40
Lingwu	592.94	300.13	204.97	518.40
Yanchi	617.37	312.50	213.41	518.40
Litong	564.31	285.64	195.07	518.40
Qingtongxia	589.61	298.44	203.82	518.40
Zhongwei	587.94	297.60	203.24	518.40

There are differences in ecological water consumption of the same plant type among different project areas besides economic forest with same irrigation volume, resulting from the different potential evapotranspiration in different project area. Moreover, potential evapotranspiration is related to environment and climatic factors, that is to say, the differences in ecological water consumption of the same plant type result from different environment and climatic factors in project area itself.

According to areas of grassland and woodland in project, and their ecological water consumptions (Table 6-4), we can calculate the total ecological water consumption in project area. As is shown in Table 6-5, the ecological water consumption is the largest of 0.8214×10^8 m^3 in Lingwu city, and Yanchi county of 0.2846×10^8 m^3 the next followed by Pingluo county, Xingqing district, Qingtongxia city and Zhongwei city, the ecological water consumption is

Table 6-5 Total ecological water consumption of grassland and different woodland for each subprogram area ($10^8 m^3$)

Region	Arbor forest	Shrub forest	Grassland	Eeconomic forest	Total
Pingluo	0.0000	0.0000	0.2430	0.0000	0.2430
Xingqing	0.0272	0.0089	0.1190	0.0086	0.1637
Lingwu	0.0510	0.0165	0.7504	0.0035	0.8214
Yanchi	0.0086	0.1204	0.1573	0.0000	0.2864
Litong	0.0317	0.0220	0.0186	0.0000	0.0723
Qingtongxia	0.1232	0.0283	0.0085	0.0000	0.1601
Zhongwei	0.0000	0.0000	0.0871	0.0000	0.0871

the lowest as 0.0723×10^8 m^3 in Litong district. This is related with forest type and size

programmed in project area. As there are differences of ecological water consumption in different forest types, which is tree's >shrub's >grass's, so the larger of the arbor and economic forest programmed area is, the larger is the total ecological water consumption, and the larger of the shrub and grass programmed area is, the lower is the total ecological water consumption relatively.

The result of ecological water consumption about different forest and grassland after project implementation is shown in the above. In order to further assessment of ecological water consumption, we need to calculate the ecological water consumption in different site type such as woodland, farmland, sand and moving sand with 5% coverage before project implementation to make comparation.

Likewise, farmland evopotranspiration is the sum of crop transpiration and soil evaporation in a period, related to meteorological condition (solar radiation, wind speed, temperature and humidity et al), soil humidity, crop species and type et al. Farmland evopotranspiration as the important parameter of farmland water consumption also can be estimate by experience using plant coefficient. Wheat and corn are the main crops in project area, the average annual evapotranspiration of wheat is 357.6 mm and corn's is 340.4 mm according to the reference (Wu et al, 2006). We can use the average of wheat and corn annual evapotranspiration (349 mm) representing farmland evapotranspiration to calculate annual water consumption of the farmland.

On the other hand, sand evapotranspiration may be calculated by land use/cover type (Zhou et al, 2006). Sand evapotranspiration is about 170 mm, the evapotranspiration of moving sand with 5% coverage is 121 mm. Grassland evapotranspiration can be calculated by potential evapotranspiration multiplied its plant coefficient.

Table 6-6 Ecological water consumption for each subprogram area before project implementation ($10^8 m^3$)

Region	Woodland	Farmland	Sand	Moving sand with 5% coverage	Total
Pingluo	0.0000	0.0000	0.0831	0.1018	0.1849
Xingqing	0.0143	0.0058	0.0049	0.0489	0.0740
Lingwu	0.0268	0.0024	0.1812	0.2411	0.4516
Yanchi	0.0791	0.0000	0.0434	0.0857	0.2082
Litong	0.0242	0.0000	0.0002	0.0078	0.0322
Qingtongxia	0.0575	0.0000	0.0000	0.0035	0.0610
Zhongwei	0.0000	0.0000	0.0203	0.0420	0.0623

According to the above theoretical direction and analysis of actual situation about site type in project area, we can get the results of ecological water consumption in project area with various site type before project implementation (Table 6-6).

As is shown in Table 6-6, the ecological water consumption in Lingwu city was still the largest with 0.4516 $\times 10^8$ m^3 in original site before project implementation, and Yanchi county with 0.2082 $\times 10^8$ m^3 the next followed by Pingluo county, Xingqing district, Zhongwei city and Qingtongxia city, the ecological water consumption in Litong district was the lowest with 0.0322 $\times 10^8$ m^3. It is obvious that the ecological water consumption after project implementation increases significantly than it's before project implementation, but the increased extent is different in each project area (Table 6-7). It is found that the increased water consumption is the largest in Lingwu city with 0.3727 $\times 10^8$ m^3 because of project implementation, and Qingtongxia city with 0.1118 $\times 10^8$ m^3 the next, the increased water consumption in Zhongwei city is the lowest with 0.0302 $\times 10^8$ m^3. These divergences result from difference in programmed forest type, area of project and original site type. So it is essential to consider the divergence of ecological water consumption in project areas during the planning period, keep the increased ecological water demand supplying timely and sufficiently in order to make sure seedlings survive and grow normally, and even ensure the efficiency of the project implementation.

Table 6-7 The ecological water consumption before and after project implementation, and the difference between them for each subprogram area ($10^8 m^3$)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei
W_1	0.1853	0.0757	0.4522	0.2098	0.0337	0.0614	0.0637
W_2	0.2451	0.1754	0.8249	0.2899	0.0754	0.1732	0.0939
△W	0.0598	0.0997	0.3727	0.0801	0.0417	0.1118	0.0302

Note: W_1 represents the total ecological water demand before project implementation, W_2 represents the total ecological water demand after project implementation, ∆ W represents the difference between ecological water demand before and after project implementation.

Up to now, the Yellow River Water Conservancy Committee allocates $76 \times 10^8 m^3$ water quantity (see Ningxia Saving Water, 2011-02-25) to Ningxia. Although this program implementation need consume $0.796 \times 10^8 m^3$ water quantity each year, the majority of these water quantity is soil water and underground water, and the consumed water to surface water is less. This will be discussed as follow.

6.2 Water balance of woodland, shrubland and grassland

Water balance is one of the most important function and characteristic of ecosystem. Study of generalized water balance consists of soil-plant-atmosphere water balance according to plant individual to research water relationship. The principle aspects are that water reaches plant root by soil, and then enters root to axis through cell transmission, arrives in leaf by plant xylem, at last spreads to airspace by leaf stomata to participate in atmospheric turbulence exchange, forming a uniform and dynamic mutual feedback continuous system, which is the soil-plant-atmosphere continuous system. The narrow water balance studies characteristics of water supply and consumption and the relationship among water supply, consumption and storage in a certain time and specific space. Water balances of woodland, shrubland and grassland in the project area referrers to the narrow water balance, which mainly contains processes of precipitation, canopy interception, soil water movement, surface runoff and evapotranspiration et al. We can build the water balance equation by determining parameters of the above processes, using the difference between water input and output to reflecting the dynamics of the water storage in ecosystem.

In the water balance equation, precipitation is an important input item in water balance. The precipitation falls to vegetation upside through the interception by branches and leaves, when it reaches surface, its quantity, speed and time have changed. The features of precipitation include quantity, intensity and distribution et al. Canopy interception adsorbs rainfall based on balancing-act between tree surface tension and water gravity by branch, leaf and stem of canopy, or saves the rainfall in bifurcation of branch and leaf. The water intercepted by canopy is stored in the canopy temporarily, the most goes back to atmosphere by evaporating. So canopy interception is actually a method of water consumption by tree.

Soil water is affected by a number of causes such as rainfall characteristic, soil texture and surface feature, landform and vegetation characteristics et al. Part of the rainfall forms runoff to loss, and the other part enters soil and becomes soil water. At some region, a part of rainfall will recharge ground water by one-dimensional movement way. Soil water plays an important role in water circulation process, because it is the directing water resource of wood transpiration.

Surface runoff is the part of flowing along surface, which is an important factor caused water loss and soil erosion. There are many factors affecting runoff, such as quantity, intensity and distribution of precipitation, initial soil moisture, topography, soil type, vegetation type and plant wetting degree et al. The size and characteristics of runoff is the integrated reflection of hydrologic effect. The factors affecting runoff velocity are various, firstly, the size of slope, the larger the slope size is, the faster is the runoff velocity. Secondly, the roughness of soil surface, it is influenced by soil structure condition and decomposition degree of litter. Thirdly, the quantity of plant stems and litter on surface, which block runoff velocity directly. Fourthly, the slope length of runoff, the shorter the runoff slope is, the faster is the runoff velocity at the bottom in a series slope.

In conclusion, evapotranspiration contains evaporation and transpiration processes. Evaporation as physical process is the woodland soil water evaporating directly, including evaporation of the water intercepted by canopy and absorbed by litter, and free water surface of standing water et al. The factors affecting soil water evaporation are vegetation coverage, weather condition, soil texture condition et al. Transpiration is a process of water released by stomata and lenticels of all the plant in forest, which is physical and biological process affected by regulation of plant physiology activity. Evapotranspiration is the most important output in ecosystem water circulation. It is affected by energy supply condition, vapor transporting condition, water supply ability of evaporation medium et al. In these factors, energy supply mainly comes from solar radiation, vapor transporting condition dependents on vapor pressure deficit and wind speed, and water supply ability of evaporation medium is determined by precipitation, underlying surface properties and cultivation coefficient. Plant evapotranspiration in arid and semiarid area is not only regulated by meteorological factors, but limited by amount of available water for vegetation rhizosphere.

The above analysis, soil water balance equation of the artificial woodland is as below

$$\Delta W = P + C - I - A - B - E_t - F$$

Among the equation, ΔW—changes of soil water storage during observation period, *C*—total condensation water in steam state during observation period, *P*—precipitation, *I*—amount of rainfall intercepted by canopy, *A*—amount of surface runoff, *B*—amount of

runoff inside the upper soil, E_t—evapotranspiration, F—amount of deep percolation.

As project area lies in arid and semiarid region, the deep percolation doesn't exist practically, the amount of gaseous water condensation nuclear, runoff inside upper soil and rainfall intercepted by canopy is negligible. Moreover, project area is mainly the sandy land with poor storage capacity and fast leakage, so it doesn't produce surface runoff. Thus, F, C, B, I and A in the equation can be neglected. The above equation can be simplified as

$$\Delta W = P - E_t$$

It can be seen that precipitation and evapotranspiration are important components of water balance in plant community of project area. In the forest research, it just uses the difference between precipitation and evapotranspiration to represent the soil water deficit, reflecting the balance relationship between wood water demand and soil water supply. That is to say, soil water deficit is another measurement for water balance in project area, it can be use to measure the water balance of woodland, shrubland and grassland.

In the circumstance of lacking observed data, especially plant coefficient, soil water deficit of woodland can be expressed by the difference between potential evapotranspiration and precipitation, indicating that actual evapotranspiration may be lower than the potential evapotranspiration during a period resulting in the shortage of plant water demand. It can be expressed as

$$DEP = PE - P$$

Among the formula, DEP— soil water deficit in the calculating period (mm), PE—woodland potential evapotranspiration during the calculating period (mm), P—precipitation during the calculating period (mm).

The result as is shown in Table 6-8, soil water deficit exists in each month and each project area. The largest water deficit is in Qingtongxia city with 73.8 mm average monthly, Lingwu city and Zhongwei city the next with 72.5 mm average monthly, the lowest deficit is 67.3 mm average monthly in Pingluo county, others' are Yanchi county > Xingqing district > Litong district > Pingluo county. According the definition of soil water deficit, there are two factors to affect it which are potential evapotranspiration and precipitation. When the potential evapotranspiration is high and the precipitation low, the soil water deficit will be large, and

vice versa. The soil water deficits of other project areas range between the above two cases. As precipitation is concentrated in the July and August, so soil water deficit is lower relatively in each project area.

As for a time, whether actual precipitation can meet the demand of evapotranspiration is the main indicator to judge whether soil water deficit will occur or not. Potential evapotranspiration indicates capacity of water evaporation within a wide range of an area and is the result of multi-factors comprehensive embodiment in the area. In the project area, the actual water consumption can not reach to the level of potential evapotranspiration, so the soil water deficit calculated by the above formula is relatively higher. In order to make soil water deficit close to real facts, we use the difference between wood real

Table 6-8 Soil water deficit of every month for each subprogram area (mm)

Region	Index	Apr	May	Jun	Jul	Aug	Sep	Oct	Total	Average
Pingluo	PE	53.6	94.0	127.8	147.5	127.6	81.5	42.9	674.9	96.4
	P	10.3	1.3	4.0	90.1	56.3	35.6	6.3	203.9	29.1
	DEP	43.3	92.7	123.8	57.4	71.3	45.9	36.6	471.0	67.3
Xingqing	PE	53.8	95.8	126.9	147.2	125.8	81.8	43.6	674.9	96.4
	P	16.3	0.2	2.3	79.4	35.8	44.1	7.3	185.4	26.5
	DEP	37.5	95.6	124.6	67.8	90.0	37.7	36.3	489.5	69.9
Lingwu	PE	56.5	100.9	132.7	157.2	131.8	82.7	40.9	702.6	100.4
	P	20.3	0.3	4.5	55.0	45.8	57.4	11.9	195.2	27.9
	DEP	36.2	100.6	128.2	102.2	86.0	25.3	29.0	507.4	72.5
Yanchi	PE	52.8	106.0	145.0	171.2	138.9	88.2	39.8	741.8	106.0
	P	10.1	1.5	0.4	27.4	107.8	93.0	6.0	246.2	35.2
	DEP	42.7	104.5	144.6	143.8	31.1	-4.8	33.8	495.6	70.8
Litong	PE	53.9	94.7	124.1	144.0	122.5	79.3	45.2	663.6	94.8
	P	13.4	0.1	3.1	45.6	45.9	62.4	7.4	177.9	25.4
	DEP	40.5	94.6	121.0	98.4	76.6	16.9	37.8	485.7	69.4
Qingtongxia	PE	57.8	99.0	130.2	152.4	129.3	81.1	44.8	694.5	99.2
	P	14.3	0.3	1.9	52.8	42.3	56.5	9.6	177.7	25.4
	DEP	43.5	98.7	128.3	99.6	87.0	24.6	35.2	516.8	73.8
Zhongwei	PE	56.7	98.8	131.3	151.3	128.6	81.4	45.3	693.3	99.0
	P	15.2	2.3	3.1	54.7	43.2	57.2	10.4	184.3	26.6
	DEP	41.5	96.5	128.2	96.6	85.4	24.2	34.9	509.0	72.5

evapotranspiration and water demand to express the water deficit, the formula is

$$DEP = ET_C - ET_0$$

Among the formula, *DEP*—soil water deficit in calculating period (mm), ET_C—wood

real water demand during calculating period (mm), ET_0—wood real evapotranspiration during calculating period (mm).

The soil water deficits of tree, shrub and grass can be calculated by the above formula. As is shown in Table 6-9, tree water demand > shrub water demand > grass water demand, but tree real evapotranspiration is not much lager than shrub's and grass', so soil water deficit of tree is lager than shrub's and grass'. The water demand, real evapotranspiration and soil water deficit of tree, shrub and grass in June and July of theirs growing season are lager than other months. That is because soil water does not meet the water demand by wood and grass normally growing in June and July with less rainfall and dry air condition, resulting in lager difference between real evapotranspiration and water demand of wood or grass and then forming the worst months of the soil water deficit. To compare the soil water deficit calculated by potential evapotranspiration, June is the worst month of soil water deficit in the above two methods, but soil water deficit is relatively lower calculated by wood water demand and real evapotranspiration. The former method is based on woodland maximum productivity by supplying sufficient water and eliminating other negative factors, but the later method is based on insufficient water supply and effectively improvement of water use efficiency. They both reflect the supply-demand relationship between soil water and wood water demand but in different aspects.

Table 6-9 Soil water deficits of tree, shrub and grass in project area (mm)

Species	Index	May	Jun	Jul	Aug	Sep	Oct	Total
Tree	Water demand	92.43	156.43	124.14	67.56	48.68	41.89	531.12
	Real evapotraspiration	64.25	100.47	99.54	65.96	27.20	22.94	380.35
	Water deficit	28.18	55.96	24.60	1.60	21.48	18.96	150.77
Shrub	Water demand	54.77	103.21	116.81	65.25	41.41	30.41	411.85
	Real evapotraspiration	35.75	76.34	77.97	45.14	34.04	25.70	294.94
	Water deficit	19.02	26.87	38.85	20.11	7.37	4.71	116.92
Grass	Water demand	36.22	48.31	56.46	47.67	30.50	15.85	235.00
	Real evapotraspiration	24.78	33.05	38.63	32.62	20.87	10.85	160.79
	Water deficit	11.44	15.25	17.83	15.05	9.63	5.01	74.21

On the other hand, it is essential to consider water balance of project area before and after project implementation by equations as below

Before project implementation $\Delta W_1 = P_1 - ET_1$

After project implementation $\Delta W_2 = P_2 - ET_2$

Among the above equations, ΔW—change of water storage in project area, *P*—precipitation, *ET*—evapotranspiration, subscript "1"—before project implementation, subscript "2"—after project implementation.

The substraction of the above equations $\Delta W_2 - \Delta W_1 = (P_2 - P_1) - (ET_2 - ET_1)$

Simplified as $\Delta(\Delta W) = \Delta P - \Delta ET$

Among the new equation, $\Delta(\Delta W)$—the difference of water storage between after and before project implementation, if $\Delta(\Delta W) > 0$, indicating that water storage increases after project implementation, if $\Delta(\Delta W) < 0$, indicating its decreases. ΔP—the difference of precipitation after and before project implementation, ΔET—the difference of evapotranspiration after and before project implementation, if $\Delta ET > 0$, indicating that the evapotranspiration increases after project implementation, if $\Delta ET < 0$, indicating its decreases. The value of ΔP is too small to neglect.

The result (Table 6-10) shows that the evapotranspiration after project implementation is larger than it before project implementation. Because afforestation will consume more water, the larger the area is, the more is the water consumption, such as Lingwu city and Yanchi county, so water storage of each project area changes a lot. Project implementation makes the original storage decrease to provide ecological water consumption for wood. From water balance consideration, it needs artificial recharge such as irrigation from Yellow River or use underground water to maintain the original water balance if the water storage is unchanged or changed a little after project implementation.

Table 6-10 The evapotranspiration before and after project implementation, and the difference between them for each subprogram area ($10^8 m^3$)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei
ET_1	0.1853	0.0757	0.4522	0.2098	0.0337	0.0614	0.0637
ET_2	0.2451	0.1754	0.8249	0.2899	0.0754	0.1732	0.0939
△ET	-0.0598	-0.0997	-0.3727	-0.0801	-0.0417	-0.1118	-0.0302

Note: ET_1 represents the evapotranspiration before project implementation, ET_2 represents the evapotranspiration after project implementation, △ET represents the difference of evapotranspiration after and before project implementation.

6.3 Scenario analysis of minimum eco-environmental water demand

To ensure ecological service function of woodland ecosystem in project area, it is essential to considerate water demand and its threshold of woodland under different ecological environment protection goals, which is minimum eco-environmental water demand of woodland. This is important in Ningxia with water shortage problem. Thus, we need to calculate the minimum eco-environmental water demand based on the programmed woodland area according to ecosystem protection goal for project area.

The minimum eco-environmental water demand is the lower limit threshold of woodland water demand. It is the least water resource consumed and occupied by woodland to maintain its growing and ecological function, comprised of woodland minimum evapotranspiration and minimum soil water content. The woodland evapotranspiration is the consumption of ecological water demand, but soil water content is not. If water supply is lower than the minimum eco-environmental water demand, the woodland ecosystem will have been seriously affected.

The process to calculate the minimum eco-environmental water demand is as below.

Firstly, we can calculate the minimum soil water content (*MSMC*) and minimum evapotranspiration (*MET*) per month (or year) of woodland according to formula (1) and (2), and then calculate the minimum ecological water demand per month (or year) of woodland based on formula (3) and (4).

$$MSMC = W_{\min} \times A \times H \quad (1)$$

$$MET_j = (ET_{\min})_j \times A/1000 \quad (2)$$

$$MEWQ_j = MSMC + MET_j \quad (3)$$

$$MEWQ = MSMC + \sum_{j=1}^{12} MET_j \quad (4)$$

Aomong the above formulas, *MSMC*—minimum soil water content per month (or year) of woodland (m^3), $W_{\min}$—minimum soil water quota per month (or year) of woodland (m^3/m^3), *A*—woodland reasonable area to meet some ecological function (m^2), *H*—soil depth (m), MET_j —the minimum evapotranspiration of the month *j* (m^3), $ET_{\min}$—the minimum evapotranspiration quota of the month *j* (mm), $MEWQ_j$ —the minimum ecological water demand of the month *j* (m^3), *MEWQ* —the minimum ecological water demand of woodland (m^3).

As is shown in the above formulas, we need to determine the minimum soil water quota of woodland, the minimum evapotranspiration quota per month and woodland area to calculate the minimum eco-environmental water demand.

The minimum soil water quota of woodland is determined by soil water content, because woodland water demand mainly comes from soil. Soil water is divided in three forms as wilting humidity, field capacity and saturated water content based on characteristics of soil water status, humidity and absorbed and utilized degree by plant. There is a critical value of soil water content between field capacity and wilting humidity, the intensity of wood growth is not limited by the soil water content from field capacity to critical soil water content. When soil water content is between the wilting humidity and the critical soil water content, wood growth intensity decreases with soil water content decreasing. When soil water content gets to the content blocking plant growth, wood can only absorb water from soil to keep survival, but it growth is blocked lack of water supply. Wood survival is threatened by the shortage of water when soil water is between wilting humidity and the content blocking plant growth, wood does not completely absorb soil water when soil water content is under the wilting humidity.

Thus, the minimum soil water quota of woodland refers to available soil water content to keep wood survival and essential growth, accounting for around 40%-50% of field capacity. We take 45% of the field capacity to calculate in project area.

The minimum evapotranspiration quota of woodland is determined by actual evapotranspiration and potential evapotranspiration. Penman thinks that actual evapotranspiration is proportional to potential evapotranspiration under insufficient water supply condition.

$$ET_a = \beta \times ET_p \qquad (5)$$

Among the formula, ET_a—actual evapotranspiration (mm), ET_p—potential evapotranspiration (mm), β—coefficient of evaporation ratio, $\beta \approx \omega/\omega_k$, ω—available soil water content (m^3/m^3), ω_k—critical available soil water content (m^3/m^3), the value of ω_k accounts for around 70%-80% of field capacity, taking 75% to calculate here.

The actual evapotranspiration accounts for 60% of potential evapotranspiration according to formula (5) when soil maintains the minimum soil water quota, which is the minimum

evapotranspiration quota.

In conclusion, the eco-environment water demand is expressed as

$$W_f = \sum_{i=1}^{n} A_i \alpha H_S + \sum_{j=1}^{12} A_i ET_j \qquad (6)$$

Among the formula, W_f—eco-environment water demand of woodland, A_i—woodland area, α—percentage of field capacity or saturated soil water content, H_s—soil depth, taking 1.5 m, ET_i—actual evapotranspiration, i—the woodland serial number, n—the total number of woodland, j—month.

The field capacity in project area can reference to some researches of sand field capacity, the results of them are the field capacity of semi-fixed sand ranging between 4.62% and 7.89%, fixed sand between 7.69% and 9.58%, fixed sand degradation between 6.17% and 9.15%.

The minimum eco-environment water demand of woodland can be calculated by formula (6), so is optimum eco-environment water demand. When minimum water demand of vegetation in woodland accounts for 60% of it potential evapotranspiration, and minimum soil water demand of woodland accounts for 45% of field capacity, the result calculated by the formula is just the minimum eco-environment water demand. While minimum water demand of vegetation in woodland accounts for 80% of it potential evapotranspiration, and minimum soil water demand of woodland accounts for 80% of field capacity, the result by the formula is just the optimum eco-environment water demand. The result is shown in Table 6-11.

As is shown in Table 6-11, the minimum eco-environment water demand and optimum eco-environment water demand are both larger in Lingwu city, respectively 1.846×10^8 m^3 and 2.631×10^8 m^3, Yanchi county and Pingluo county the next with minimum eco-environment water demand of 0.7802×10^8 m^3 and 0.7136×10^8 m^3 followed by Xingqing district, Zhongwei city, Qingtongxia city, the minimum eco-environment water demand in Lingtong district is smaller, 0.1065×10^8 m^3. The differences of the minimum eco-environment water demand in project areas result from different programmed woodland area, site type, field capacity and potential evapotranspiration in project areas. Because water plays an important role in ecosystem of woodland, so it is essential to consider the minimum eco-environment water demand of project area before afforestation, and ensure the minimum water supply according

to afforestation plan and present situation of water resource in project area, in order to make sure the effect of recovery and reconstruction the ecological environment.

Table 6-11 The minimum and optimum eco-environment water demand for each subprogram area (10^8m^3)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei	Total
W_{min}	0.7136	0.2855	1.7743	0.7802	0.1065	0.1838	0.2499	4.1989
W_{opt}	1.0187	0.4083	2.5284	1.1099	0.1523	0.2621	0.3570	5.9878

Note: W_{min} represents the minimum eco-environment water demand; W_{opt} represents the optimum eco-environment water demand

6.4 The loss value analysis of eco-environment water demand shortage in project area

The shortage of eco-environment water demand affects normal ecological processes of ecosystem to some extent, resulting in ecosystem function loss and disorder. Therefore, it is necessary to analyze the loss of ecosystem value caused by eco-environment water demand shortage quantitatively.

Firstly, we need to determine the shortage of eco-environment water demand by present situation of eco-environment water consumption and demand, and then calculate the loss of ecosystem value.

Table 6-12 The present water consumption and shortage for each subprogram area (10^8m^3)

Region	PWC	W_{min}	W_{opt}	WS_1	WS_2
Pingluo	0.6708	0.7136	1.0187	0.0428	0.3479
Xingqing	0.2229	0.2855	0.4083	0.0626	0.1854
Lingwu	1.4643	1.7743	2.5284	0.3100	1.0641
Yanchi	0.6525	0.7802	1.1099	0.1277	0.4574
Litong	0.0846	0.1065	0.1523	0.0219	0.0677
Qingtongxia	0.1498	0.1838	0.2621	0.0340	0.1123
Zhongwei	0.1743	0.2499	0.3570	0.0756	0.1827

Note: PWC represents present water consumption, W_{min} represents the minimum eco-environment water demand, W_{opt} represents the optimum eco-environment water demand, WS_1 represents water shortage Ⅰ, WS_2 represents water shortage Ⅱ.

Setting two notable cases to discuss the problem of water shortage, (1) the water shortage calculated by the minimum eco-environment water demand and present water consumption (water shortage Ⅰ), (2) the water shortage calculated by the optimum eco-environment water demand and present water consumption (water shortage Ⅱ). The result

is shown in Table 6-12.

The loss value causing by eco-environment water demand is determined by the minimum of water shortage. As is shown in Table 6-12, the present water consumption in project area does not reach to the minimum and optimum eco-environment water demand, and the amount of water shortage is different in project area. The minimum water shortage in Lingwu city is the largest with 0.3100×10^8 m^3, and Yanchi county the next with 0.1277×10^8 m^3 followed by Zhongwei city, Xingqing district, Pingluo county, Qingtongxia city and Litong district. For the project area as a whole, the water shortage of the minimum eco-environment water demand ranges from 0.0219 to 0.31×10^8 m^3, of the optimum eco-environment water demand from 0.067 to 1.0641×10^8 m^3. We can arrange the priority of water by the value of the water shortage in project area.

According to "bucket theory" of economics, water shortage is the limited factor for the ecological process of ecosystem under other suitable conditions, resulting in the ecological loss dividing into direct loss and indirect loss. The direct loss is the value losing in the process of the environmental resource directly satisfaction people's production and consumption need. The indirectly loss is losing the function value of supporting the current production and consumption served by environment. The index system of value loss caused by eco-environment water demand shortage in project area is shown in Figure 6-1.

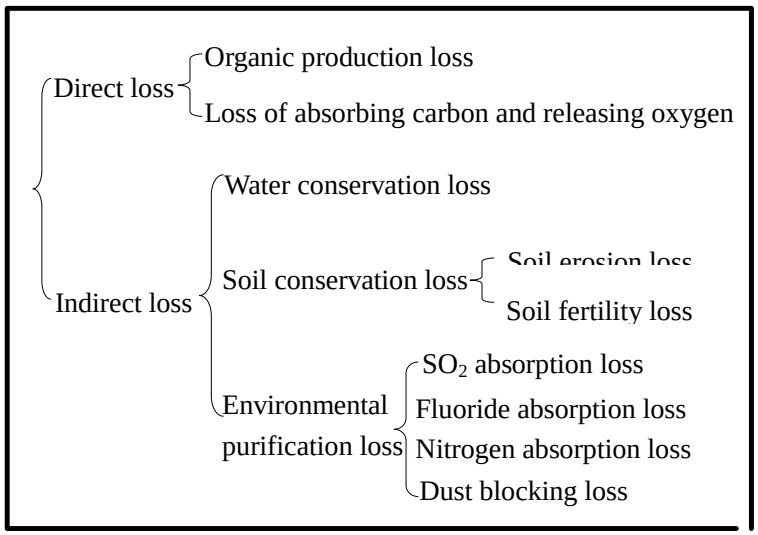


Figure 6-1 The index system of value loss caused by shortage of eco-environment water demand

The direct and indirect loss caused by eco-environment water demand are calculated as

follows

6.4.1 Direct loss

(1) The loss of organic production by vegetation in arid area

Plants synthetize organics from inorganic through photosynthesis, the organics can be taken directly and indirectly use as human or all animal food, and also as industrial materials. The equation of photosynthesis is

$$6CO_2+12H_2O \rightarrow C_6H_{12}O_6+6O_2+6H_2O$$

According to the above equation, we can extrapolate the organic production loss caused by shortage of eco-environment water demand by two substitution methods.

① Taking the direct use value to estimate the organic production loss caused by shortage of eco-environment water demand, the formula is

$$Q_1=P_m \times Q \times \alpha \times \beta \times \omega$$

Among the above formula, Q_1—the annual loss of organic synthetized by natural vegetation in arid area caused by annual shortage of eco-environment water demand according to photosynthesis mechanism, P_m —wood price, Q —the annual shortage of eco-environment water demand by natural vegetation, α—the ratio of photosynthesis water consumption to eco-environment water demand, β—the ratio per unit quantity of water to organic yield in photosynthesis process, ω—accumulation coefficient of organic production.

② Taking the substitution method of energy fixing to estimate the organic production loss. The value of organics produced by vegetation can be expressed by the quantity and price of energy stored by vegetation, the formula is

$$V_m = P_{coal} \times (Q_1 \times \lambda)/N$$

Among the formula, V_m—the annual loss of organic synthetized by natural vegetation in arid area caused by annual shortage of eco-environment water demand, P_{coal} — the price of standard coal, Q_1—the loss of organic synthetized by natural vegetation in arid area caused by shortage of eco-environment water demand, λ—energy accumulation coefficient per unit organics, N—energy accumulation per unit standard coal.

(2) Loss of absorbing carbon dioxide and releasing oxygen

Green plant constantly carries on photosynthesis, absorbing carbon dioxide and releasing oxygen to make their contents stable. We can adopt Zhou-Zhang model to calculate the loss of

absorbing carbon dioxide and releasing oxygen caused by shortage of eco-environment water demand. It is known from the photosynthesis equation that vegetation can absorb 1.62 g carbon dioxide and release 1.2 g oxygen when it synthetizes 1 g dry matter. The formula is

$$V_E = P_{CO2}Q_1\alpha_1+P_{O2}Q_1\beta_1$$

Among the above formula, V_E—the annual loss of absorbing carbon dioxide and releasing oxygen by vegetation in arid area caused by annual shortage of eco-environment water demand, P_{CO2}—the tax rate of CO_2 stated by Carbon tax, P_{O2}—the industrial oxygen price, Q_1—the loss of organic synthetized by natural vegetation in arid area caused by shortage of eco-environment water demand, α_1—the coefficient of CO_2 consumption per unit organic production, β_1—the coefficient of O_2 release per unit organic production.

6.4.2 The indirect loss

(1) Water conservation loss

When the eco-environment water demand is not satisfied, the organic production will decrease, resulting in the timber stock volume decrease and the function of water conservation falling. According to woodland area converted by the loss of organic production from the average timber stock volume decrease, it is used the alternative engineering method based on the water conservation quantity per unit woodland area. The formula is

$$V_w = f(Q\times\alpha\times\beta\times\omega/q_1)\times q_2\times P_{water}$$

Among the above formula, f— the stage coefficient of regional development, Q—the annual shortage of eco-environment water demand for natural vegetation, α—the ratio of photosynthesis water consumption to eco-environment water demand, β—the ratio per unit quantity of water to organic yield in photosynthesis process, ω—accumulation coefficient of organic production, q_1—timer stock volume per unit area of vegetation in arid area, q_2—water conservation quantity per unit area of vegetation in arid area, P_{water}— water price.

(2) Soil conservation loss

Soil conservation functions of vegetation in arid area include reducing soil erosion, alleviating sediment deposition in rivers and lakes, and conservation soil fertility et al.

① Soil erosion loss, the formula is

$$V_1=(Q\times\alpha\times\beta\times\theta/q_1)/A_s\times P_{land}$$

Among the above formula, Q—the annual shortage of eco-environment water demand

for natural vegetation, α—the ratio of photosynthesis water consumption to eco-environment water demand, β—the ratio per unit quantity of water to organic yield in photosynthesis process, q_1—timer stock volume per unit area of vegetation in arid area, θ—the reduced soil loss per unit area of vegetation in arid area, A_s—the thickness of soil plough layer, P_{land}—land price.

② Soil fertility loss

Soil erosion takes away lots of soil nutrients, mainly as organic matter, nitrogen (N), phosphorus (P), potassium (K). It is mainly to estimate the soil fertility loss caused by N, P and K here, the formula is

$$V_2=(Q\times\alpha\times\beta/q_1)\times\theta\times\rho\times\sum(P_{1i}\times P_{2i}\times P_{3i})$$

Among the above formula, i —soil organic matter (N, P, K), ρ—soil volume per unit mass, P_{1i} —the content of soil organic matter, P_{2i}—the ratio of organic matter converting to fertility, P_{3i}— the sales price of spending, the rest parameters are same as the above.

(3) Environmental purification loss

According to forest area converted by the loss of organic matter production caused by shortage of the eco-environment water demand, we can calculate the environmental purification loss, including SO_2 absorption loss, fluoride absorption loss, nitrogen oxides absorption loss, dust blocking loss, sterilization loss and noise reducing loss et al.

① SO_2 absorption loss

The formula is $V_1= Q\times\alpha\times\beta\times\omega/q_1\times B_1\times\eta_1$

Among the formula, B_1—the average ability of absorbing SO_2 per unit woodland area, η_1—cost of SO_2 treatment per unit. The rest parameters are same as the above.

② Fluoride absorption loss

The formula is $V_2= Q\times\alpha\times\beta\times\omega/q_1\times B_2\times\eta_2$

Among the formula, B_2—the average ability of absorbing fluoride per unit woodland area, η_2—the standard charge per unit of fluoride discharge. The rest parameters are same as the above.

③ Absorption nitrogen oxides loss

The formula is $V_3= Q\times\alpha\times\beta\times\omega/q_1\times B_3\times\eta_3$

Among the formula, B_3—the average ability of absorbing nitrogen oxides per unit

woodland area, η_3 —the standard charge per unit of nitrogen oxides discharge. The rest parameters are same as the above.

④Dust blocking loss

The formula is $V_4 = Q \times \alpha \times \beta \times \omega / q_1 \times B_4 \times \eta_4$

Among the formula, B_4—the average ability of blocking dust per unit woodland area, η_4—price of blocking dust, using the charge standard of atmospheric pollutants emission from coal-fired furnace here. The rest parameters are same as the above.

The parameters of calculating the value loss caused by shortage of eco-environment water demand are shown in Table 6-13.

Table 6-13 Parameters of calculating loss caused by shortage of eco-environment water demand

Parameter		Value	Parameter		Value	Parameter		Value
P_{coal}	¥/t	300	P_{water}	¥/t	6.703	P_{3K}		1400
λ	kJ/g	6.7	θ	$m^3/(hm^2\ a)$	250	δ	%	24
N	kJ/g	10	ρ	t/m^3	1.1	σ	t/m^3	1.28
P_m	¥/m^3	127.3	A_s	cm	50	P_1	¥/m^3	5.714
α		1	P_{land}	¥/hm^2	5480.5	P_2	¥/t	12.33
β		0.83	P_{1N}	%	0.19	B_1	$kg/(hm^2\ a)$	215.6
ω		1.1	P_{2N}		132/14	η_1	¥/(t a)	600
P_{co2}	¥/t	135.5	P_{3N}		2200	B_2	$kg/(hm^2\ a)$	2.277
P_{o2}	¥/t	100	P_{1P}	%	0.02	η_2	¥/(t a)	160
α_1		1.62	P_{2P}		132/31	B_3	kg/hm^2	6
β_1		1.2	P_{3P}		2200	η_3	¥/(t a)	1340
q_1	m^3/hm^2	25.12	P_{1K}	%	0.08	B_4	t/hm^2	21.655
q_2	$t/(hm^2\ a)$	492.1	P_{2K}		75/39	η_4	¥/(t a)	560

The loss value caused by shortage of minimum eco-environment water demand is shown in Table 6-14, the result shows that the economic losses caused by shortage of eco-environment water demand should not be neglected. The loss value is largest in Lingwu city with $¥65.184\times10^8$,Yanchi county with $¥26.913\times10^8$ the next followed by Xingqing district, Pingluo county, Qingtongxia city, Zhongwei city and Litong district. The differences of the loss values in project areas result from the amount of water shortage when the minimum eco-environment water demand is unsatisfied in project area. The loss value has a positive correlation with minimum eco-environment water shortage, the larger it is, the lager is the loss value, and vice versa. Other project areas are between these two cases. We can see the value of ecological function from the side through the value loss degree of the vegetation

ecological benefit in project area. If the present water resource situation can satisfy the minimum eco-environment water demand in project area, the loss value caused by ecological water shortage will be saved. That is to say, as long as minimum eco-environment water demand is satisfied in project area, the value of ecological function will be create at least equal with the loss value caused by water shortage. Thus, it is very key and essential to make sure water supply, at least reaching to minimum eco-environment water demand in process of project implementation.

Table 6-14 The loss value caused by shortage of minimum eco-environment water for each subprogram area (10^8 yuan)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei
OPL	5.785	8.390	41.302	17.053	2.999	4.694	4.570
ACROL	1.231	1.785	8.788	3.628	0.638	0.999	0.972
CWL	0.522	0.756	3.724	1.537	0.270	0.423	0.412
SEL	0.394	0.571	2.812	1.161	0.204	0.320	0.311
SFL	0.172	0.249	1.226	0.506	0.089	0.139	0.136
ASL	0.205	0.297	1.460	0.603	0.106	0.166	0.162
AFL	0.067	0.097	0.478	0.197	0.035	0.054	0.053
ANL	0.213	0.309	1.520	0.628	0.110	0.173	0.168
BDL	0.543	0.787	3.873	1.599	0.281	0.440	0.429
Total	9.130	13.241	65.184	26.913	4.733	7.408	7.213

Note: OPL- organic production loss, ACROL- loss of absorbing carbon and releasing oxygen, CWL-loss of water conservation, SEL-soil erosion loss, SFL-soil fertility loss, ASL-loss of absorbing SO_2, AFL-loss of absorbing fluoride, ANL-loss of absorbing nitrogen oxides, BDL- loss of blocking dust.

6.5 The influence of project implementation on groundwater resource

The groundwater resource is referred as the general term of various underground waters with available value, and continuous replacement ability, part of earth water resource. It is the important material condition on which plant growth, human living and society development relies. The groundwater resource is susceptible to various factors such as geology, geomorphy, soil, vegetation, hydrogeology, hydrology and meteorology, and anthropic factors, such as construction irrigation facilities, excavation irrigation canal, irrigation and exploiting groundwater resource et al. The quality and yield of it changes anytime and anywhere, but it replenishment and consumption forms the dynamic balance usually. During a year, groundwater is mainly consumed in dry season, and will be replenished in rainy season. It is found from the interannual change that groundwater consumption is more than the

replenishment in dry years, but in wet year, the groundwater replenishment by rainfall infiltration can not only meet the demand of water consumption itself, but also offset the water deficit caused in dry year. Thus, keeping dynamic balance of groundwater resource is the basic principle to utilize it rationally.

In order to analyze the impacts of project implementation on groundwater resource, firstly, we must find out the present status of groundwater resource and its available utilization, as well as development potential in project area, and estimate groundwater consumption by grassland, and other woodlands to take groundwater impact assessment. Then, we can realize the rational development and utilization of groundwater resource to ensure the ecological restoration project implementation smoothly.

There are two significant characteristics of groundwater in project area, the one is bad water quality. Mineralization degree of groundwater is 1-2 g/L mainly in Pingluo county, and < 1 g/L the next, 2-3 g/L and >3 g/L showing flower distribution. In most part of Zhongwei city and Xingqing district, the mineralization degree of groundwater is 1-2 g/L, the other part <1 g/L, so is Qingtongxia city. In Hedong irrigation of Lingwu city, the mineralization is 1-2 g/L, it is higher in the northwest of 3-5 g/L as in Lingwu farm and Platanus village, but with smaller distribution. The mineralization degree is 1-2 g/L mainly in Litong district, part of it is <1 g/L. The water quality is worse along the Balang Lake and Golden-silver beach in southeast of Wuzhong city, the mineralization degree is 3-5 g/L, and even 10 g/L in Kidneny bay of the Golden-silver beach. In the north of Yanchi county, the mineralization degree is mainly 3 g/L with 3-5 mg/L of fluoride content. The other characteristic is the conversion relationship between groundwater and surface water closely. Shallow groundwater of Yellow River irrigation relies on irrigating canals and field leakage to recharge. The average recharge module of Yinchuan plain is more than 3×10^5 t/km^2 a,the phreaticline changes with the irrigation and unirrigation period, the Yellow River and phreatic water constitute the unified equilibrium circulating system.

The quantity of groundwater resource is the foundation whether this project can implement or not. In general, the groundwater resource is the most abundant with 3.43×10^8 m^3 in Qingtongxia city of project area (Table 6-15), and so is the exploitation with 2.4×10^8 m^3. Because there are many canals passed by Xigan canal, Hanyan canal and Tanglai canal *et al*.,

so the groundwater relies on surface runoff to recharge timely and sufficiently, resulting in groundwater resource abundance. The order of groundwater resource quantity in other project areas is Xingqing district, Litong district, Pingluo county, Zhongwei city, Lingwu city and Yanchi county. Changes of land use type of project area not only affect the groundwater replenishment, but also have effects on groundwater balance.

Table 6-15 The quantity of groundwater resource and available exploitation for each subprogram area

Region	Area (km^2)	Groundwater resource module ($10^4m^3/km^2$ a)	Groundwater resource (10^8m^3)	Available exploitation (10^8m^3)
Litong	426	49.200	2.100	1.730
Qingtongxia	697	49.200	3.430	2.400
Lingwu	376	49.200	1.850	1.300
Yinchuan	815	39.000	3.180	2.230
Zhongwei	445	55.600	2.470	1.730
Pingluo	1286	21.700	2.790	1.950
Yanchi	625	4.384	0.274	0.206

Table 6-16 The consumption of groundwater and soil water afterr project implementation for each subprogram area (10^8m^3)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei
Groundwater consumption	0.0109	0.0188	0.0331	0.0323	0.0357	0.0989	0.0335
Consumption of soil water	0.0923	0.0443	0.2976	-0.0031	0.0013	0.0067	0.0041
Total	0.1032	0.0631	0.3307	0.0323	0.037	0.1056	0.0376

Planting tree and grass on sand land results in evapotranspiration increase, causing the water consumption increasing. Tree, shrub and grass mainly consume groundwater in inter dune, but in slop dune and top dune they consume soil water. Learned from the on-site inspection, the inter dune accounts for 30% of total sand area in Xingqing district, and for 10% both in Pingluo county and Lingwu city. That is to say, construction vegetation in these areas of inter dune will consume groundwater resource, and the others of top and slop dune consume soil water. We can calculate the groundwater consumption by grassland and woodland after project implementation based on the basic information such as different land utilization types and areas, therefore to assess the impact on groundwater after project implementation.

The results of groundwater and soil water consumption are shown in Table 6-16, estimated by evapotranspirations of tree, shrub and grass, the annual average precipitation and the programmed areas of the project. As is shown in Table 6-16, the groundwater and soil water consumption is the largest with 0.3307×10^8 m^3 in Lingwu city, because the programmed area of woodland is relatively large, and the water deficit of the woodland and ecological economic forest is also large, so resulting in the largest groundwater consumption in Lingwu city. The next is Qingtongxia city with water consumption of 0.1056×10^8 m^3, also resulting from the programmed area of woodland. The order of groundwater consumption is Qingtongxia city, Xingqing district, Zhongwei city and Litong district, the minimum water consumption is 0.0323×10^8 m^3 in Yanchi county. According to the soil water consumption, it is the largest in Lingwu city, Pingluo county the next, the smallest is in Xingqing district. Because there is a large area of sand with more slope dune and top dune in Lingwu, the water consumed is mainly soil water. It is specially illustrating the situation in Yanchi county that tree and shrub all consume groundwater, and the precipitation can basically satisfies the needs of shrub and grass growth, even surplus, resulting in the negative groundwater consumption. We put them in the soil water consumption to emphasize the situation. Comparing the soil water, groundwater consumption and groundwater exploitation in project areas (Table 6-15), we can see that the groundwater consumption by planning in project area is far from its available groundwater exploitation except Yanchi county, in which the groundwater consumption by planning is close to its available groundwater exploitation. It is indicated that the quantity of groundwater resource in project area can support the task of afforestation and grass breeding on project planning areas.

6.6 The influence of project implementation on surface water resource

Surface water is the general term of various liquid and solid waters, including static water such as rivers, lakes, swamps, glaciers and permanent snow et al, and dynamic water such as river runoff, glacier runoff et al. In project area, there is only Yellow River flowed past, so the impact of project implementation on surface water is embodied in the utilization of Yellow River water.

As mentioned, Ningxia is located in the Yellow River basin, within 397 km length of

Yellow River on the territory. Since ancient times, water utilization mainly relies on Yellow River resources. According to solution of Yellow River water distribution by State Council in 1987, the available consumption of Yellow River water resource is $40\times10^8\,m^3$ in Ningxia, the Yellow River mainstream is $37\times10^8\,m^3$ and the branch is $3.0\times10^8\,m^3$. That is to say, the transit flow of Yellow River mainstream is $325\times10^8\,m^3$ every year, but available utilization for Ningxia is $40\times10^8\,m^3$.

Statistics indicates that (Table 6-17) the surface water resource is the most abundant in Pingluo county with $0.418\times10^8\,m^3$ in project area, and it is the lowest in Litong district with $0.131\times10^8\,m^3$, other project areas are in the above two situation. It is worth explanation that surface water resource in Yanchi county is not the lowest in project areas with $0.185\times10^8\,m^3$, higher than Lingwu city and Litong district, but its surface water resource distributes mainly in southern, not in the project area which is in north of Yanchi county, so the surface water resource is lower than its in Litong district.

Although the surface water is poor in project area, it is closely related to groundwater. Changes in pattern, method and degree of surface water resource development and utilization will affect groundwater relationship of recharging, runoff and discharge deeply. The quantity of recharge and discharge will cause changes of available exploitation finally.

In the project area, the implementation of ecological restoration projects such as afforestation, sealing sand to afforestation and grass breeding will affect surface water and

Table 6-17 The statistic of total surface water resource for each subprogram area

Region	District area (km^2)	precipitation ($10^8\,m^3$)	Surface water ($10^8\,m^3$)	Total water resource ($10^8\,m^3$)	Years of average water production module ($10^4\,m^3/km^2$)
Xingqing					
Zhongwei	13208	2.536	0.280	0.583	4.826
Lingwu	3685	7.247	0.165	0.229	0.621
Pingluo	2053	4.170	0.481	0.905	4.408
Litong	984	1.801	0.131	0.187	1.900
Qingtongxia	1886	3.025	0.225	0.324	1.718
Yanchi	6655	17.669	0.185	0.427	0.642

groundwater, as well as their convertion at the same time to a certain degree. And grass and different trees do not always consume single surface water or groundwater, sometimes they

use the two type of water at same time, for example, arbor forest consume surface water and groundwater at same time in Zhongwei city located in the irrigation area, although it is difficult to identify each part of water consumption, this is helpful for efficient utilization of water resource. Thus, it is important to combine using of surface water and groundwater in process of project implementation according to actual water resource utilization in project area, in order to balance surface water and groundwater resource. The advantage of this is mainly reflected in the following three aspects. Firstly, utilizing surface water or groundwater flexible. The shallow groundwater of the piedmont plain should be exploited and used sufficiently to decrease the strong invalid evaporation in dry condition, but the management of exploitation should be strengthened. For example, the surface water should be greatly used in wet season, the water-saving irrigation technique should be vigorously developed, such as converting the flood irrigation to sprinkler or drip irrigation, in order to save water resource. Secondly, improving underground water quality. The storage of surface runoff in wet reason can play the diluting effect on groundwater with high salt. Thirdly, adjusting groundwater level. The construction of the large reservoirs and irrigation region can increase the groundwater replenishment, and cause the groundwater level rise, resulting in the irrigation land waterlogging and secondary salinization. In these areas, some measures can be applied to resolve the above problems, such as utilizing groundwater with surface water drainage which can cause the groundwater level fall, and carrying out comprehensive treatment for drought, waterlogging and salinization. But groundwater excess exploitation will cause groundwater level fall, and long-term groundwater over-exploited will form a funnel of large area groundwater level fall, resulting in harms as ground subsidence et al. In this situation, the surface water can be indraught to make the groundwater exploitation decrease, and recharge groundwater to adjust groundwater level. According to the optimization scheme of surface water and groundwater, groundwater level should be control to safety range in serious soil salinization area, the optimal ratio of groundwater to surface water is 0.8-1.2, it is 0.6-0.8 in medium salinization area, and lower than 0.6 in area to a lesser degree of salinization. Thus, only making surface water and groundwater scheme optimizing can achieve the purpose of rational water resources utilization, and ensure the development of ecological restoration project smoothly.

Based on the analysis of surface water resource, the quantities of surface water resources are different in project areas, and so are the surface water consumptions of different programmed forest kinds in project areas.

The result is shown in Table 6-18, the surface water consumption is 0.0003×10^8 m^3 in Qingtongxia program area and 0.0001×10^8 m^3 in Lingwu program area, but there is no surface water consumption in Zhongwei city, Pingluo county, Xingqing district, Litong district and Yanchi county.

Table 6-18 The surface water consumption after project implementation for each subprogram area (10^8m^3)

Region	Pingluo	Xingqing	Lingwu	Yanchi	Litong	Qingtongxia	Zhongwei
Surface water consumption	0.0000	0.0000	0.0001	0.0000	0.0000	0.0003	0.0000

In conclusion,the total surface water consumption of the project implementation is 0.0004×10^8 m^3 per year in project area, accounting for about 0.00005% of the annual Yellow River water utilization. Thus, the project implementation almost has no effect on surface water resource.

On the other hand, the project implementation resists the sand input Yellow River, and effectively reduces the riverbed silt, in favor of Ningxia and NeiMenggu river regulation. This complies with the "Protection Planning of Water Resources" issued by the Yellow water resource conservancy commission. To a certain extent, the project implementation will be beneficial to surface water resources.

According to the calculation results of water balance and ecological water consumption theory, the project fully considers the variety of the precipitation within and between years, in arid and semi-arid areas, the project adopts the following mitigation measures, including increase the closure areas, select species with drought resistant and less evaporation such as Hedysarum scoparium, Caragana korshinskii etc., and establish straw check board, and barriers to realize the quick natural rehabilitation of the vegetation. These species can survive through precipitation without artificial watering.

In the areas with water sources and irrigation condition, the project designed protective shelterbelt plantation, there is no need to add new water sources, the plants can survive

through penetration water from agricultural irrigation.

With the adoption of the measures mentioned above, the implementation of the project will not cause major adverse impacts on the water resources in the project region. In the medium and long term, the project implementation will promote the economic development and ecological protection in the region, therefore the project is feasible.

6.7 Impacts of pesticide and fertilizer on environment duringr project implementation

6.7.1 Impact of pesticide application on environment

Metcal (1980) has estimated that the pesticide gushed from the spraying equipment only 25%-50% could sediment on plant leaves, less than 1% of it could deposit on the target pests, and only less than 0.03% could play the insecticidal role. Xu and Jiang (2005) indicated that 80%-90% of the used pesticides would go into soil, part of them could be absorbed by soil particles, especially by organic matter (some stable pesticide as 666, DDT residues in soil for 10 years). The residues of pesticides in soil can be calculated by the formula $R=C-KT$, among the formula, *R*—the pesticide residues, *C*—the quantity of pesticide use, *K*—constant, *T*—the time of applying pesticide. It is indicated that the longer the time of pesticide applying, the fewer is the pesticide residues, and the larger the quantity of the pesticide use, the larger is the pesticide residues.

Impacts of pesticide application on environment, firstly they show as the direct influence on soil, water and atmosphere. And then the indirect influence on animals and humans related with the environment. For the direct influence, impacts on soil contain all kinds of pesticides effects on various micro-organism species, number and activity related to soil fertility, plant development and growth and plant pathology. Water effects include the floating pesticide in air returning to soil with precipitation or directly drops, and than entering the surface water with the precipitation and irrigation water, or into the underground aquifer with permeable water, causing water pollution finally. Atmosphere effects mainly include air pollution caused by pesticides floating because of it underserved utilization. As for the indirect impacts, firstly, it is the damage on natural animals and microbes, pesticides will kill the pests and their natural enemies at the same time, resulting in the balance between animal and microbes lost.

Furthermore, pesticides dropped in soil will directly or indirectly kill soil microbes, thereby affecting the soil decomposed and air permeability, as well as wood growth and development. Secondly, the influence is on the relationship between the biological enrichment of pesticides and the food chain. Although pesticide residue in environment is little, it can be enriched continuous in biology through the food chain transformation, making its concentration of one hundred to tens of thousand of times improvement. Thirdly, the influence is on people and livestock. In the process of utilization, pesticides can pass alimentary tract, skin and respiratory tract into people and livestock's body directly. On the other hand, the pesticide residues in plant, soil and water will go into people and livestock's body through food or food chain indirectly. It is indicated the severity of direct and indirect influences by pesticide application on environment. Thus, it should strictly grasp pesticide dosage and master the applied method, in order to make harms on environment to the minimum in project implementation process.

In this project, the arbor forest of 5214.05 ha might use pesticide. There is no pesticide application in shrub land and sealing sand for afferestation and grass breeding. According to the average usage of pesticides for plant diseases and insect pest prevention every year during 2005 to 2009, the annual possible usage of pesticides can be calculated in project areas based on the programmed areas of arbor forest.

In conclusion, wide use of pesticides certainly causes great negative impacts on environment, but proper and reasonable use of pesticides can make the negative impacts into a permissible limitation. It is suggested to use biological pesticide such as matrine, nicotine, Bt, SNPV et al, and low mammalian-toxic pesticides such as chlorbenzuron, diflubenzuron, imidacloprid, fenoxycarb et al during the construction process.

6.7.2 Impacts of fertilizer application on environment

Wide use of fertilizer also has effects on ecological environment in three aspects as soil, water and atmosphere respectively. In the aspect of soil, excessive fertilizer application can make soil acidification and harden, leading to soil fertility decline. The harmful materials in fertilizer can cause soil pollution, such as application of phosphorus fertilizer inevitably brought some harmful substances as cadmium, strontium, fluorine and radium et al to soil, lots of utilization of nitrogen fertilizer caused soil NO_3^- rapidly accumulation and surplus,

finally acceleration soil secondary salinization. In the aspect of water, long-term massively application fertilizer is the important reason for causing groundwater nitrate pollution and water eutrophication by nutrient elements such as phosphorous, nitrogen et al through surface runoff into water. In the aspect of atmosphere, ammonia volatilization, nitrogen oxides release and CH_4, CO_2 emission will increase nitrogen content in atmosphere and bring a series effects. Thus, in fertilization process, it needs to utilize fertilizer scientifically and reasonably to make it effective, alleviate and avoid the negative influence on environment if possible according to soil ecological condition in project areas.

In this project, there is no fertilizer application in arbor forest and sealing sand for afferestation and grass breeding, so the impact of chemical fertilizer can not consider.

6.8 Impacts of small infrastructure construction on environment

The small infrastructures include access tracks, seedlings base, forest protection sites, office facilities and construction of environment monitoring sites.

Among them, the project will constructed 555.5 km access tracks, the width of access roads is 4m, the road surface will be paved with 20-30 cm gravel. The gravel roads serve for transportation of seedling materials to sites and for supervision and fire control. The road alignment will be determined during the detail design.

The potential environmental impacts of access tracks construction are as follow: it may destroy original vegetation on the sand dune, the vehicles will have noise, waste gas and flying dust impacts. The construction of access tracks will produce flying dust. It just put the gravels on the tracks surface, and all the construction labors are nearby farmers, the project will not construct camps, therefore the construction of access tracks will not produce waste water, domestic wastes, and construction solid wastes.

The construction sites of the access tracks located in remote sand dunes, the potential impacts mentioned above are temporary, minimal and localized, the following mitigation measures will be implemented: spray water before pave the gravels, the alignment of access tracks will choose the sites without vegetation or sparse vegetation so as to reduce the destroy for the original vegetation. The project will not construct camps, no domestic wastes, waste water and other solid wastes will be produced. The project will only use the vehicles passed

the annual inspection, and the speed of the vehicles will be controlled on the construction sites.

In the long run, the access tracks will serve for fire control, patrolling in the project areas, and stop the movement of the dunes. The rainfall will be easily accumulated along both sides of the access tracks, which is beneficial to the rapid rehabilitation of the vegetation along the access tracks.

6.9 The impact of the project implementation on land use

According to the total land area, forestry land area and agricultural land area of the project in each county (city, area) (Table 6-19, Table 6-20), we use SPSS for principal component analysis, in order to understand the differentiation characteristics of the use of the land in the project.

Table 6-19 The forestry land for the subprogram regions (10000 ha)

Region	Total land area	Forestry land area	Forest land area	Sparse forest land area	Shrub land area	Young forest land area	Enclosure young forest land area	Suitable afforest land area
Xingqing	8.28	2.07	0.15	0.00	0.14	0.14	0.00	1.64
Zhongwei	15.32	1.52	0.36	0.00	0.16	0.05	0.11	0.83
Lingwu	45.33	18.75	0.65	0.03	4.35	4.30	0.25	9.17
Pingluo	26.33	5.45	0.39	0.03	0.93	0.16	0.19	3.75
Litong	13.14	2.59	0.21	0.00	0.71	0.03	0.46	1.19
Qingtongxia	24.41	4.68	0.62	0.03	1.13	0.18	0.53	2.21
Yanchi	85.52	36.50	0.96	0.14	13.90	5.13	0.12	16.25

Table 6-20 The agricultural cultural land for the subprogram regions (10000 ha)

Area	Paddy	Wheat	Maize	Potato	legume	Oil plants	Medical plants	Vegetable	Melon and fruit	Other
Xingqing	1.29	0.45	1.10	0.00	0.01	0.08	0.11	0.85	0.02	0.18
Zhongwei	1.28	1.01	1.19	0.00	0.02	0.08	0.00	0.98	0.13	0.02
Lingwu	1.09	0.56	0.85	0.00	0.16	0.07	0.04	0.14	0.06	0.22
Pingluo	1.14	1.49	2.44	0.00	0.24	0.38	0.02	1.13	0.06	0.06
Litong	0.67	0.80	1.12	0.00	0.02	0.13	0.05	0.50	0.17	0.58
Qingtongxia	0.69	1.56	1.81	0.00	0.55	0.06	0.00	0.32	0.03	0.01
Yanchi	0.00	0.06	0.81	0.68	0.07	0.34	0.38	0.03	0.16	2.05

Table 6-21 The eigenvalues of every principal component for the land type

Principal component	Eigenvalues	% of variance	Cumulative (%)
1	6.71	95.86	95.86
2	0.238	3.395	99.255
3	0.042	0.603	99.858
4	0.005	0.073	99.931
5	0.003	0.042	99.973
6	0.001	0.02	99.993
7	0.001	0.007	100
8	6.71	95.86	95.86

Table 6-22 The component matrix of every variance for the land type after rotating

Component	1	2	3	4	5	6	7	8
1	0.745	0.667	0.02	0.006	0.01	0.002	0.006	0.745
2	-0.668	0.744	0.013	0.002	0.002	-0.001	0.001	-0.668
3	0.007	0.024	-0.994	-0.076	-0.055	0.021	-0.038	0.007
4	0	0.002	0.066	-0.829	0.144	0.536	0.015	0
5	0.007	0.009	0.078	-0.189	-0.905	-0.048	-0.37	0.007
6	0.002	0.002	0.015	-0.489	0.231	-0.815	-0.205	0.002
7	0	0	-0.008	-0.178	-0.323	-0.213	0.905	0
8	0.745	0.667	0.02	0.006	0.01	0.002	0.006	0.745

Generally speaking, for principal component analysis, if the accumulation information of the first two principal component features roots reaches 85%, then we can conclude that target matrix vector can reflect specific actual situation, that is, can undertake principal

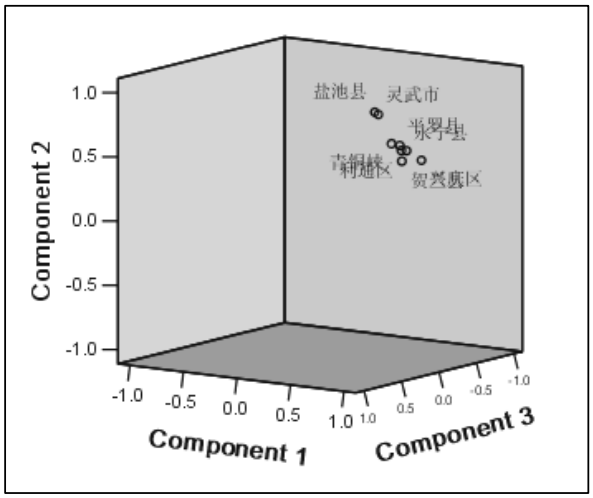


Figure 6-2 The principal component analysis results of land area for each subprogram region

component classification analysis. From Table 6-21, we can see that, the cumulative information of the two main component characteristics root has amounted to 99.112%, explaining that the first two principal components include the information of all land type, so the principal component analysis results can be used to explain real phenomenon (Table 6-22) In other wards, the information of total land area and forestry land area can be used for analyzing the features of the use of land in each county (city, area) of the project.

Principal component analysis classification shows that (Figure.6-2), land use differentiation condition of the county, city in the project can be divided into two categories, one is Yanchi county and Lingwu city, the rest for the other. This largely reflects the status quo of land use in these counties. the land condition and land use status of Yanchi county and Lingwu city are similar, mainly shows that, (1) Total land area is larger, respectively, 85.52 million ha and 45.33 million ha, Far more than other areas; (2) A large proportion of forestry land, respectively, 36.50 million ha and 18.75 million ha; (3) A large proportion of newly established forests and forests, respectively accounted for the 96.66% and 95.04% of their forestry land area. This shows in the seven subsidiaries, the land resources of Yanchi county and Lingwu city are abundant, the development space of forestry is great. This is available to finish this program.

6.10 The impact of the project implementation on national nature reserves

This project is involved with two national nature reserves: Baijitan in Lingwu and Habahu in Yanchi.

6.10.1 Outline of the nature reserves of Baijitan in Lingwu and Habahu in Yanchi

Baijitan national nature reserve in Lingwu was promoted to be national nature reserve in April, 2000. It is on the boundary of Mu Us Sand Land, which is in the desert to the east of Yellow River irrigation area in Lingwu, Ningxia. It is located in 106 °20'22"~106 °37'19"E, and 37 °49'05"~38 °20'54"N, and also a nature reserve for desert ecosystem. The whole nature reserve is 61km long from south to north, and 21km wide from east to west, which covers 74.8 thousand hm^2. The core zone covers 31 318 hm^2; the buffer zone covers 18 606 hm^2; while the experimental zone covers 24

919 hm^2.

There are two main protective targets in Baijitan national nature reserve in Lingwu: the natural bush wood ecosystem and the shrub desert ecosystem. The former one covers 17.3 thousand hm^2 and is dominated by *Caragana microphylla*, while the latter one covers 20 thousand hm^2 and is dominated by *Oxytropis aciphylla*. There are 53 families, 170 genera and 306 species for wild plants and 23 orders, 47 families and 115 species for wild animals, which is 43.3% of number of all animal species in Ningxia. There is one species of national first-class protective plant—*Nostoc commune*; one species of national second-class protective plant—*Agropyron mongolicum*; there are two species of national first-class protective animal—*Cioconia nigra* and *Otis tarda*; 20 species of national second-class protective animal such as *Milvus korschun*, *Cygnus cygnus*, *Aix galericulata* and so on. There are 23 species which are in the lists of the convention on international trade in endangered species of wild fauna, such as *Anas crecca*, *Platalea leucorodia*, *Saker falcon* and so on; 39 species which are in the lists of China-Japan agreement on the protection of migratory birds and their habitat, such as *Podiceps cristatus*, *Ardea purpurea*, *Cannabis* and so on; 8 species on the lists of the China-Australia agreement on the protection of migratory birds and their habitats, such as *Sterna hirundo*, *Anas querquedula*, *Anas clypeata* and so on.

Habahu national nature reserve was promoted to be national nature reserve in February, 2006. It is on the western boundary of Ordos platform, which is located in the original Cretaceous megasyncline and the folded zone of Helan Mountain—Qinglong Mountain, which is in spinal area of "hill" font structure made by Qilian Mountain, Lvliang Mountain and Helan Mountain in Bulunmiao town. It is located in 106°53′~107°40′E, 37°37′~38°03′N, and also a nature reserve of desert wetland ecosystem. It comprises several geomorphic units such as loess erosion plateau hill, gentle slope hill, flat swale, river gully sand dune and so on, among which sand dune is one of the main geomorphic types. This nature reserve is higher in south and lower in north. Its elevation is 1300-1622 m. It covers 84 thousand hm^2, among which, the core zone covers 30.7 thousand hm^2; the buffer zone covers 22.3 thousand hm^2 while the experimental zone covers 31 thousand hm^2.

The core zone of Habahu national nature reserve is 36.5% of the whole preservation area.

Its main protective targets are three parts: the natural bush wood of *Hippophae rhamnoides*, *Agropyron mongolicum* and *Salix yadongensis* in south; the bush wood of *Caragana korshinskii* and *Caragana microphylia*, natural community of *Agropyron mongolicum* , *Ephedra sinica* and *Radix glycyrrhiza* and the distribution area of wet land and rare animals in northeast; and the community of natural bush wood of *Salix psammophila*, *Agropyron mongolicum* and *Radix glycyrrhiza* and the distribution area of rare animals in northwest. The buffer zone covers 26.5% of the whole preservation area, while the experimental zone covers 37% of the whole area.

6.10.2 Requirements in Regulations on the Nature Protection Regions of the People's Republic of China

The related articles in <Regulations on the Nature Protection Regions of the People's Republic of China> (the decree of the state council No.167 of People's Republic of China, 9th in Oct., 1994) are as follows:

Article 28 Tourism, production and trading activities are prohibited in the buffer zone of nature reserves. In buffer zone of nature reserves, the non-destructive activities such as scientific research, educational practice and specimen collection for teaching or scientific research, applications and activity plans shall be submitted to the administrative agency of the nature reserves in advance, and be approved by the same agency.

Article 32 No production installations shall be built in the core zone and buffer zone of nature reserves. **In the experimental zone, no production installations that cause environmental pollution or do damage to the natural resources or landscapes shall be built**. Other installations to be built in these areas must not exceed the discharge of pollutants prescribed by national or local discharge standards. If the installations that have been built discharge more pollutants than are specified by the national or local discharge standards in the experimental zone of nature reserves， such pollution shall be eliminated or controlled within a prescribed period of time. Remedial measures shall be adopted to the damage caused.

The projects constructed in the outer protection zone of nature reserves must not affect the environmental quality inside the nature reserves. If the damage has been done, the relevant units shall be ordered to eliminate and control the pollution within a prescribed period of time.

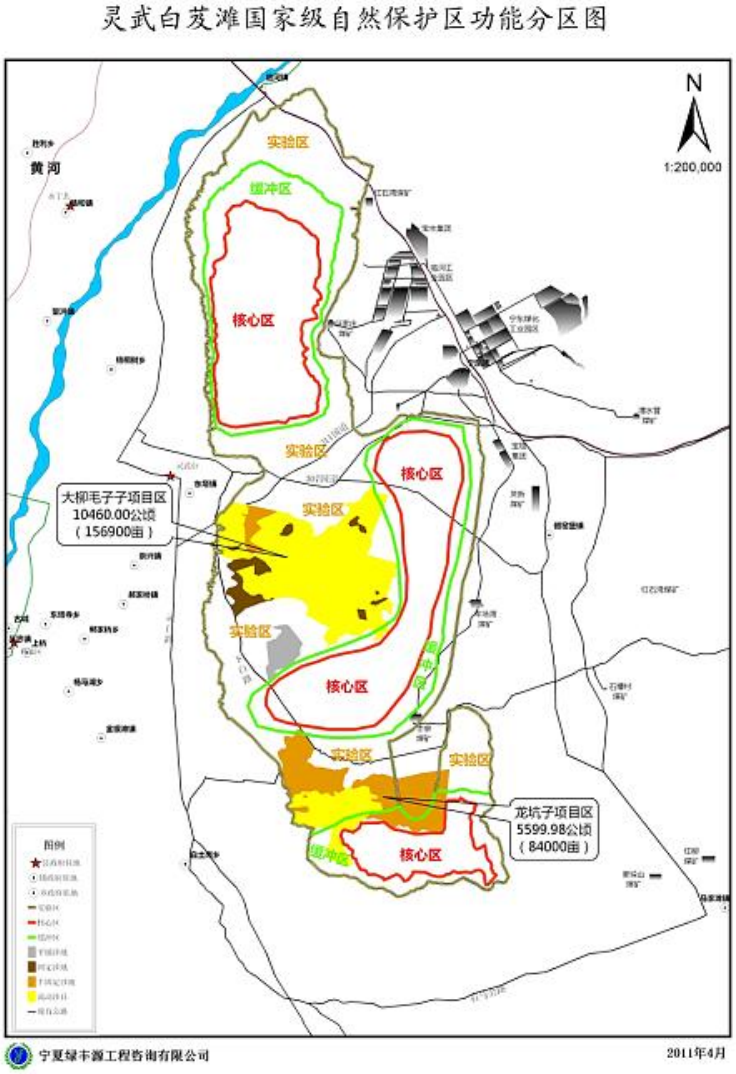
The decision to eliminate and control pollution within a prescribed period of time shall be made by the agencies specified by relevant laws and regulations. Any enterprise or institution receiving such an order shall complete its Tasks of eliminating and controlling pollution on time.

6.10.3 Influence of the project construction on the two nature reserves

According to the article 28 in <Regulations on the Nature Protection Regions of the People's Republic of China>, tourism, production and trading activities are prohibited in the buffer zone of nature reserves. However, according to the article 32, production in the experimental zone in alternative, which is beneficial to nature reserves is allowed.

According to the distribution layouts of Habahu nature reserve and Baijitan nature reserve, which are made by the initiation unit, and submitted by the project office of autonomous region of "project of prevention and control of desertification in Ningxia"(Fig. 6-3), we know that the distribution areas in Habahu nature reserve and Baijitan nature reserve are both in experimental zone.

After that, we received a confirmation from project office of autonomous region of "project of prevention and control of desertification in Ningxia", which submitted by project office in subproject area. Then we confirmed that the distribution areas of this project in Habahu nature reserve and Baijitan nature reserve are both in experimental zone.



中国·宁夏荒漠化土地治理与生态保护项目

-盐池县项目区规划图

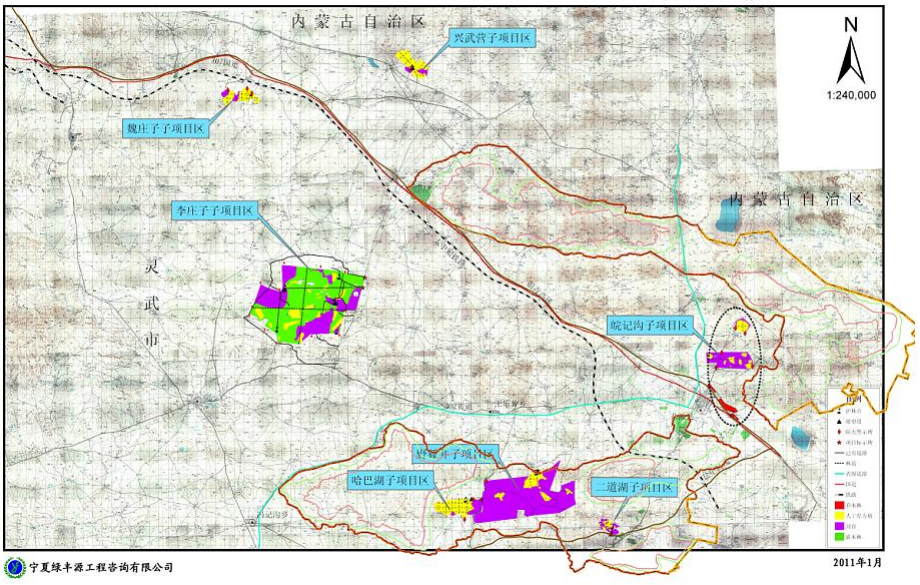
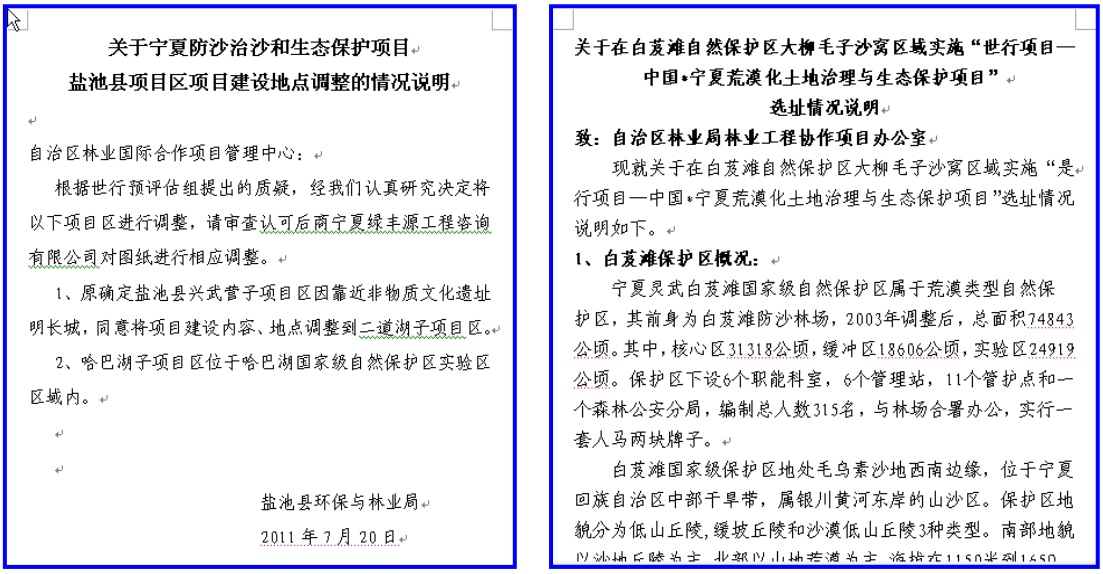


Fig. 6-3 Location of the project in Habahu nature reserve and Baijitan nature reserve



关于宁夏防沙治沙和生态保护项目
盐池县项目区项目建设地点调整的情况说明

自治区林业国际合作项目管理中心：

根据世行预评估组提出的质疑，经我们认真研究决定将以下项目区进行调整，请审查认可后商宁夏绿丰源工程咨询有限公司对图纸进行相应调整。

1、原确定盐池县兴武营子项目区因靠近非物质文化遗址明长城，同意将项目建设内容、地点调整到二道湖子项目区。

2、哈巴湖子项目区位于哈巴湖国家级自然保护区实验区区域内。

盐池县环保与林业局
2011 年 7 月 20 日

关于在白芨滩自然保护区大柳毛子沙窝区域实施“世行项目—中国•宁夏荒漠化土地治理与生态保护项目”
选址情况说明

致：自治区林业局林业工程协作项目办公室

现就关于在白芨滩自然保护区大柳毛子沙窝区域实施“是行项目—中国•宁夏荒漠化土地治理与生态保护项目”选址情况说明如下。

1、白芨滩保护区概况：

宁夏灵武白芨滩国家级自然保护区属于荒漠类型自然保护区，其前身为白芨滩防沙林场，2003年调整后，总面积74843公顷。其中，核心区31318公顷，缓冲区18606公顷，实验区24919公顷。保护区下设6个职能科室，6个管理站，11个管护点和一个森林公安分局，编制总人数315名，与林场合署办公，实行一套人马两块牌子。

白芨滩国家级保护区地处毛乌素沙地西南边缘，位于宁夏回族自治区中部干旱带，属银川黄河东岸的山沙区。保护区地貌分为低山丘陵,缓坡丘陵和沙漠低山丘陵3种类型。南部地貌

Fig. 6-4 Certification submitted by the subproject offices in Habahu nature reserve and Baijitan nature reserve

Fig.6-5 EIA group is investigating in Liumaozi subproject area in Baijitan nature reserve

Based on our field survey in Liumaozi subproject area in Baijitan nature reserve (Fig. 6-5), we think that, the construction of artificial straw checkerboard barriers is beneficial to ecological protection of the nature reserves, and also positive for forest fixation, wind erosion reduction and sand storm control. Therefore, under the condition of ecological protection, the

construction of the project is positive for Habahu nature reserve and Baijitan nature reserve.

However, it is prohibited to build roads. Meanwhile, environmental protection measures must be carried out during the process of construction.

6.11 Specific mitigation measures in the project

6.11.1 Artificial straw checkboard system needs to add barrier

The integrity mechanical system to defend the sand composed of artificial straw checkboard. In environmental assessment work, After investigating the mechanical system that preventing sand in Lingwu city, Pingluo county, we found that the mechanical system that preventing sand in these places are not standardized, lack of sand fence to resist sand (Figure

Figure 6-5 Inspection on mechanical sand-control system in Lingwu in the process of EIA

Table 6-24 The effects for the mechanical system wind-preventing and sand-fixing in Shapotou

Index	Quicksand	Before and after the installation of fence			In the straw checkboard area		
		Before 2m	After 0.2m	After 12m	No.1	No.2	No.3
2m wind speed(m/s)	8.1	7.2	8.4	8.3	6.9	8.3	7.1
0.2mwind speed(m/s)	6.6	5.6	4.1	4.7	4.7	4.3	4.0
Sediment discharge(g/cm/min)	4.615	3.256	0.259	0.139	0.017	0.013	0.005
The ratio of sand and sediment discharge(%)	100	70.6	5.6	3.0	0.37	0.28	0.11

Notes: This table is quoted from the Ling Yuquan, 1991.

6-5). For the mechanical system, the lack of sand fence is a fatal error. Studies have shown that blocking sand fences can significantly impede the flow of sand, blocking sediment load (Table 6-24).

Observations showed that, dunes moved 6m a year (He Xingdong, 2001). If you do not set the resistance of sand fence, means that the artificial straw checkboard system was set would be buried 6m each year, this has been repeatedly demonstrated.

Therefore, in the implementation of the artificial straw checkboard projects, need additional fence, used to enhance preventing effect, prolong mechanical system life of preventing sand, produce investment beneficial result.

6.11.2 The design of drip irrigation needs to improve

Drip irrigation system consists of the central hub, the pipeline system and planting system. In drip irrigation design, according to the lift of head pump determine the diameter of the pump; according to relevant hydraulics conversion determine the diameter of tubes and capillary, then according to the site's natural conditions and specific object of drip irrigation to determine the emitters.

In these years, Ningxia has carried out the work of drip irrigation; however, drip irrigation remains to be improved, especially in dune areas. In our study, we found that, established vegetate in the sand dune and irrigated by drip exist two problems, Firstly, in some areas no water drops dripping, drip useless; secondly, some areas accumulate large amounts of water , not only outlay a lot of water, but also led to soil salinization. In fact, this issue has been resolved by domestic counterparts, and implementated on a large scale in the dunes.

Therefore, in the design of the drip irrigation, we should cooperate with other colleagues to achieve good results.

6.11.3 Afforestation should use radication matter and preserve water matter

Application of radication matter **(**SAP) and (preserve water matter) ABT in sand-binding and afforestation could significantly increase the survival rate of planted forest.

SAP can rapidly absorb several hundred times more than its own weight of water, after absorbing water, the hydrogel can be slowly released for plant use of water. SAP improve

survival rate and promote growth of trees, by enhancing the capacity of water- absorbing, water-conserving, fertilizer-conserving. Luke Cheng and Liu Kui (2003) showed that, SAP can improve the survival rate of by 21% to 27%. But to do this, at present, SAP was widely used in crop planting and afforestation in United States, Britain, France, Russia and other countries, etc..

Herewith, Recommended three kinds of SAP application modes: (1) seed balls of clothing. Mixed seeds, SAP and water according to the proportion of 100:1:50 into coating fluid, put into seed, stir well, diluted, dried or dried fish, timely for direct sowing. (2) The method of seedling/cutting. Mixing water and SAP by the ratio of 1:100 ~ 1:200 and made into hydrogel, soak seedling root (or cuttings base) 8-10 h (cuttings 2-3h)and take out , bandage roots with plastic film or straw mat, prepared for planting. (3) Direct method. Mixed SAP and fine loam by the ratio of 1 ~ 2:100, applied directly into soil hole (planting pits), nursery container, seedling planting bed.

ABT is a new broad-spectrum, highly efficient, composite plant growth regulator, can be used for transplantation, cultivation of a variety of plants. Strengthen and regulate and control of plant endogenous hormone levels and the activity of important enzymes, promote the synthesis of biological macromolecules, Induce morphogenesis of plant adventitious roots or Adventitious bud , regulate the intensity of plant metabolism, to achieve the purpose of improving survival rate of seedlings. Applied to cutting propagation, promote rooting, make plants that difficult to root reproductive successfully, break through many difficulties that many rooted plant difficult to propagate; applied to tree planting, seedling transplantation, significantly improved survival rate and growth; applied to planting seedlings, can increase the germination rate, preservation rate.

Zhang Dunming (2006) showed that, soaked annual seedling of *Haloxylon scoparium* ammodend with ABT, seedling survival rate were higher than the contrast from 10% to 38.10%, while growth was also better than the control. Sun Zhiqiang (1997) deal airplane seeding plant seeds of *Hedysarum scoparium*, Astragalus adsurgens Pall with ABT in Shenmu, Jingbian and other places. The results show that Seedling density was increased by 45.2% ~ 84.4%, Seedling area is higher than the control rate of 22.0% ~ 46.9%, the amount of seeding rate broadcasted can reduce one third in the original basis. Visibly, sand-fixation

afforestation needs to use ABT.

Similarly, two usage patterns is recommended: (1) Treat the seeds with ABT by 20 ~ 50 mg / kg then sow directly; (2) Treat the cuttings and seedlings with ABT by 50 ~200 mg/kg then plant.

6.11.4 Alleviating measures on plan design

As mentioned above, the negative environmental impact of the project reflected in the consumption of water resources, construct small-scale infrastructure, use a small amount of chemical fertilizers and pesticides, and so on. In the stage of EIA of this program, we denied the ecological economic forest that consume the more surface water, and eliminate Yongning subprogram area from planed area; we denied the building road in the enclosure sand vegetation area as this will destroy natural vegetation; we put forward the advices to regulate the tasks in the natural reserve that refer to the regulation of the World Bank. The works of EIA have played positive role in this program. As for the mitigation measures in planning and design stage, construction stage and operation stage, they are listed in the Environmental Management Plan in Chapter 9.

7 Analysis of the project alternative solution

7.1 The comparing analysis of impacts on environmental with / without the program

In the chapter five and six, we have analyzed the various impacts of project implementation on the physics environment, social economic environment and biological environment respectively, so we do not repeat them here. “The ecological protection project of protecting and controlling desertification” is a project of preventing and controlling desertification in essence, therefore, we only qualitatively analyze the environmental effects of sand stabilization, enclosure and forestation with / without the program (Table 7-1).

7.2 Analysis of forestation trees selection

If the species of sand stabilization are not selected appropriately, the plants will not survive and the aim of sand stabilization will not be achieved. Consequently, it is crucial to select the appropriate tree species according to the different surroundings.

The tree or plant species that can adapt to the bad environment to survive have several similar ecological traits, such as enormous roots, resistance to be barren, wind erosion resistance, sand pressure adaptation, more branches and wide canopy, strong ability of windbreak and sand-fixation, wet and salt resistant. When we choose tree species, we not only need to consider whether they are local species, but also think about whether they are fit to the economic needs of the sands areas, such as supply of feed, fertilizer, firewood, medicinal materials or other forest product. The main forestation species and stabilization plants and their traits are shown in Table 7-2.

The programmed tree species in project area are *Pinus sylvestris* var. *mongolica, Elaeagnus angustifolia*, *Populus bolleana*, and *Robinia pseudoacacia* etc.. The shrubs are *Hedysarum scoparium*, *Salix mongolica*, *Caragana microphylla*, *Calligonum mongolicum, Periploca sepium Bunge*. The economic fruit species are grape and red jujuble (Table 7-2). As is shown in Table 7-3, the species of forestation tree and sand fixing plant are basically feasible except *Salix matsudana* as it is not suitable for the dry habitat in the project area, we should get rid of it in the process of implementation.

Table 7-1 The comparison of environmental effects by dune-fixating forestation with / without the program

Type	With project	Without project
Aspect of sand stabilization	Drift sand is fixed, and there is no longer sand flow. The surrounding farmlands, pastures, rural houses and roads are protected, and the quantity of drift sand in project area flowed into the Yellow River decrease greatly.	The harm of drifting or semi-drifting sand dune is very serious. Due to accumulation of the moving sand, or the airflow carrying, it will burry farmlands, grasslands and channels, resulting in direct harm to the production. Meanwhile the sand carried by storm has a strong shock, causing sand cutting, and destroys crop seedlings. The drifting sand dune moves to roads and covers it, and the grain sand falling down to road due to the impacts of barrier near the roads on airflow carrying sand, affecting the transports. The sand grains carried by wind accumulate around the wall and house when meeting obstacles such as house, as time went by, they will burry the house finally. The drifting sand dunes in XingQing district, LingWu city and PingLuo county of project area are close to the Yellow River, thus lots of sand will enter the Yellow River, causing the water sediment concentration increase and negative effects on downstream areas.
Aspect of enclosure	The enclosure inhibits grazing and firewood. Reseeding grass and shrub, and perennial shrubs flatting can promote the regeneration. The original vegetations recover gradually, and community coverage, vegetation productivity, biodiversity and ecosystem service value are corresponding improved, the health of ecological systems is also be promoted	The unreasonable utilization methods such as overgraze and excessive firewood can destroy the initial vegetation in project areas, they can also make the community coverage, vegetation productivity, biodiversity and the ecological service value decrease.
Aspect of forestation	It can slow down the harm of dry and hot wind, and relive soil salinization in bad drainage location significantly. It also can increase the crops production and farmer's income, as well as landscape diversity.	The dry and hot wind prevails in summer, the soil salinization in bad drainage location is serious, crop productions is low, so is the farmer's income, and the landscape is single.
Conclusion	Recommended	Not recommended

Table 7-2 Tree species choice comparison for with and without project

Growth form	Without project	With project
Arbor	*Ulmus pumila, Platycladus orientalis, Populus cathayan, Salix matsudana, Populus hopeiensis, Populus nigracv, Populus Canadensis.*	*Elaeagnus angustifolia, Ziziphus zizyphus, Robinia pseudoacacia, Populus euphratica, Pinus sylvestnis.*
Shrub	*.Tamarix chinensis. Sabina vulgaris, Hippophae rhamnoides, Caragana korshinskii, Salix psammophila, Hedysarum scoparium.*	*Ammopiptanthus mongolicus, Zygophyllum xanthoxylum, Nitraria tangutorum, Periploca sepium, Reaumuria soongonica, Caragana korshinskii, Oxytropis aciphylla, Artemisia ordosica, Hedysarum scoparium.*
Herb	*Melilotus officinalis, Glycyrrhiza uralensis, Astragalus adsurgens.*	*Cynanchum komarovii, Sophora alopecuroides, Melilotus officinalis, Astragalus adsurgens.*
Conclusion	Recommended	Not recommended

Table 7-3 The comparison assessment on afforest tree and fixing plant for the Ningxia Desertification Control and Ecological Protection Program

Species	Family/ Genus	Previous projects	This program	Conclusions
Zygophyllum xanthoxylum	*Zygophyllaceae Zygophyllum*	no chosing	chosing	recommended
Nitraria tangutorum	*Zygophyllaceae Nitraria*	no chosing	chosing	recommended
Salix alba	*Salicaceae Salix*	no chosing	chosing	recommended
Haloxylon persicum	*Chenopodiaceae Haloxylon*	no chosing	chosing	recommended
Ulmus pumila	*Ulmaceae Ulmus*	chosing	chosing	recommended
Melilotus officinalis	*Leguminosae Melilotus*	chosing	chosing	recommended
Platycladus orientalis	*Cupressaceae Platycladus*	no chosing	chosing	recommended
Artemisia halodendron	*Compositae Artemisia*	no chosing	chosing	not recommended
Tamarix chinensis	*Tamaricaceae Tamarix*	chosing	chosing	recommended
Robinia pseudoacacia	*Leguminosae Robinia*	chosing	chosing	recommended
Convolvulus tragacanthoides	*Convolvulaceae Convolvulus*	no chosing	chosing	recommended
Lonicera	*Caprifoliaceae*	no chosing	chosing	recommended

tatarica	*Lonicera*			
Populus cathayana	*Salicaceae Populus*	chosing	chosing	recommended
Glycyrrhiza uralensis	*Leguminosae Glycyrrhiza*	chosing	chosing	recommended
Periploca sepium	*Asclepiadaceae Periploca*	no chosing	chosing	recommended
Lycium chinense	*Solanaceae Lycium*	chosing	chosing	recommended
Salix matsudana	*Salicaceae Salix*	chosing	chosing	not recommended
Populus hopeiensis	*Salicaceae Populus*	chosing	chosing	not recommended
Onobrychis viciaefolia	*Leguminosae Onobrychis*	no chosing	chosing	recommended
Reaumuria soongonica	*Tamaricaceae Reaumuria*	no chosing	chosing	recommended
Ziziphus zizyphus	Rhamnaceae Ziziphus	chosing	chosing	recommended
Populus euphratica	*Salicaceae Populus*	chosing	chosing	recommended
Lespedeza bicolor	*Leguminosae Lespedeza*	no chosing	chosing	recommended
Hedysarum scoparium	*Papilionaceae Hedysarum*	chosing	chosing	recommended
Salix gordeivii	*Salicaceae Salix*	chosing	chosing	not recommended
Cotinus coggygria	*Anacardiacea Cotinus*	no chosing	chosing	not recommended
Achnatherum splendens	*Gramineae Achnatherum*	no chosing	chosing	recommended
Populus canadensis	*Salicaceae Populus*	no chosing	chosing	not recommended
Populus nigracv	*Salicaceae Populus*	chosing	chosing	not recommended
Sophora alopecuroides	*Leguminosae Sophora*	no chosing	chosing	recommended
Artemisia frigida	*Compositae Artemisia*	no chosing	chosing	recommended
Rhamnus erythroxylon	*Rhamnaceae Rhamnus*	no chosing	chosing	recommended
Gymnocarpos prezewalskii	*Caryophyllaceae Gymnocarpos*	no chosing	chosing	not recommended
Alhagi	*Leguminosae*	no chosing	chosing	not recommended

sparsifolia Alhagi				
Oxytropis aciphylla	*Leguminosae Oxytropis*	no chosing	chosing	recommended
Populus tomentosa	*Salicaceae Populus*	chosing	chosing	not recommended
Ulmus macrocarpa	*Ulmaceae Ulmus*	no chosing	chosing	not recommended
Salix mongolica	*Salicaceae Salix*	chosing	chosing	recommended
Ephedra przewalskii	*Ephedraceae Ephedra*	no chosing	chosing	not recommended
Cydonia cblonga	*Rosaceae Cydonia*	no chosing	chosing	not recommended
Caragana korshinskii	*Leguminosae Caragana*	chosing	chosing	recommended
Cynanchum komarovii	*Asclepiadaceae Cynanchum*	no chosing	chosing	recommended
Nitraria sphaerocarpa	*Zygophyllaceae Nitraria*	no chosing	chosing	recommended
Psammochloa villosa	*Gramineae Psammochloa*	no chosing	chosing	recommended
Astragalus adsurgens	*Leguminosae Astragalus*	chosing	chosing	recommended
Sabina vulgaris	Cupressaceae	no chosing	chosing	not recommended
Ammopiptanthus mongolicus	*Leguminosae Ammopiptanthus*	no chosing	chosing	recommended
Calligonum mongolicum	*Polygonaceae Calligonum*	chosing	chosing	recommended
Hippophae rhamnoides	*Elaeagnaceae Hippophae*	chosing	chosing	recommended
Salix psammophila	*Salicaceae Salix*	chosing	chosing	recommended
Atraphaxis bracteata	*Polygonaceae Atraphaxis*	no chosing	chosing	not recommended
Agriophyllum squarrosum	*Chenopodiaceae Agriophyllum*	no chosing	chosing	recommended
Elaeagnus angustifolia	*Elaeagnaceae Elaeagnus*	chosing	chosing	not recommended
Oxytropis racemosa	*Leguminosae Oxytropis*	no chosing	chosing	recommended
Armeniaca sibirica	*Rosaceae Armeniaca*	no chosing	chosing	not recommended
Populus	*Salicaceae*	no chosing	chosing	not recommended

davidiana	*Populus*			
Hedysarum fruticosum	*Leguminosae Hedysarum*	chosing	chosing	recommended
Corispermum declinatum	*Chenopodiaceae Corispermum*	no chosing	chosing	recommended
Atriplex canescens	*Chenopodiaceae Atriplex*	no chosing	chosing	recommended
Haloxylon ammodendron	*Chenopodiaceae Haloxylon*	chosing	chosing	not recommended
Xanthoceras sorbifolia	*Sapindaceae Xanthoceras*	no chosing	chosing	not recommended
Caragana stenophylla	*Leguminosae Caragana*	no chosing	chosing	not recommended
Populus pseudo-simonii	*Salicaceae Populus*	chosing	chosing	not recommended
Caragana microphylla	*Leguminosae Caragana*	chosing	chosing	recommended
Populus simonii	*Salicaceae Populus*	chosing	no chosing	not recommended
Populus alba	*Salicaceae Populus*	chosing	chosing	recommended
Salicornia europaca	*Chenopodiaceae Salicornia*	no chosing	chosing	not recommended
Halocnermum strobilaceum	*Chenopodiaceae Halocnemum*	no chosing	chosing	not recommended
Halostachys caspica	*Chenopodiaceae Halostachys*	no chosing	chosing	not recommended
Kalidium foliatum	*Chenopodiaceae Kalidium*	no chosing	chosing	not recommended
Hedysarum laeve	*Leguminosae Hedysarum*	chosing	chosing	recommended
Populus alba	*Salicaceae Populus*	chosing	chosing	not recommended
Ammodendron bifolium	*Leguminosae Ammodendron*	chosing	chosing	recommended
Artemisia ordosica	*Compositae Artemisia*	chosing	chosing	recommended
Pinus tabulaeformis	*Pinaceae Pinus*	chosing	chosing	not recommended
Pinus sylvestnis	*Pinaceae Pinus*	chosing	chosing	no recommended
Salsola passerina	*Chenopodiaceae Salsola*	no chosing	chosing	recommended
Artemisia	*Compositae*	chosing	chosing	recommended

sphaerocephala	*Artemisia*			
Amorpha fruticosa	*Leguminosae Amorpha*	chosing	chosing	recommended
Populus nigravar	*Salicaceae Populus*	chosing	chosing	not recommended

7.3 The analysis of selecting forestation models

When we design the model of protection forest, we should consider the zonal vegetation of climax community, specific phreatic water condition, irrigation condition and Aeolian sandy environment firstly, and then think about the specific protective objects and protection purposes, and finally consider the structural layout to make design optimization according to the suitable species of tree and plant selected by the natural condition.

The types of soil are mainly sierozem, light sierozem, salinization light sierozem, aeolian soil in this project area. The site type areas include two region as LingYan terrance and YinChuan plain. LingYan terrance is located in the front of Mu Us sand land, belonging to desertification control regions, the natural vegetations are mainly the sahel composed of xerophytic and super xerophytic plants, and the desertification grassland composed of psammophytes and mesophyte, including five project areas as PingLuo county, XingQing district, YanChi county, LiTong district. In these areas, water resources are exceedingly poor with sandy soil texture. The types of sand dune are trellis dune, crescent-moon-shaped sand dune chain, tile sand and fixation sand. YinChuan plain, the transition zone of cities and countrysides, belonging to salinization desertification controlling areas, is an old agriculture area with several aeolian sand lands distribution, including ZhongWei and QingTongXia. Among of them, QingTongXia belongs to the Yellow River alluvial plains with flat terrain, crisscrossed ditches, various lakes and fertile land. In these two site types, the design units plan three tree species as sand fixation forest, farmland shelterbelt and artificial grassland. But, we should consider the following actual conditions when determine these forestation models.

Firstly, sand fixation forest should select shrub but not arbor. Because it is not suitable for most arbor to live, such as the pine not resistant to drought and soil alkaline, the elm not resistant drift sand and barren soil, the poplar with undesirable growth lack of water in the sand grown into bush shape. The suitable subshrubs include *Artemisia ordosica*, and the shrub

as *Hedysarum scoparium*, *Caragana microphylla*, *Salix mongolica* and *Calligonum mongolicum*. For examples, the *Hedysarum scoparium* is the pioneer plant, it would die when drift sand fixed. *Artemisia ordosica* lives well in the sand-protecting barrier with strong ability of sand-fixation, but it is necessary to adjust it with later sand-fixation plants reasonably. The *Caragana micropyhlla*, with a strong ability of adaption, is a later sand-fixation plant and grows on sand steadily, so the combination use of *Artemisia ordrsica* and *Caragana microphylla* will strengthen the effect of sands fixation.

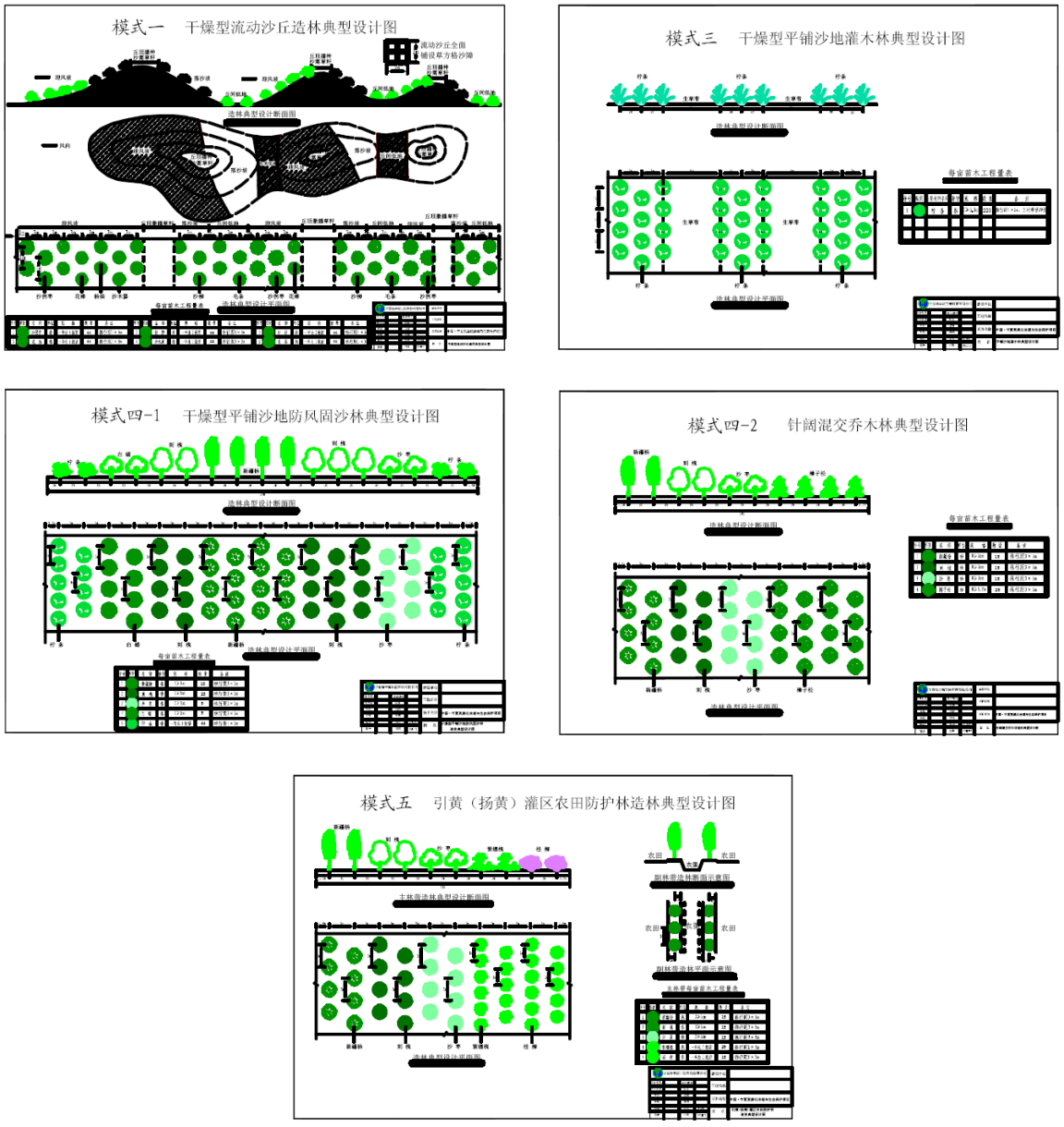


Fig. 7-1　Afforestation mode for Ningxia desertification control and ecological protection program

Table 7-4 Comparison between traditional forestation model and project model

Index	Traditional model	Project model
Types of model	(1)Straw checkerboard barriers bush wood (2)Enclosure sand vegetation (3)Bush wood (4)Fixation forest (5)Coniferou and broad leaved mixed forest (6)Agricultural protection forest (7)Artificial prairie	Model 1 Straw checkerboard barriers + bush wood construction model Model 2 Enclosure construction model Model 3 Bush wood construction model Model 4-1 Fixation forest construction model Model 4-2 Coniferou and broad leaved mixed forest construction model Model 5-1 Agricultural protection forest construction model Model 5-2 Artificial prairie construction model
Management method	Traditional forestation model: local forest bureau assign the task, then the forestation will be completed by local farmers. The forestation effect is unknown, while the reservation condition is poor.	Project models have 3 advantages: (1) Forest construction and acceptance of construction can guarantee the survival rate; (2) construction management can guarantee normal management after forestation; (3) construction supervisor can guarantee the achievement of forestation.
Conclusion	Deprecate	Recommend

Secondly, arbors are mainly chosen for farmland shelterbelt, because they can bear tasks of wind resistance and windbreak. On the other hand, the water demand of arbor is high, and it can be satisfied because there are impeccable irrigation systems in YinChuan plain. However, the poplars as farmland shelterbelt in Yinchuan plain were chopped completely down due to the longicorn hazards, in present, the main species are *Sophora japonica*, *ailanthus* and *populus bulleana* not suffer longicorn harm, moreover, the elm and *populus tomentosa* can also be chosen. Additionally, the mixture of *Lespedeza*, *Amorpha fruticosa* and *Atriplex canescens* can be chosen in part of serious salinizaiton site.

Thirdly, the local tree species should be considered as they adapt to the local environment easily with strong ability of resisting natural disaster for less administration, and they would not cause threaten on natural environment and other species, such as *Lycium barbarum* and *Hippophae rhamnoides*.

The planning units have proposed five afforestation models (Fig. 7-1). The afforestation mode comparisons for with and without program is listed in Table 7-4.

7.4 Analysis of location and planting scale selection

7.4.1 Analysis of location selection

The location selection depends on urgent degree of environment restoration and its effects on economic life.

The 43% of land area along the Yellow River distribution, including YinChuan, Shizuishan, Wuzhong, Zhongwei, Pingluo, Qingtongxia, Lingwu, Zhongwei, Yongning, Zhongning, holds 57% of NingXia population, 80% of towns, and 90% of urban population, and creates more than 90% of GDP and financial income in Ningxia. There are NingDong energy chemical base, Hedong airport, LinHe industry park, coalification industry park and LingZhou industry park distributed in this area, as well as YueYa lake, Sand Lake, ChangLiuShui, BingGou, HuangShaGuDu et al scenic spots, and BaiJiTan and HaBa Lake of YanChi national natural reserves. The economy of NingXia will not develop healthily until the ecological deterioration problems are solved.

On the other hand, this area is one of areas with most prominent desertification and vulnerable ecological environment, one of three areas with high frequency of sandstorm, and also the important transfer station and guttural thoroughfare for west sand transporting to east. It is essential to do the work of desertification prevention and control well, with vital significance for ecological barrier construction in the western China. There are many drifting dunes, fixed and semifixed dunes distributed in the area with serious sand hazards, for examples, it needs to fix sand for forestation, build shrub in straw checkerboard, seal sand for afforestation and grass breeding in Gaoren town of Pingluo county, Yueya lake in Xingqing district, Langnan road in Lingwu county and Dongdaliu in Xiabai road. It is necessary for other land to build farmland shelterbelt, such as Xuguangtan in YanChi country, SunJiaLou in LiuSiQu river basin and large areas of farmland around Binhe Avenue in YinChuan. It can relive the harm of dry and hot wind.

Investigation shows that the location selection is reasonable in project (Table 7-5). The region for dune-fixation forestation and sealing sand to grass breeding needs treatment emergently. The project implementation in programmed location will help to reduce the harm of sand flow, sandstorms, dry and hot wind in summer. In addition, it will also maintain the

ecological safety and improve the living bases.

Table 7-5 Comparison of site selections between traditional forestation model and project model

Index	Traditional model	Project model
Advantages and disadvantages	(1)More random for site selection; (2)Site selection is a hard task; (3)No consideration about nature reserves; (4)No consideration about land property; (5)No consideration about restoring force of natural vegetation.	(1)Prefer national or provincial planning ecological zone that has serious ecological issues; (2)Avoid nature reserves and cultural heritage sites. It is prohibited to select the areas located in the range less than 2000m far away from human historical and cultural heritage, distribution area of rare plants, habitat of rare animals and various reserves; also prohibited in the range less than 100m far away from public welfare forests; (3)Should be located in the areas where government would like to repay loans, farmers are volunteer to join into and no conflict about land property; (4)The sand control project should be located in areas which is under moderate and severe desertification; (5)Reservation engineering should be located in the distribution area of endangered species and important indigenous plants. The cover degree of the plant community should be more than 10%.
Conclusion	Deprecate	Recommend

7.4.2 Analysis of planting scale selection

Determination of planting scale is based on capital factor consideration.

The project will apply 80 millions dollars for World Bank loans. The funds will be used in three aspects directly excepting construction management funds, prospect designing funds, project supervision funds and invisible funds (accounting for 1%, 1.5%, 1.2% and 3% of direct funds respectively). Three aspects are (1) Forestation constructing project includes ecological protection forests of 76000 ha, among them, arbor forest of 5214.05 ha, shrubbery of 5296.5 ha, shrubbery of straw checkerboard sand barrier 20096.96 ha, sealing sand for afforestation and grass breeding 44303.56 ha, and artificial grassland 866.66 ha. (2) Basic infrastructures include forest road construction 555.5 km, 16 sightseeing towers, 32 warning signs, 37 forest protection sites, 9 sets of work facilities, 7 positioning monitoring stations of environmental factors. (3) Ability constructs include 11000 people to join in international, domestic and basic training.

Restricted by the funds, the project is only the present constructing scale. If money can be

applied more, we suggest increase the construction scale according to the present desertification condition.

7.5 Analysis of operation and management measures selection

In aspects of operation and management, there are obvious differences between project and traditional sand-fixation forestation. (Table 7-6).

Table 7-6 The comparation of operation and management measures between sand-fixation forestation models of the project and the traditional

Type	Traditional sand-fixation forestation model	The project sand-fixation forestation model
Organization	There is no special project office responsible for project implementation.	There are special project office composed of finance department, development and reform commission, and forestry department is responsible for plan established, project operation, funds use, information collection, analysis and feedback in project implementation.
Planning and design	There is no planning design, determined by forestry leaders.	There is qualified company to write the scheme of planning and design.
Construction management	The local villages are responsible for construction according to construction task assigned by superior without construction supervision, strict acceptance and standard management. The whole project management is loose.	The qualified corporations are responsible for construction by the planning and with project supervision and strict acceptance. There are specialized person and operation procedures in management process. The whole project management is all-around.
Scientific research	Scientific researches are lagged.	The sub tasks will be set up based on some targeted problems in planning and designing the project.
Technology generalization	The new technology extention is difficult.	Water-saving equipments are laid in some sections to implement supplement irrigation. The technologies of drip irrigation, tiny pipe irrigation and membrane irrigation are applied New breeds and new technologies are easily popularized.
Funds input	Financial appropriated and funds are difficult in place.	The World Bank supplies load to the project, funds is available in time.
Staff training	On staff training	Carrying out various levels of person training, improve the quality of forestry staff and technology of forestation.
Environment monitoring	There is no environment monitoring plan.	There are environment monitoring plan and environmental dynamics and impacts report.
Conclusion	Not recommended	recommended

8 Public participation and information disclosure

Public participation in the environmental impact assessment is a two-way exchange between project or EIA party with the public. As a method of supervising the environmental management and improving the validity of environmental evaluation, public participation is an indispensable component of the EIA system and plays an irreplaceable role in the improvment of the EIA system.

8.1 Objectives and principle of public participation

8.1.1 Objectives of public participation

The core objective of public participation is to improve the validity, the rationality and the authenticity of the environmental evaluation. The public participation guarantee the public rights to information and to participate in, make the public in areas influenced by the project timely understand the infornmation of related environmental problems in the project area, and have an opportunity to express themselves through usual channels. Through exchange and feedback of the relevant infornmation, the mutual understanding could e promoted and the conflict could be avoided. Through public participation, the project party can understand sensitively environmental and social problems on which the public focus, especially those vital and potential problems probably caused by the construction of the project, adopt specific environmental protection measures in the project implementation to enhance the environmental rationality and the social acceptability of the project. Through the public participation, the EIA party can comprehensively determine the potential or long-range impactes on environmental resources to make up the possible missing or negligence in EIA, ensure environmental protection measures feasible, reasonably evaluate the values of environmental resources, such as sights, cultural heritage which are hard to convey by the form of monetization, enhance the rationality and authenticity of the environmental evaluation, and promote the improvement of EIA system. The public participation promotes the participants' levels of knowledge, consciousness and the enthusiasm to environmental protection and improves the economic, social and environmental benefits unitedly.

8.1.2 Principles of public participation

The public participation obeys the following six principles: (1) Principle of policy. The

public participation must abide by the state's laws, industrial policies, national policies for environmental protection and economic development plans. (2) Principle of efficiency. The efficiency of public participation includes effectiveness of participants, effectiveness of survey and statistic methods, effectiveness of investigation content and time. (3) Principle of equity. The public participation should be typical，ensure that the public participating in discussion come from every corner of the society and stand for some sociological aspect. (4) Priciple of pertinence. Introduce or make the public that take part in the discussion know the positive or negative impacts of the projects awaiting construction on environment, economy, society, resources and human health, so that the public could understand clearly the whole situation of the project and convey their opinions properly farther. (5) Principle of simplicity. The evaluation index or factors that need to ask about the public opinions shoud be stated simply and clearly to make the public understand the project impact on environment instantly and in detail. (6) Principle of operationality. Indexes or contents of public inquiry should be helpful to statistical analysis quantitatively, and the EIA results can be more convincing and easily used in policy-making.

8.2 Methods and contents of public inquiry

In the investigation, many kinds of methods are adopted in the public participation (Figure 8-1), such as posting the notice in the project area, calling villagers' meeting, collective interview, symposium, individual counseling, distributing questionnaire and so on. Among these, as the main method, the questionnaire is to put farward surveyed questions to the public in a standard way and order, then exchange with the public. The concrete contents see Table 8-1. The contents of questionnaire designed are sealed, by the form of choice question, closely related with the World Bank project of prevention and control of deserfication and its environmental effects which are the points of the project. All the questions were brief and to the point, at the same time, easy to answer and be analyzed statistically.

In the investigation, by taking densely populated area as the sampling center, outward decreasing gradually, and multistage stratified random sampling method, the samples are

A-Convoking symposium

B-Collective investigation

C-talking with villagers

D-Questionaire survey

Fig. 8-1 The symposium and questionnaire on public participation in this program

determined with the sample size 500. The respondents consist of the staffs working in enterprises and institutions, peasants and self-employed people who are different in professional, education and assorted ages.

At the same time, through visiting some farmers' families, give an insight into the existing woodlands, the application of pesticide and fertilizer, field and domestic water consumption, standard of living, understanding and attitude to the project.

8.3 Results of public inquiry and public opinions

Total 500 questionnaires were extended in seven counties (cities, districts)Xingqing district, Litong district, Lingwu city, Qingtongxia city, Pingluo county, Yanchi county and Zhongwei city in this investigation, 500 questionnaires were recalled, only 463 effective，the rate of effective questionnaires 92.6％. The statistic results of questionnaire see Table 8-1 and

Table 8-2.

Table 8-1 Questionnaire results for the Ningxia Sand Control Ecological protection Program

Main investigation contents			
How do you think the ecological environment in your hometown?	Good	Bad	Uncertain
	138	314	11
	29.8	67.8	2.4
Do you think the project “World Bank-Prevention and Control of Desertification and ecological protection of Ningxia” will help to retard floating sand, dust and sandstorm?	Yes	No	Uncertain
	451	12	0
	97.4	2.6	0.0
Do you think the project “World Bank-Prevention and Control of Desertification and ecological protection of Ningxia” will help to improve the local economic development and the living standard of farmers?	Yes	No	Uncertain
	292	137	34
	63.1	29.6	7.3
Do you think the project “World Bank-Prevention and Control of Desertification and ecological protection of Ningxia” will improve the local ecological environment?	Yes	No	Uncertain
	453	3	7
	97.8	0.6	1.5
Were chemical fertilizer, pesticides and insecticides used in the woodland of your hometown?	Yes	No	Uncertain
	207	256	0
	44.7	55.3	0.0
Do you think the project construction will produce chemical fertilizer and pesticides pollution?	Yes	No	Uncertain
	109	354	0
	23.5	76.5	0.0
If the project “World Bank-Prevention and Control of Desertification and ecological protection of Ningxia” strictly obeys the relevant state environmental regulations, can you accept the negative environmental effects resulted from the project construction?	Yes	No	Uncertain
	458	2	3
	98.9	0.4	0.6
Do you think the project implementation practicable?	Yes	No	Uncertain
	451	3	9
	97.4	0.6	1.9

Table 8-2 Basic data of people involved in the qstionnaire

Career	Percentage(%)	Age	Percentage(%)	Education	Percentage(%)
worker	20.4	>60	1.6	College/univeristy	10.6
farmer	56.6	50-60	8.6	Secondary technical school	1.8
Self-employed people	3.2	40-50	6.4	High school	21.4
Undergraduate student	5.4	30-40	34.2	Middle school	50.4
Staff working in institution	7.0	20-30	41.8	Primary school	8.4

The public viewpoints in this survey the summarized are as follows: 67.8% of the informants thought that the ecological environment in their hometown is bad; 97.4% of the informants thought that the project "World Bank-Prevention and Control of Desertification and ecological protection of Ningxia" was helpful to decelerate sand blowing, floating dust and dust storm; 63.1% of the informants thought that the project could promote the local economic development and the growth in the living standard of local peasants; 97.8% of the informants thought that the construction of the project could improve the local ecological environment; 55.3% of the informants thought that no chemical fertilizer and pesticides had been used in the forest land; 76.5% of the informants thought that the construction of the project could not produce pesticides and chemical fertilizers pollution; 98.9% of the informants can accept the negative environmental impacts of the project if the project "World Bank-Prevention and Control of Desertification and ecological protection of Ningxia" abided by the national legislations on environmental protection strictly; 97.4% of the informants thought that the construction of the project was feasible.

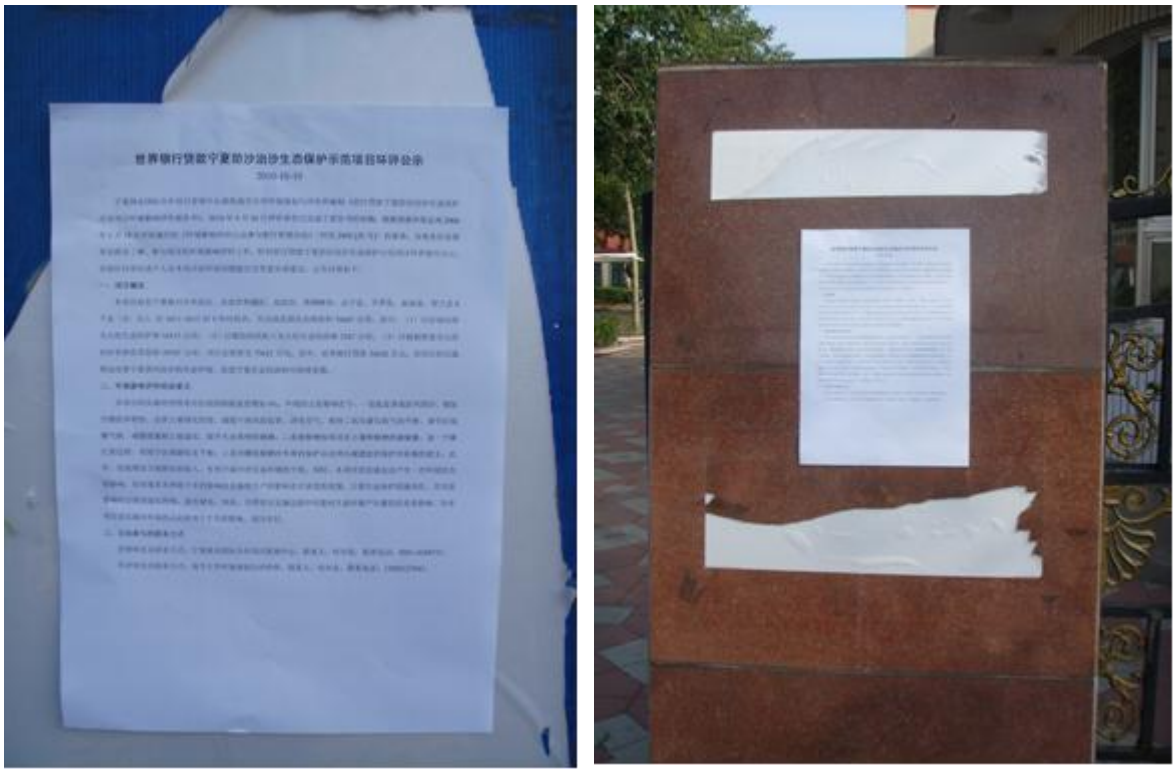
8.4 Information opening and viewpoint feedback

8.4.1 Information opening

In this work of EIA, the environmental information was announced two times. The contents and forms of the information announcements of EIA were shown in Table8-3. The first time of the announcement is on July 11, 2010, the secnd time was on October 10, 2010，the places of the announcement were in the front of the gates of peopls' government and forestry bureau of all counties(cities, districts) (Fig. 8-2).

Table 8-3 Contents of the project EIA bulltin

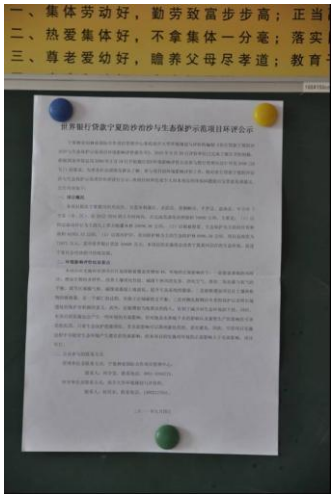
Project Name and Construction contents	"World Bank-Prevention and Control of Desertification and ecological protection of Ningxia" Construction scale of the project 76667 hm^2, total investment 736,250,000 yuan.
Mangement unit and contact ways	International cooperation projects in Ningxia forestry management center Tel：0951-4104715; Contact person: He Quanfa
EIA unit and contact ways	Environmental Plan and Assessment Institue of Nankai University Tel：13802127641; Contact person:He Xingdong
Main contents of EIA	Basic information of the project construction, possible environmental effects, measures to take in controlling or mitagating environmental effects and the conclusion of the EIA
Major items	Through qstionnaire and forum, investigate and collect the public opinions on the possible environmental effects caused by the project construction and environmental protection measures.
Ways of public submitting opinion	The public can make comments to the EIA agency by telephone, letter, etc, and also talk directly to the releted people of construction or EIA agencies.



A-In aviso column of the county government B-In front of the gate of the forestry department

Fig. 8-2 The second public notification of environmental information for this program

A-Notification in Ningxia Forest Information Network



B- Notification in Forest Bureau

C-Opening to villager

D-Villager discussion

Fig. 8-3 The third information opening of this program in the program area

After finished the first draft of the EIA report on September 30, 2010, we discussed with the environmental expert of the world bank and completed the revision of the first draft on October 26, 2010. Then, we carried out the third environmental information opening (Fig. 8-3).

8.4.2 Feedback of opinion

Almost a hundred feedback opinions were received after information disclosure. Main opinions were as follows: (1) Hope to increase loan limits, provide prepayment, increase regional supporting funds, and conducte the project as quickly as possible. (2) Hope to obtain technical support, training and job opportunity. (3) Hope to adjust and increase planting areas of production forests. (4) Hope to apply the method of direct afforestation without soil preparation in the dune fixation afforestation to avoid the desertification caused by land

clearing at the beginning period of planting. (5) Hope to be compensated in time for the landless peasants and herdsmen to ensure the benefits of peasants. (6) Hope to use more biopesticides and organic fertilizers instead of chemical pesticides and fertilizers. (7) Hope to build countryside roads at the same time of forestry construction. (8) Hope to enlarge the area of this program, and increase the loan quantity (Table 8-4).

Table 8-4 The process of interviewing the relevant units and farmers on Ningxia ecological protection project of prevention and control of desertification

Num-ber	Time	Site	Participant	The content of discussion	Feedback and opinion
1	2010-07-12 ~ 07-15	Pingluo Subproject areas: Xiaotangkou township in Gaoren town of Taole county, Gaoren township in Gaoren town, Mataigou in Taole town, Miaomiaohu in Taole town	Regional project office, EIA(environmental impact assessment) group of Nankai university, Pingluo project office, subproject area owners, local farmers	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project. (5) Supplementary survey. Obtaining insufficient information in the first survey and supplement it, and in October 2010, according to the comments and suggestions of world bank experts to collect more information and data for additional investigation.	(1) Hoping to increase credit lines and support advances to increase regional matching funds. (2) Giving timely farmers and herdsmen whose land expropriated compensation to ensure the farmers' interests.
2	2010-07-15 ~ 07-18	Xingqing Subproject areas: Yueyahu forest farm of control desertification, Hongdunzi forest farm,	Regional project office, EIA(environmental impact assessment) group of Nankai university, Xingqing project office, subproject area owners, local farmers	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and	(1) Hoping to get supports of technology and training and provide employment opportunities. (2) Hoping to develop forestry and

		Hedong modern ecological garden of comprehensive demonstration base		other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project. (5) Exploration and field visiting the forest farms involved in project area and discussion with staff representatives and leaders in forest farm of control desertification, and knowing forestry farmers' attitudes on project construction and listening to their suggestions and measures about the impacts of project implementation on the surrounding environment and villagers.	meanwhile repairing rural roads.
3	2010-07-19~ 07-22	Lingwu subproject areas: Maanshan management station in Baijitan, Liumaozi Shawo, Japanese Xiaoyuan fund project, Changliushui management station, Daquan forest farm	Regional project office, EIA(environmental impact assessment) group of Nankai university, Lingwu project office, subproject area owners, local farmers	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project. (5) Exploration field of the natural preservation areas involved in project area and discussion with staff representatives and leaders in natural preservation area, and knowing forestry farmers' attitudes on project construction and listening to their suggestions and measures about the impacts of project implementation on the surrounding environment and villagers.	(1) Hoping afforestation can be run directly without soil preparation in stabilization of sands to avoid sandy problems caused by soil preparation in initial planting.
4	2010-07-23 ~ 07-25	Qingtongxia subproject areas: Tangtan	Regional project office, EIA(environmental impact assessment)	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and	(1) Hoping to increase credit lines and carry out

		village of Yesheng town	group of Nankai university, Qingtongxia project office, subproject area owners, local farmers	interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project.	the project as soon as possible. (2) Less use of chemical pesticides and chemical fertilizers, and more use of biological pesticides and organic fertilizers.
5	2010-07-25 ~ 07-28	Yanchi subproject areas: Sunjialou in Liusiqu river basin of Yaergou county, Wanglejing in Yaergou, Haba lake management station of national nature reserve.	Regional project office, EIA(environmental impact assessment) group of Nankai university, Yanchi project office, subproject area owners, local farmers	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project. (5) Exploration field of the natural preservation areas involved in project area and discussion with staff representatives and leaders in natural preservation area, and knowing forestry farmers' attitudes on project construction and listening to their suggestions and measures about the impacts of project implementation on the surrounding environment and villagers.	(1) Hoping to regulate and increase the area of economic forest. (2) Hoping to expand the area in Yanchi project.
6	2010-07-29	Litong subproject areas in Wuzhong:	Regional project office, EIA(environmental impact assessment) group of Nankai university, Litong	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support,	(1) Hoping to get supports of technology and training, and provide employment

			project office, subproject area owners, local farmers	participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project.	opportunities. (2) Hoping to increase area of project.
7	2011-03-12 ~ 03-15	Zhongwei subproject areas: Western forest farm, north side of Bolan railroad	Regional project office, EIA(environmental impact assessment) group of Nankai university, Zhongwei project office, subproject area owners, local farmers	(1) Inspecting and understanding the economic and social situation and environmental impacts could be caused by the project implementation in subproject area. (2) Investigating and interviewing the benefited and damaged project-related units to know the support, participation and demand for project. (3) Discussion with the Land Bureau, Agriculture and Animal Husbandry Bureau, Forestry Bureau, Finance Bureau, Water Conservancy Bureau and other departments to promote its attention and efficiency of project. (4) Investigating and interviewing the benefited and damaged townships and villages, and sampling farmers' questionnaires mainly to know the support, participation and farmers' demand for project.	(1) Hoping to increase the project area and credit line.

8.5 Treatment of feedback opinion in the public participation

The public feedback opinions support the project implementation and consider that the project could improve the local social-economic and ecological environment. Through the communication and coordination, the project parter A made promises as follows: compensate the landless peasants and herdsmen in the implementation of the project in time by the construction organization; positively supply technical support and training, try to provide more job opportunities for local farmers by implementing the project; avoil land preparation in afforestation of the sandstorm areas; spread environmental friendly pesticides and fertilizers actively; build countryside roads and forestry production at the same time.

Meantime, according to suggestions of the EIA unit, it is suitable to protect the integrality of the enclosure sand vegetation, revoking the design in plan to build the countryside road. On the other hand, due to limiting by water resource, it is suitable to revoke the ecological economic forest, so the suggestion that ask for enlarging the scale of the ecological economic forest was denied. By the EIA, Yongning subprogram area in plan design was rovoked. In brief, the most suggestions of public feedback in environmental information announcement of the EIA were basically solved reasonably.

9 Environmental management and monitoring program

9.1 Former forestry projects of WB and managerial experience

Since World Bank (WB) loan was introduced in 1985, our country has successfully developed “Forestry Development Project (FDP)”, “National Afforestation Project (NAP)”, “Forestry Resource Development and Protection Project (FRDPP)”, “Forestry Composite Development and Protection Project in Guangxi” and “Ecological Afforestation Project in Shandong” and so on. The development of all of these projects led to the enhancement of forestry management and produced a whole set of fashioned forestry managerial experience, which includes four aspects as follows:

(1)Improve managerial system

The management of projects is based on “Quality” and “Benefit”. Eight supporting systems are built, including organizing, technology, planning, finance, germchit supply, scientific spreading, environmental protection and information system.

①Organization and managerial systems

Form corresponding project leadership groups and WB project offices that are in charge of organizing and implementation in practice from top to bottom, which all the departments concerned should take part in. The leaders are managers who are in charge of administration. At the same time, financial, planning and forestry personnel will play a role individually in the overall management to make sure effective implement of the whole project.

②Technical managerial system

Soil preparation, planting, transplanting, nurture and cutting must all follow strict operation specifications. As for afforestation, the management process of “training before construction”, “guiding during construction” and “checking after construction” must be followed. As for quality control, checking methods combined “checking in branch operation” and “checking in different classes” is used. As for construction supervision, the technical guiding contract responsibility system is formed for the entire technician to distribute individual task to them.

③Planning managerial system

At the beginning of the year, according to the general project planning, preplans are

established and transmitted to lower levels. Personnel in each level should prepare for the key aspects such as mating fund, germchit, field choosing and labor on base of the preplan, make and transmit a new official plan.

④Financial system

Control all the activities and keep a close watch of the raising, application, distribution and recovery of funds during the whole process of the project in order to make full use of limit fund.

⑤Germchit supply system

It is explicitly stipulated in "National Afforestation Project" that, all the germchit must be first class. The management of "three fixation" and "two certifications" must be obeyed. Any unqualified germchit mustn't be used.

⑥Scientific spreading system

Start the subtopic study of mycorrhiza, fertilizing and afforestation technology; develop test forests, demonstrative forests and pilot plant test forests which depend on the entire project and advancing science and technology.

⑦Environment management system

Make "Environment protection regulation", build corresponding environment protection groups in each level, and set up environment impact monitoring points that are in charge of monitoring the erosion modulus, hydrological dynamics, soil fertility, plant diseases and insect pests.

⑧Information managerial system

Set up information database system of the project, collect and reorganize the information of afforestation technology, forest growth, project schedule, fund utilization, materials management, forest resource and changes of lumber market during the program.

(2)Increase the technological content in project

Set up specific supporting leading groups and specific spreading groups that are in charge of studying the essential technology that will help with the difficulties may appear during the construction. At the beginning of the project design, pay a special attention to specific spreading and make a perfect specific spreading plan.

Firstly, build various demonstration forests that show achievements of science and

technology spreading so as to embody “Science and technology constitute the primary productive force” in practice and make it easier to learn and imitate.

Secondly, publish and distribute practical technology brochures.

Thirdly, combine technological design of the project and blend scientific achievements in design of documents and technological processes.

Fourthly, hold training classes. During the construction, train the personnel in each level in job design, forest culture and management design, soil fertilizing, environment protection, finance and computer skills according to different procedures, in order to use the scientific and technological achievements in practical afforestation.

(3)Strengthen the development and cultivation of germchit

With the close cooperation of project management, germchit and scientific research, set up WB project germchit producing and supply conciliation groups that coordinate and operate the support safeguarding. The responsibilities of these groups are as follows: Firstly, identify the compartment of plant resource for project, define the standards for plantlet, control the plantlet and fixed-point nursery garden strictly; Secondly, guide the germchit department to arrange the producing and supply of plantlet on the basis of quality and quantity. In practice, make sure “fixed-point seed supply”, “fixed-point seedling grow” and “fixed-point seedling supply”, namely “three fixation” methods and “qualified certificate” and “first-class seedling using certificate”, namely “two certificate” system.

(4) Strengthen economic leverage of funds

The management of WB loan fund is rather strict. Fund management of project must be based on three key procedures—disbursement, utilization and refundment of funds—and formulate normalized procedure so that make it to be commercial loan.

Firstly, strict financial control. The financial control of project means supervision and control activities of fund procurement, utility, distribution and recovery during the construction, aiming at making funds management an important way to implement project and control the quality. The system of “rendering accounts”, namely “getting reimbursement after construction” plays a role in fund appropriation, which means getting an approval is necessary for you to render an account according to “three tables and a contract (construction inspection table, fee settlement table, reimbursement application table and construction

contract)". Reimbursement can be applied only twice every year. Moreover, it is necessary to audit annually so as to find the problems and correct them.

Secondly, the supporting funds must be full specified amount not only in place but also in time. Since reimbursement systems are performing in credit funds, it is essential for afforestation to maintain enough initial funds, which is supporting funds. Provincial supporting funds are allocated proportionally to counties, depending on capital implement degree. The counties that do not allot will be restricted or even prevented by project office to afforest.

Thirdly, claims and liabilities must be clear. Project debt is passed to governments in all levels by means of signing a lending agreement. On the other hand, project debt must be passed to every afforestation entity to put claims and liabilities in practice. At the same time, according to the situation and willing of afforestation unit, loan methods (which are mortgage mainly) must be ready.

9.2 Environmental management plan

Table 9-1 shows that the negative effects of the program implementation and their mitigation measures, monitoring contents and other environmental management plans during the design phase, construction phase and operation phase of the whole process of Ningxia Desertification Control and Ecological Protection Project.

Table 9-1 The environmental management plans

of Ningxia Desertification Control and Ecological Protection Project

Phase	Project activity	Negative effect	Mitigation measure	Monitoring content	Implement-ation unit	Supervision unit
Design phase	Selection of tree species	Improper tree species will influence the project success.	1. Carefully selecting species and protecting native species from interference of exotic species. 2. Tree species selected by each county should be more than 5 in artificial shrubbery construction. 3. Don't choose arbor species to fix sand in mobile dune. 4. *Salix psammophila* and *Hedysarum scoparium* should be planted separately in the mobile dune due to their allelopathy.	Surveying tress species applied in project construct-ion	Program supervision and monitoring unit	Regional project office

	Selection of site	Improper site will affect the project purpose and could bring disputes.	1. The site should be chosen in the city or provincial planning ecological area where ecological problems are highlighted. 2. The project should be located away from the natural reserve or cultural heritage, and it can not be in human historical and cultural heritage, rare plants distribution, wildlife habitat, buffer zone outside of protection area within 2000m and range of 100m outside of commonweal forest. 3. The project site should be in the area where the government is willing to repay the loan, farmers voluntarily take part in the project and no land ownership disputes. 4. Sand protecting project site should be in the moderate and severe desertified land. 5. The project of closed native grassland should be located in the distribution area of endangered species and important native plants, the coverage of plant community should not be less than 10%.	Verifying the construction site consistency with planning site.	The county government and forest administrative department in charge	Regional project office
Implementation phase	Preparation of soil	Improper soil preparation will result in desertification	1. The soil preparation ways of ecological economic forest can be chosen the forms of hole, strip and whole reclamation. 2. The area of severely bare sand should not be prepared and should be seeded and planted directly. 3. Artificial shrubs in Yinchuan plain should be prepared only in the narrow planted line。	Surveying the ways of soil preparation.	Program supervision and monitoring unit	Regional project office
	Planting	Incorrect planting will influence the survival rate of trees.	1. Use of small pits to plant trees in dune- fixing afforestation, the pit size is 30cm×30cm×50cm. 2. Use of large pits to plant trees in ecological economic forest, the pit size is 80cm×80cm×80cm. 3. Use of medium pits to plant trees in agricultural protection forest, the pit size is 50cm×50cm×70cm.	Examining the size of pits.	Contractor	Regional project office
	Protection of water source	Improper use of water will increase the water crisis.	1. Pipe irrigation, drip irrigation and other ways of water saving irrigations should be taken in the supplementary irrigation. 2. Reasonable irrigation system should be established to prevent soil salinization caused by irrigation. 3. Water quantity and level should be monitored to prevent water from pollution of pesticide and fertilizer. 4. Using of surface water instead of groundwater as much as possible.	Monitoring ground water level and quantity.	The county government and forest administrative department in charge	Regional project office

			5. Salt and drought tolerant plants should be planted in the area of low water level.			
	Protection of Ming great wall	Inappropriate action will destroy historic site.	1. Strengthening the advertisement on protection of Ming great wall to construction team.	Inspecting the adjacent historic spots.	The county government and forest administrative department in charge	Regional project office
Operation phase	Tending seedling	Improper collection of firewood will destroy vegetation.	1. It is the best to plant leguminous plants which can improve the soil quantity. 2. Prohibition of using herbicides when weeding. 3. Use of organic fertilizer when fertilizing. 4. Prohibition of grazing and collecting firewood in the area of closed native grassland.	Monitoring the ground cover.	The county government and forest administrative department in charge	Regional project office
	Prevention and control of disease and pest	Improper pesticide will harm the environment.	1. Specially development of "Integrated Pest Management Plan" and implementation. 2. The method of integrated pest management plan (IPM) should be taken on prevention and control disease and pest, and use of chemical pesticides must comply with three classes of pesticides ruled by the world health organization. 3. Promoting use of biological pesticides. 4. Prevention the occurrence of pests and diseases by mixing different tree species.	Monitoring the types and doses of pesticides	The county government and forest administrative department in charge	Regional project office
	Prevention and control of fire	Fire can damage vegetation.	1. Strictly implementation of LYJ127-1991 "Standards of prevention forest fire technology". 2. The work of prevention forest fire in project area should be included in the system of prevention forest fire by each county. 3. Prohibition of burning grass and dry branches and leaves around forest. 4. Local rules and regulations will be established and arson will be strictly punished, strengthening village team of prevention forest fire. 5. When operating in the forest, fire separation zone and fire prevention road should be constructed, and observation station and forest protection room should be set up and equipping with communication facilities in the project area.	Going around and inspecting the facilities and personnel.	County fire proventing office	Regional project office
	Protection of biologica	Improper measure will	1. Strengthening the management and investigation of grassland and pasture. 2. Enhancing the monitoring of soil microorganisms, nutrients and organic matter,	Monitoring species density,	The county government and forest administrativ	Regional project office

	l diversity	affect biological diversity.	calcium carbonate. 3. Strengthening the monitoring of variation of species diversity index. 4. Enhancing the monitoring of deflation and sand burying and soil erosion. 5. The destruction of natural vegetation should be avoided by small-scale infrastructures as much as possible.	coverage and frequency	e department in charge	
	Protection of rare species	Improper measure will cause the loss of species.	1. Strengthening the protection and investigation of *Ammopiptanthus mongolicus* and *Populus euphratica*. 2. Replanting *Ammopiptanthus mongolicus*. 3. Strictly prohibition of gathering *Populus euphratica* and *Ammopiptanthus mongolicus*.	Monitoring population's density and coverage	The county government and forest administrative department in charge	Regional project office

9.3 Environmental monitoring plan and execution

Three kinds of monitoring are considered in this project. (1) Schedule monitoring, which means make sure the schedule of construction in practice is the same as prediction; (2) Consistency monitoring, which means comparing the current situation with the environmental criterion, regulation, enabled condition and promises in project plan; (3) Effect monitoring, which means establishing clear relationship between the environmental impact of construction and long-term objectives in the project.

The main objective of this plan is to make sure all the remedial measures in EIA practicable, assess the monitoring data, judging if the proposed environmental protection measures are contributing and make sure the sustainable utilization of natural resources.

9.3.1 Monitoring plan outline

This plan mainly aims at the negative problems to environment mentioned in unit 6. Monitoring items include surface water quality, ground water level and quality, soil physical and chemical properties (physical structure, nutrient, moisture, salinity and pH value), biodiversity, water conservation, soil and water conservation, sandstorm effects, plant diseases and insect pests condition. Based on study and observation results of ecological shelter forest species in two decades, several consensus results of natural vegetation of Ningxia Autonomous Region, and our investigation results, we have concluded the

monitoring plan (Table 9-2).

Table 9-2 The environmental monitoring plan of Ningxia Desertification Control and Ecological Protection Program

Stage	Monitoring content	Index	Method	Frequency	Layout of site	Unit price (Yuan)	Total price (Yuan)	Implementing unit	Supervision unit
Baseline monitoring	Soil matrix	Soil bulk density, total porosity, capillary porosity and non-capillary porosity, field water capacity, organic matter, total N, available N, total P, available P, $CaCO_3$, pH, soil water and salts	TDR for soil water, Cutting Ring for bulk density and porosity, the aerometric method for $CaCO_3$, 0.5 M $NaHCO_3$ extraction and the molybdenum stibium anti-color method for AP, the H_2SO_4-H_2O_2-Semi-micro-Kjeldahl method for total N, the dichromate titration method for organic C, the diffusion and alkaline hydrolysis method for AN	One time before the construction	Respective 1 plot for 7 subprogram areas of Xingqing, Litong, Pingluo, Yanchi, Lingwu, Zhongwei and Qingtongxia	5000	35000	Engaging speciality institution	Autonomous region project office
	Wind-sand effect	Thickness of wind erosion and sand burying, sand transport quantity	Insert rod method for erosion and burring, sand-transprting instrument for the quantity	One time before the construction	Respective 1 plot for 4 subprogram areas of Xingqing, Litong, Pingluo, Yanchi, Lingwu,	7200	28800	Engaging speciality research institution	Autonomous region project office
	Biological diversity	Shrub and grass species,	3 fixed sample plots for each forest type, 50×50	One time before the	Respective 1 plot for the 7	6000	42000	Engaging scienti	Autonomous region

		density, coverage and frequency	m^2 for arbor, 25×25 m^2 for shrub, 4×4 m^2 for semi shrub, 2×2 m^2 for herb, according to ecological method to survey	construction	subprogram areas			fic teaching institution	project office
Operation phase	Soil matrix	Soil bulk density, total porosity, capillary porosity and non-capillary porosity, field water capacity, organic matter, total N, available N, total P, available P, $CaCO_3$, pH, soil water and salts	TDR for soil water, Cutting Ring for bulk density and porosity, the aerometric method for $CaCO_3$, 0.5 M $NaHCO_3$ extraction and the molybdenum stibium anti-color method for AP, the H_2SO_4-H_2O_2-Semi-micro-Kjeldahl method for total N, the dichromate titration method for organic C, the diffusion and alkaline hydrolysis method for AN	Respective 1 time in the first year, third year and fifth year	Respective 1 plot for 7 subprogram areas of Xingqing, Litong, Pingluo, Yanchi, Lingwu, Zhongwei and Qingtongxia	5000	315000	Engaging speciality institution	Autonomous region project office
	Wind-sand effect	Thickness of wind erosion and sand burying, sand transport quantity	Insert rod method for erosion and burring, sand-transprting instrument for the quantity	Respective 1 time in the first year, third year and fifth year	Respective 1 plot for 4 subprogram areas of Xingqing, Litong, Pingluo, Yanchi, Lingwu,	7200	209200	Engaging speciality research institution	Autonomous region project office
	Biological diversity	Shrub and grass species, density,	3 fixed sample plots for each forest type, 50×50 m^2 for arbor, 25×25	Respective 1 time in the first	Respective 1 plot for the 7 subprogr	6000	630000	Engaging scientific	Autonomous region project

		coverage, frequency, biological diversity index, community stability index	m^2 for shrub, 4×4 m^2 for semi shrub, 2×2 m^2 for herb, according to ecological method to survey	year, third year and fifth year	am areas			teaching institution	office
	Protection of rare species *Ammopiptanthus mongolicus*	Density, coverage, frequency and biological diversity index	Three Quadrats with area 25×25 m^2	Respective 1 time in the first year, third year and fifth year	1 site in Hongdunzi	2000	100000	Engaging scientific teaching institution	Autonomous region project office

By the above monitoring and analysis, it reflect some background values monitored in the construction stage and its changes before and after the project implementation in the environmental monitoring report system, and analyze the benefits of the project.

9.3.2 Monitoring content and plan in different periods of the project

According to the monitoring plan outline, three phases are divided, including period baseline monitoring, construction and after construction.

9.3.2.1 Baseline Monitoring

The monitoring before construction aims at two aspects. Firstly, check up if the alleviating measures in EIA reports have been listed in the final construction contract with design documents. Secondly, assess current environmental situation.

At the same time, natural reserve needs to be monitored. In the project areas that near the natural reserve, when the initial plan shows violation to natural reserve, project offices of autonomous region should keep the natural reserve from violation all the time. If artificial forest is near to some natural reserve, it is necessary to amend the initial design according to national law and regulation.

9.3.2.2 Monitoring during construction

The construction activities of project may influence several environmental parameters

such as water resource, vegetation, soil and biodiversity. It may cause slight influence to air quality, sound environment and public health in short term. During the construction, we need to monitor the variation of each environmental parameter that may be influenced according to the environmental monitoring plan for construction. With the development of the entire project, supervisory personnel should monitor air quality, sound environment and public if it is necessary. We suggest listing every short-term monitoring item in order to help the groups to find the most proper action plan and make it practical under special conditions.

As for monitoring air quality, we should reduce dust amount generated by the construction by means of dust control. During construction, we should assess the effectiveness of these methods by means of on-site inspection. If potential problems are confirmed by environmental supervision personnel, then it is necessary to monitor according to air quality monitoring plan (Table 9-3).

As for noise monitoring, it is mainly focused on the influence of construction noise to resident nearby. Environmental supervision personnel will decide whether it is necessary or not. If it is necessary, apartment concerned will be contacted and be responsible to monitor according to the noise monitoring plan (Table 9-4).

Table 9-3 Air quality monitoring plan during construction period

Site	Item	Frequency	Time	Executor
Tourist spots or villages within 100 m	TSP	Once in a quarter of a year if is necessary	Random	Project office, environment supervision personnel or entrusted corresponding environment monitoring station

Table 9-4 Noise monitoring plan during construction period

Site	Frequency	Duration	Time	Executor
Environmental sensitivity area with 100 m	Nonscheduled	One day	Once in the morning, once in the evening	Environment supervision personnel or environment monitoring stations

Table 9-5 Public health monitoring plan during construction

Site	Object	Item	Executor
Each construction site	peasant-workers	epidemic diseases including hepatitis, diarrhea, typhoid, hemorrhagic fever, leptospirosis, pertussis and phthisis	environment supervision personnel of epidemic disease control station

As for monitoring public health, environment supervision personnel should know if there is epidemic disease. The entire situation should be reported to corresponding apartment if there is any. If by any chance a certain epidemic disease broke out in work shed, environment supervision personnel or project office in autonomous region should inform and entrust local epidemic disease control station as soon as possible and monitor the situation at all times, especially for the peasant worker who is from outside construction site. Public health monitoring plan can be seen in Table 9-5.

As for garbage disposal monitoring, garbage monitoring in construction site would be completed by environment supervision personnel. Their mission is to make sure that the construction brigades have chosen the proper site and method to pile and dispose the garbage according to the final project design.

As for the surface and ground water pollution monitoring, the gasoline, engine oil and fuel from construction machines will pollute water and soil, which will then influence the environment. Environment supervision personnel will supervise the mechanical equipment strictly. Once any fuel or gasoline leak happened, the equipment must be mended rapidly. At the same time, it is important to ensure a certain distance between gas stations or transportation sections and any surface water or wells in open in order to prevent pollutant from entering the water.

As for soil erosion monitoring, the construction of project will accelerate the soil erosion and wind erosion because of the extensive reclamation of land, especially in forestation and tending period. Soil erosion may happen in construction area, forest way, area along the construction and area that is ready for forestry, raising seedlings or weeding. This kind of erosion may raise the amount of sediment in rivers and lakes so that to influence the plants and animals in water. Office in each level and the environment supervision personnel must confirm all the influence that may encounter and take measures.

9.3.2.3 Monitoring after construction

The goals of environment monitoring plan after construction are to know the influence to environment after construction, improve environment management and supervision plan with information already gained, and then reduce or prevent any unpredictable serious influence to environment in the next stage.

Main monitoring content after construction contains surface water quality, ground water level, soil physical and chemical properties (physical structure, nutrient, moisture and salinity), biodiversity, soil and water conservation, sandstorm effect, styles and hazard levels of plant diseases and insect pests, utility of pesticide and so on. All above will be decided and carried out by environment supervision personnel in each level. Detailed content of monitoring plan is as follows:

(1) Soil nutrient and salinity monitoring

Soil fertility monitoring point will be built to monitor the annual dynamic changes of soil fertility index after afforestation, such as pH value, nutrient (N, P, K) level of soil, and also the salinity as well.

A. Monitoring items

Bulk density, total porosity, capillary porosity, noncapillary porosity, capillary maximum capacity, field capacity, organic matter, total nitrogen, total phosphorus, total potassium, available nitrogen, available phosphorus, available potassium, pH value, enzymatic activity, moisture, and total salinity of soil.

B. Monitoring methods

Fixed standard sample area is chosen to observe and analyze. Monitoring database of soil physical structure, fertility, moisture and salinity and monitoring models are built. More specifically speaking, choose typical fixed standard sample area which cover an area of $0.1hm^2$ in typical area on the basis of different afforstation models, lay inbuilt special tubes in standard plot's soil and measure soil moisture with TDR. Dig and get the profile of soil in standard plot, sample and quantify. Measure the soil porosity by means of ring sampler, measure soil mineral nutrition by means of flame spectrophotometry, measure total nitrogen content with azotometer, measure organic matter content by means of Qiulin method, measure salinity with conductiviry meter and analyze the constitute of soil grain size with soil sieve.

C. Monitoring frequency

In the growing season from April to October of the 1st, 3rd and 5th year of project construction, 3 times a month for soil water while 1 time a month for soil nutrient..

D. Monitoring sites

There is one monitoring point in the biggest area of each subproject.

E. Schedule

In the 1st year, we will make the monitoring plan of physical and chemical properties and fertility of soil, choose standard fixed sample plots on the basis of different afforestation models, sample and quantify. Soil physical properties and fertility will be measured. Finally, we will build the monitoring models and database of physical properties, fertility, and salinity of soil and then submit annual monitoring report. In the 3rd year, continue previous monitoring, submit annual monitoring report, refresh database and hold medium-term discussion and convention about influence to soil physical properties, fertility and salinity. In the 5th year, also continue previous monitoring, submit annual monitoring report, refresh database and hold final discussion and convention on the influence to soil physical and chemical properties.

(2) Wind-sand effect monitoring

A. Monitoring index

Wind speed, wind direction, air humidity, the height, crown size, density, cover degree of arbors and shrubs, wind erosion thickness and sand buried thickness.

B. Monitoring methods

Choose the typical area in two afforestation models--Humid shifting dune and semi-humid shifting dune, which repeat 3 times. The 6 points are in the forest, at the points locate in that 5, 10, 15, 20 times the distance to forests or edge tree and in the open field (as contrast). Sand buried thickness will be monitored by inserted brazing method. That means a sample line will be arranged 2 to 3 meters away from edge of forest in the direction of down wind and then one brazing will be inserted every 5 to 10 meters. The sand buried thickness will be observed by mini-meteorological station both in summer and after leaf falling in the winter respectively. Meanwhile, we will measure and record the afforestation survival rate, species, height, density, structure, age, canopy density or cover degree of arbors and shrubs, sand buried thickness and so on.

C. Monitoring frequency

In the spring of 1st, 3rd and 5th year of the project construction, monitor 3 times a year.

D. Monitoring sites

There is one monitoring point in the biggest area of subprojects as follows: Xingqing, Pingluo, Lingwu and Yanchi. One contrast will be build outside of the forest as well.

E. Schedule

In the 1st year, we will make the monitoring plan of soil erosion. Suspended sediment discharge and wind speed will be observed in 8 monitoring points. Then monitoring database of sandstorm effect will be built and earlier monitoring report will be finished. In the 3rd year, continue the previous monitoring, refresh database and hold medium-term monitoring discussion and convention. In the 5th year, also continue previous monitoring, refresh database, finish the final monitoring report and hold discussion and convention of windbreak and sand fixation.

(3) Biodiversity monitoring

Biodiversity usually includes genetic diversity, species diversity, ecosystem diversity and landscape diversity. The construction of ecological shelter forest may affect biodiversity as well.

A. Monitoring items

Species and individuals of plants, frequency, density, coverage and biomass.

B. Monitoring methods

Choose the typical area by means of field trip. For arbors, at least set up 3 fixed samples which is 50×50 m^2 and set contrast in similar forests (with the same species, density and age) outside the project area. Survey the species, individuals and growing condition of arbors to calculate the diversity of arbors. For shrubs, set up 4 samples which is 25×25 m^2, survey the species, individuals and growing condition of shrubs and calculate the diversity of shrubs. For herbs, set up at least 3 samples which is 1*1m^2, survey the species, individuals and growing condition of herbs and calculate the biodiversity of herbs.

C. Monitoring frequency

Monitor once in the 1st, 3rd and 5th year of the construction. The entire monitoring duration is 5 years.

D. Monitoring sites

There is one monitoring point in the biggest area of each subproject.

E. Schedule

In the 1st year, we will make the monitoring plan of biodiversity, choose the samples and investigate according to the plan, build monitoring database and finish the earlier monitoring report. In the 3rd year, continue previous monitoring, refresh database and hold medium-term monitoring discussion and convention. In the 5th year, also continue previous monitoring, refresh database, finish the final monitoring report and hold final discussion and convention about biodiversity.

(4) Plant diseases, insect pests, and rodent pest monitoring

A. Monitoring index

The types and density of insect pests, rate of insect-attacked trees and area; the types, infected index of diseases, rate of infected individuals and area; the types and area of rodent pests; kinds and dosage of pesticides.

B. Monitoring methods

By means of sample survey and fixed point observation. We will choose one fixed sample which is 0.1hm^2 in standard area for each afforestation model.

a. Investigation of diseases

The diseases mainly contain Cytospora chrysosperma, Melampsora larina-populina, Marssonina mali, apple canker, grape leaf spot and grape powdery mildew. According to the law of occurrence, we will survey 2 to 3 times in a year. Survey will carry on in peak of infection and end of September respectively each year. Furthermore, the infection index and rate of infected individual will be calculated.

b. Investigation of insect pest

The main kind of insect pest contain: *cerura menciana Moore, Clostera anachoreta*, *Stilpnotia candida Staudinger*, *Apocheima cinerarius*, *Parathrene tabaniformis Rottenberg*, *Anoplophora glabripennis*, *Obolodiplosis robiniae* (Haldemann) , *Zamacra excavata Dyar*, *Eulecanium kuwanai*, *Eucryptorrhynchus brandti*, *Cossus orientalis Gaede*, *Holcocerus vicarius Walker*, *Agrilus planipennis Fairmaire, Malacosoma neustria testacea Motschulsky*, *European red mite, Grapholitha inopinata Heinrich, Cicadella viridis, Eulecanium gigantean*,

Dasyneura datifolia, *Epitrimerus zizyphagus Keifer*, *Orgyia ericae Germar*, *Asclerobia sinensis*(Caradja), *Bruchophagus neoc-araganae*, *Pristophorodes florella* and so on.

Survey of the target pests will be conducted in peak time of occurrence and foraging of larva of every generation.

c. Investigation of rodent pest

The main species are *Microtus fortis*, *Lepus tolai*, *Rhombomys opimus*, *Microtinae*, zokor and so on. Survey of the target pests will be conducted in the peak time of foraging.

d. Statistics of occurrence area

Classify the data of different types of diseases pests from investigation into three ranks: mild, moderate and serious. Mild means the damage level is Ⅰ-Ⅱ, moderate means level Ⅲ while serious means level Ⅳ-Ⅴ. Then collect the data of local pest occurrence in different species and summarize.

C. Monitoring frequency

Monitor once a year during the construction. The monitoring duration every time is 6-9 days. The monitoring report of plant diseases and insect pests will be finished in the 1st, 3rd and 5th year of the construction respectively.

D. Monitoring sites

There is one monitoring point in the biggest area of each subproject.

E. Schedule

In the 1st year, we will make the monitoring plan of Plant diseases, insect pests, and rodent pest, monitor in chosen standard fixed sample in different afforestation models, build monitoring database and finish the earlier monitoring report. In the 3rd year, continue previous monitoring, refresh database and hold medium-term monitoring discussion and convention. In the 5th year, also continue previous monitoring, refresh database, finish the final monitoring report and hold final discussion and convention about diseases, insect pests, and rodent pest.

All above is the monitoring plan of 6 main environmental parameters: surface water quality, ground water level, nutrient and salinity of soil, soil erosion, sandstorm effect, biodiversity, and plant diseases, insect pests, and rodent pest. These plans should be carried out freely in practice, which depends on local conditions, in order to become more effective. At the same time, we suggest the management to conclude and analyze the plans and the

results duly so that to reduce the influence of project construction to environment to the least.

(5) Variation of natural meadow and pasture

The same with the biodiversity monitoring plan.

(6) Variation of *Ammopiptanthus mongolicus* and *Populus euphratica*

The same with the biodiversity monitoring plan.

9.3.3 Execution of environment monitoring plan

The project offices of Autonomous region will be in charge of the execution of the monitoring plan. Under the leadership of the project office of Autonomous region, the project office in each level will be in charge of the specific monitoring activities of territory themselves.

According to the jurisdictions division, environment monitoring stations in each level will monitor the surface water quality, ground water quality and soil condition. Meanwhile, Autonomous Region Forestry Bureau will monitor the fixing effects of ecological shelter forest, the water and soil preservation effects of enclosure, effects of ecological economic forest and other related issues. Furthermore, the project office of Autonomous region should sign contracts with monitoring stations in each level before the construction. According to the environment management plan and monitoring plan, the environmental supervision personnel will inspect the implementation of all the monitoring stations.

9.4 Monitoring report system and funds

9.4.1 Management departments and responsibilities

In the stages of plan’s designation, implementation and operation, the environment monitoring project defines clearly the duty of each department in the process of designation and development which is in the aspects of implementing plan, carrying out the remission and monitoring activities. The implementation of the monitoring plan needs the supervision of the regional project office and environmental protection department. Each county project office urges and supervises the action of the monitoring plan, and informs the autonomous regional project office and environmental protection department about the related matters occurred in the project. According to the environmental monitoring plan, the local monitoring groups implement and complete the duty of environmental monitoring and write monitoring reports

at last. The completion of the whole report needs various departments mutual coordination and mutual cooperation, and does their job respectively to finish the task altogether. The Specific managements and responsibilities of the relevant organizations and departments are in the Table 9-6.

As the same time, each level of the environmental protection department takes their responsibility of supervising environment within their own authority. In the each stage of feasibility study, construction and operation, each department have different responsibilities and does their own job, but they also maybe adjust their own responsibility constantly in the process of the project development. In order to make sure the plan's implementation is instead of the minimum environmental cost, we compile the environmental monitoring plans as Table 9-7, which needs the corresponding department conforming and executing.

Table 9-6 Relevant organizations and responsibilities of environmental monitoring

Organizations	Responsibilities of environmental management and monitoring
Environmental protection monitoring groups of all levels of Forestry Bureau	1. Implement the regulation of the state environmental protection laws and the environmental criteria; Monitor surface water, groundwater, soil erosion, soil fertility and salinity, plant diversity, water conservation, soil erosion and sand-fixing effect Regularly, and do a good job of monitoring data report and archiving. 2. Complete the monitoring mission, compiling the monitoring reports and timely reporting the problems and its causes found in the work and treatment measures and suggestions to the environmental monitoring group in the regional forestry according to the monitoring results. 3.Strengthen the environmental monitoring equipment maintenance and repair, checking, to make sure the monitoring on the rail。 4. Enhance the staff exchange and training improve the professional quality, accept superior's assessment and take responsible for the available environmental monitoring data. 5. Municipal and county environmental monitoring groups are responsible for the background changes of the natural environment including the soil and water conservation, hurricane and wind damage and so on, and report to the regional environmental monitoring group.
Project offices of all levels of Forestry Bureau	1.To ensure that all the environmental management and monitoring plan have been implemented on the project counties and the forest farm level, and notify the regional project implementation organizations and the county environmental protection agency of the project related issues occurring in the environment, also take responsible for data collection and providing the related environmental officials technical support. 2.Propaganda and education the environmental issues and environmental

	protection knowledge on the level of the project counties and forest farm, and is responsible for a variety of new technologies for the promotion and application on the environmental protection work. 3. Establish Environmental information file for the project, do well the statistical work of environmental protection.
All levels of Environmental Protection Agency(EPA)	1. Directly responsible for the supervision and inspection of environmental management and monitoring of the implementation and the relevant national environmental laws have an potential environmental impacts on each part of the project. 2. The county environmental protection agency and the environmental monitoring stations are responsible for the daily inspection and supervision on the aspect of the project's environment.
Project office of local Forestry Bureau	1. Execute the environmental monitoring project and supervision the monitoring organization, to make sure taking the sample timely according to the provisions of the monitoring plan. 2. Report to the relevant environmental management and World Bank about the environmental problems during the project construction and operation regularly. 3. Handle environmental complaints and accept the supervision of the environmental protection department. 4. Arrange the environmental monitoring stations' staff visited. 5. Take responsible for the other matters required by implementing environmental management and monitoring plan.
Regional Environmental Protection Agency(EPA)	1. Supervise and inspection the biodiversity conservation and the wildlife protection in the project's design phase. 2. Responsible for the approval process of the domestic EIA, and the unscheduled inspections of the project according to the EIA requirements and the approval contents.
Monitoring groups of regional Forestry Environmental Protection	Take responsible for the task of monitoring the environmental quality in the level of autonomous regional monitoring sites by regularly organizing regional Academy of Forestry and the units of the project in accordance with the national environmental standards, and check monitoring under the regional project office authority to submit the dynamic technology report of environment monitoring on time.
Regional Environmental Protection Bureau(EPA)	Responsible for project EIA documents for approval, supervision and management by the Board within the Department is responsible for supervision of provincial environmental management and monitoring plan to check all parts of the project the successful implementation of mitigation measures.
Regional project office	1. Organize and coordinately complete the environmental impact of forest monitoring. 2. Take responsible for the municipal annual inspection and acceptance in the afforestation projection. 3. Responsible for the inferior project office's supervision and summary of the implementation environmental management.

Table 9-7 The project environmental monitoring plan

Phases	Organizations	Items	Requirement
Argumentation	Ningxia EPA and World Bank	Review the draft of the environmental management and monitoring plan	1. Determine the project could cause the potentially important environmental issues. 2.The county environmental protection agency(EPA) give suggestions and put forward some practical mitigation measures
Designation and Construction	Ningxia EPA and World Bank	1.Examinate the preliminary design of the environmental management monitoring plans	1. Execute the environment management and monitoring program Strictly. 2. Consider all the national laws and regulations relate to the project implementation.
	Ningxia EPA and World Bank	2.Verify the environmental protection investment is in place	3. Make sure enough environmental protection investment in place.
	Regional and local EPA and World Bank	3. To verify the choice of project area.	4. Verify the project area is suitable for the development of ecological shelter forest and make the project won't affect biological diversity seriously. 5. Make sure that the project area is far away from the natural reserve buffer zones and core zone not to block the wild animal's migration routes.
		4. If find the pollution of dust and noise, supervise and manage it.	6. Take the control measures in the environmental management and monitoring plans. 7. Have the builders to follow the environmental management and monitoring plans. 8. Execute the work schedule forcibly according to the environmental management and monitoring plans.
		5. Check for the underground cultural sites.	9. Protect the cultural sites.
		6.Check up the sewage and waste disposal on the construction site	10. Deal with the solid waste and sewage according to the state and local laws and regulations, and keep the surface water and groundwater from pollution.
		7. Check whether the project construction	11. Make sure that the soil erosion control measures comply with environmental

		accelerate soil erosion.	management and monitoring plan, and make the state and local laws in place.
Operation	Regional and local EPA	1. Check the implementation of the environmental management and monitoring plan. 2.Check whether it is necessary to further take environmental protection measures	1. Protect the environment to minimize the environmental effects during the operation period. 2. If necessary, verify and improve the environment management and monitoring program. 3. Make sure the sewage treatment reach the standard. 4. Ensure that the project's impacts on natural resources, especially on the natural forests and water have minimized influence.
	Regional and local EPA	1. Check whether the pollution discharges meet the national standards or not. 2. Whether the impact on the source of water. 3. Examine whether influence on the nature reserve and rare animals and plants. 4. Check whether speed up soil erosion. 5. Examine the use of pesticides.	5. Make sure that the pollution emission meet the national standard. 6.To ensure that the project don't cause the increase of natural forest degradation 7. Report to relevant management agencies any mistakes behavior. 8. Make sure that the project doesn't have negative effects for the water and downstream water users, and report any mistakes behavior to the relevant management institutions. 9. By strengthening the implementation of the environmental management and monitoring plan to prevent the project on nature reserves, rare animals and plants cause any potential negative effects. 10.Supervise and check the use of pesticides in the pest control, and make sure that the pest management plan implement overall, don't use of I pesticides, and don't cause the pollution of surface water and underground water.

9.4.2 Environmental report system

The environmental monitoring project will be implemented under the supervision of the autonomous regional and local environmental protection bureau. All level of environmental protection bureaus and the environmental monitoring stations cooperate closely and divide the work definitely to complete the monitoring plan. The regional central environmental

monitoring station takes charge of the environmental quality in their authorities under the lead of the autonomous regional environmental protection bureau. The local environmental monitoring stations take their own responsibility under the lead of local environmental protection bureau.

When the task of monitoring finished, the monitoring group must compile the report, which included some dates to reflect the plan's implementation and suggestions to improve the protection measure. At the last, the report is submitted to the regional management office and the superior environmental protection administrative department. As long as acquiring the report, the office of management and the primary department take some kinds of measures to resolve the problem of the report. During the stage of the plan's implementing and operating, the regional management office should put in the annual environmental management and monitoring report to the World Bank. If this report be needed for the regional environmental protection bureau and the state environmental protection administration, and should get all those submitted report.

9.4.3 The budget of monitoring funds

The budget of the monitoring plan's implementation consists of the pre-implementation's budget, inter-implementation's budget and the operation's budget. The pre-implementation's budget is 105.8 thousand Yuan, the inter-implementation's budget is 105.8 thousand Yuan and the operation's budget is 1611.5 thousand Yuan. In all, the budget of the environmental monitoring is 1825.8 thousand Yuan (Table 9-8).

According to the relevant of fees in "the notice about issuance the administrative fees and standards in environmental protection system" issued by the national price bureau and the finance department in April 1992 and " the notice about adjustment the professional service fees standards of Ningxia environmental monitoring"(from the file of Ningxia price fee standards, 2002, number 138) issued by the autonomous regional price bureau and the finance department, combine the actual situation of each project area and establish the budget of environmental monitoring funds. Calculating the total capital invested in the environmental monitoring is 1825.8 thousand Yuan, including the laboratory for equipment configuration and setup fees, the salaries of employee are out.

Table 9-8 The budget of the project's environmental monitoring funds

Phases	Environmental Parameters	The budget：Yuan	
		Used money	Sum
Before construction	Soil matrix	35000	105800
	Wind-sand effect	28800	
	Biological diversity	42000	
Implementation period	Soil matrix	35000	105800
	Wind-sand effect	28800	
	Biological diversity	42000	
Operation period	Soil matrix	315000	1614200
	Wind-sand effect	209200	
	Biological diversity	630000	
	Plant diseases and insect pests	360000	
	Ammopiptanthus mongolicus nurse	100000	
Total	*1825800*		

9.5 Strengthen institution and environmental monitoring training

9.5.1 The purpose of training

The training purpose of environmental monitoring are further strengthening the capacity of all levels officials in project management office who are responsible for the implementation of environmental management and monitoring plan, to ensure that they successfully perform the mitigation and monitoring plans established in the environmental impact assessment during the periods of the project implementation and operation. The training can also include forest and company's staff.

To ensure the training courses completed successfully, the staff who are arranged to carry out environmental supervision and attend the training courses should have a university degree, and the majors that they learned are best to be natural science, such as forestry management, water resources, environmental ecology, soil science and agriculture, etc..

The project will make production and scientific research as a whole, in the course of project implementation, extending technic and training. First, take method of combining classroom and field together, and train the forestry technicians and management staff of all levels of relevant departments, to improve their technical quality and practical level. Second, have domestic and international inspection training between projects, and learn advanced management ideas and technology, to enhance the project staff's capacity and experience. The

third is an approach of “please come in and send out”, inviting experts consulted and imparting technic at home and abroad, to strengthen the capacity building of the project.

9.5.2 The tasks and funding of training

The project intends to train the people of 1929, of which 1,800 have a grass-roots training, 110 people domestic training, 18 people international training. Hold international exchange of 5 times.

The total of training funds is 2.605 million Yuan (Table 9-9).

Table9-9 The number of trainees and costs of environmental monitoring project for each subprogram region

Sites	Grass-roots training (person)	Domestic training(person)	International training(person)	Sum (person)
Xingqing	1300	50	1	1352
Lingwu	2500	150	2	2651
Pingluo	1300	100	2	1401
Yanchi	2300	150	2	2452
Litong	1000	20	1	1021
Qintongxia	1500	150	1	1652
Zhongwei	0	10	6	16
Autonomous regional forestry administration	100	5000	30000	-
Unit cost (Yuan)	111	325	48	484
Total (Million Yuan)	1300	50	1	1352

9.5.3 The courses of training

Table 9-10 shows the plan of the training.

Under the leadership of the Ningxia PMO, the courses of environmental training will include the following:

1. World Bank and Chinese government understand and apply the environmental laws, regulations, standards and norms on environmental protection.

2. The environmental management standards is applied by World Bank.

3. Environmental protection technologies and environmental monitoring technologies specifically including.

Table 9-10 The project training plan

Types	the content	Sponsor	Objects	Methods	Materials
Provinces	1. understand and apply the World Bank and the Chinese government about the environmental laws, regulations, standards and norms. 2. carry out and control the environmental management and environmental protect rule, including the positive and negative environmental effects, the environmental protection rules and management. 3. the principle, the plan and the implementation of the integrated pest management program, and the method of using pesticide safely. 4. the environmental monitoring plan and implementation, including choosing and setting up the environmental sites, observing in field and analyzing in laboratory the environmental factors and reporting the monitoring results.	Provincial PMO	the city level of management personnel, technical personnel and information management personnel	training class	environmental management and environmental protection regulations, environment management and monitoring program, pest control plan, the environmental effects manual or guides.
Cities	1. the environmental management and environmental protect rules, including the positive and negative environmental effects, the environmental protection rules. 2.The plan and the implementation of the integrated pest management program, and the method of using pesticide safely 3. the environmental monitoring plan and implementation, including choosing and setting up the environmental sites, observing in field and analyzing in laboratory the environmental factors and reporting the monitoring results.	PMO of city forestry bureau	the county level of management personnel, technical personnel and the environmental management personnel	training class	
Counties	1. the basic understanding of degradation of vegetation, different vegetation types and ecological system. 2. the technology and the method of biological diversity monitoring. 3. the principles and the methods of soil	PMO of ministry of forestry	towns and forest farms workers	training class, training meeting and field guidance	

	erosion control. 4.the technique of pest control and the knowledge of pest's identification, life history, biological characteristics, diseases, etc.				
Towns and Forest farms	1. the main environmental protection measures taken in the design of construction and the project implementation. 2. the main pest's identification and prevention. 3. the pesticide types recommended and the ways of using and storing the pesticides. 4. The operation of pest control and using pesticide.	county and town forestry station	afforestation group and farmers	training class, field guidance and operation	

a. The principle of hydrology and surface water quality measurement.

b. The basic knowledge of environmental monitoring.

c. The basic understanding of degradation of vegetation, different vegetation types and ecological systems.

d. The principles of soil erosion and different ways of soil erosion control.

e. The technology of pest control and the principles of integrated pest management program (IPM).

f. The sampling and processing of basic methods identified in soil and sediment in the Environmental management and monitoring plan (EMMP).

g. Preparation of environmental monitoring report.

In addition, it is recommended to farmers to carry out a specific training program, training for the use of pesticide, the program of pest and disease control and the principle and use of integrated pest management, not only to protect the environment, but also to reduce the costs of operation.

10 Conclusions of environmental impact assessment

The Ningxia Desertification Control and Ecological Protection Promgram will complete the control sand desertification land with 76000 ha during 2012~2016, which distributes in Xingqing district of Yinchuan city, Litong district of Wuzhong city, Lingwu city, Qingtongxia city, Zhongwei city, Pingluo coungty and, Yanchi county. In this program, it mainly includes: (1) 20096.96 ha of shrub forest with artificial straw chechboard barrier used for fixing shifting sands; (2) 44303.53 ha of the enclosure sand vegetation used for ecological restoration; (3) 6086.58 ha of ecological shelter forest used for pretecting farmland or the Yellow River. The total investment of the program is 719.71 million Yuan, among which 504 million Yuan is World Bank loan. The program implementation will improve the ecological environment along the Yellow River in Ningxia and promote the local social and economic development.

The implementation of the project will increase the ground vegetation coverage by 4%, the positive effects of the environment focus on that the program implemetation: (1) significantly control wind and sand, increase the biodiversity, improve the soil physical and chemical properties, mitigate the hot wind hazard, purify air, maintain the balance of carbon dioxide and oxygen, regulate the regional micro-climate, slow down or curb land degradation and improve the health of ecosystems; (2) is a process of carbon sink, and can increase carbon storage in soil and plants in the project area and, is helpful of the balance of regional carbon sequestration; (3) has positive effects on the protection of the endangered plant, *Ammopiptanthus mongolicus*, and the site of Ming Great Wall; in addition, also increase the income of local people and help to reduce the interference on the ecological environment. Meanwhile, the implementation of the project will have some negative environmental effects, but the impacts on underground water and production of animal husbandry are in the affordable range as long as ecological protection measures are adopted in time, and its negative effects can be minimized or even avoided.

Consequently, although the project implementation may have potential negative environmental impacts, the positive impacts on the environment are greater than the negative. The project is practicable, and the Ningxia Sand Control Ecologial Protection Program can be implemented.

Appendix: List of the table and figure in the EIA report